Reduction in Unnecessary Clinical Laboratory Testing Through Utilization Management at a US Government Veterans Affairs Hospital

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ABSTRACT

***Objectives**: To implement an electronic laboratory utilization management system (laboratory expert system [LES]) to provide safe and effective reductions in unnecessary clinical laboratory testing.*

***Methods**: The LES is a set of frequency filter subroutines within the Veterans Affairs hospital and laboratory information system that was formulated by an interdisciplinary medical team.*

***Results:** Since implementing the LES, total test volume has decreased by a mean of 11.18% per year compared with our pre-LES test volume. This change was not attributable to fluctuations in outpatient visits or inpatient days of care. Laboratory cost savings were estimated at $151,184 and $163,751 for 2012 and 2013, respectively. A significant portion of these cost savings was attributable to reductions in high-volume, large panel testing. No adverse effects on patient care were reported, and mean length of stay for patients remained unchanged.*

***Conclusions:** Electronic laboratory utilization systems can effectively reduce unnecessary laboratory testing without compromising patient care.*

Health care expenditures in the United States continue to rise at an alarming rate. They are projected to reach $4.4 trillion by 2018 (20.3% of projected gross domestic product).[1] Such an unsustainable rise presents many risks for the future of the nation's health care system as well as its economy. Laboratory testing is one factor that contributes to rising health care expenditures.[2] It is estimated that laboratory and pathology testing accounts for 4% of all yearly health care costs.[3] From 2005 to 2010, Medicare spending on all part B laboratory services increased by 29%.[4] This increase was significantly disproportionate to the 10% increase in enrollment in Medicare part B.[4] It is becoming increasingly evident that cost stabilization and reduction, including within-laboratory services, are necessary to place our nation's health care system back on a sustainable course.

Depending on the country, clinical setting, method, and specific tests evaluated, studies have shown that a relatively large percentage (up to 42%) of laboratory testing can be considered wasteful.[5-8] Moreover, commonly ordered tests or test panels are often cited as being overused.[8] Redundant testing alone has been estimated to waste up to $5 billion annually in the United States.[9] Redundant testing can occur when tests are ordered by multiple clinicians treating a given patient, when recurring orders are placed on a given patient (eg, daily CBC) without recurring assessment of clinical necessity, when orders are repeated at short time intervals that are unlikely to detect a clinically relevant change, or when large panel testing is repeated to address a disturbance of one or a few analytes.

Laboratory utilization management systems are one method that can effectively curtail a significant amount of these unnecessary tests. Furthermore, utilization management can also help to reduce many often overlooked consequences

of inappropriate testing. For example, false-positive testing can result in other inappropriate laboratory or defensive diagnostic testing. In addition, individuals without health insurance may have to bear the financial impact of unnecessary testing. For inpatients, a high frequency of blood draws can be disruptive and lead to interruption of normal sleep patterns. In extreme cases, repetitive blood draws can lead to hospital-acquired anemia.[7] Moreover, unnecessary testing can act to divert nursing and phlebotomy staff from their performance of other important tasks. In contrast, the potential exists for patient harm if utilization management is carried out with only cost reduction as an end point. Therefore, utilization rules are best targeted at tests that are demonstrably overused or ones for which evidence-based guidelines exist. Ideally, hospital-based clinical peer committees should establish specific test utilization rules that are tailored to meet the demands of their respective institutions.[10,11]

A variety of different laboratory utilization systems have been proposed.[2,10,12] Success in reducing redundant or unnecessary laboratory testing has been demonstrated by passive noninterruptive alerts that provide decision-making support for physicians.[12] This can include providing information on test costs, previous test results, test information, or ordering advice.[12] Interruptive alerts that require an action by the physician (eg, closing a pop-up alert) can also be used.[12] Finally, a more restrictive approach has been described and effectively used.[10] Test ordering frequency filters for up to 44 tests were introduced following consultation with clinical staff and resulted in an overall reduction of 0.56% of total test volume and a reduction in laboratory costs of 0.33%.[10] Regardless of the method used for laboratory utilization, the end goal in all settings is to minimize unnecessary laboratory expenditures without having an adverse effect on patient outcomes.

Given the sheer bulk and complexity of testing services offered at the typical clinical laboratory, the control of unnecessary laboratory testing is best accomplished at the time of order entry. This is facilitated by the widespread use of computerized physician order entry (CPOE) systems that allow for system-defined rules for utilization management.[12] Indeed, while many laboratory information systems allow for the adoption of utilization management rules, the implementation of testing rules in hospitals without CPOE systems is largely ineffective, as they fail to provide decision support to the ordering physician.[12] CPOE systems have been shown to introduce significant quality improvements to patient care, particularly in the reduction of medical errors (reviewed in Cutler et al[13]).

The implementation of a robust and effective laboratory utilization system can be a challenging undertaking for any institution. It requires a significant amount of work and communication from administrators, clinicians, laboratory personnel, and information technology personnel. How the utilization software will be designed and integrated into existing ordering systems must be determined. Rules for test appropriateness must be established based on a daunting amount of information (eg, empiric or research-based evidence, national guidelines, clinician and laboratory director input, administrative input, cost reduction potential). The tests that will be regulated must also be decided depending on the specific needs and overarching goals of the institution. Despite all of these challenges, it is an undertaking that can positively affect laboratory expenditures and help providers use laboratory testing more efficiently and effectively. In this article, we describe our experience with a laboratory utilization management system (Laboratory Expert System) at the Richard L. Roudebush VA Medical Center.

Materials and Methods

Clinical Setting

The Veterans Health Administration (VHA) is the government branch of the United States that is responsible for the medical care of the nation's veterans and dependents. The VHA operates the largest health care system in the United States, operating a nationwide network of 151 Medical Centers, 300 Veterans Centers, 820 Community-Based Outpatient Clinics (CBOCs), and 135 nursing homes that provide care to more than 8 million veterans. The Richard L. Roudebush VA Medical Center, located in Indianapolis, Indiana, provides acute inpatient medical, surgical, psychiatric, neurologic, and rehabilitation care, as well as both primary and specialized outpatient services for approximately 60,000 veterans per year. It also serves as a tertiary referral center for other Veterans Affairs (VA) facilities in Indiana and Illinois, with 613,000 outpatient visits and almost 7,900 inpatient episodes of care per year. The 150-bed medical center also serves as a teaching hospital for the Indiana University School of Medicine.

Laboratory Expert System

The laboratory expert system (LES) is a set of subroutines that have been incorporated into the VA hospital and laboratory information system (also known as VistA: Veterans Health Information Systems and Technology Architecture). VistA is an integrated set of software applications that allow coordination between the electronic health record, known as the Computerized Patient Record System (CPRS), computerized order entry, electronic pharmacy prescribing, and clinical guidelines. The LES is a gatekeeper software system that allows the laboratory to suppress

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redundant testing by defining order frequency rules for specific tests or test panels for any given patient. At the time of order entry into CPRS, a request for a specific laboratory test or panel will be declined if the order exceeds the predefined rule for order frequency. Rules can be turned off for specific patient populations by test ordering site (eg, emergency department and intensive care units). Clinicians were also initially allowed to request that LES rules be turned off for a specific patient for a defined period of time. Finally, the ordering clinician could still obtain testing by contacting the laboratory and asking for an exception for an individual patient. Clinicians could not turn off the frequency filter directly through CPRS; this functionality is only available to the laboratory. A similar approach using a much smaller number of tests was reported by a hospital facility in the Netherlands.[10]

System Implementation, Monitoring, and Revision

In the spring of 2011, the clinical laboratory was tasked with reducing its annual budget of $7.5 million by $2 million. In response to a solicitation for budget reduction ideas, the Syracuse VA Medical Center (Syracuse, NY) suggested the implementation of its LES laboratory utilization management system. As initially obtained from the Syracuse VA Medical Center in July 2011, the LES consisted of a set of subroutines that could be written into VistA and supported frequency filter rules for 12 tests. In September 2011, the LES was presented to the chief of staff and chiefs of service, and the decision to implement the system was obtained. From September through December 2011, the laboratory procedure was written, the initial rules were developed in consultation with the clinical chiefs of service, and training was implemented for all involved participants. The LES allowed for unit-specific exclusion from the utilization management rule sets. In general, patient test requests that originated from critical care units and the emergency department were automatically excluded.

On January 1, 2012, the system went live with initial rules developed for 23 tests. During the first 4 days, the laboratory had additional staff present to handle questions, although this proved to be unnecessary. The laboratory monitored test volumes, cost savings, exclusions by clinician, and other test utilization patterns to detect workaround efforts. The laboratory continued to meet with the chief of staff and chiefs of services on a monthly basis to review these data, establish new test ordering rules, or edit existing rules. When needed for specific tests, physicians from relevant subspecialties were consulted to establish appropriate frequency filters. Attempts by clinicians to work around the LES, such as an increase in ordering of renal panels, were dealt with by incorporating the renal panel into the LES rule set. From 2012 through 2014, the rules were expanded to include up to 125 different tests (Supplemental Table 1; all supplemental materials can be found at *American Journal of Clinical Pathology* online).

Cost Savings Calculations

The Indianapolis VA system provides laboratory services under a contractual agreement with equipment manufacturers using a basic cost per reportable for each laboratory test performed. Cost per reportable includes reagents, calibrators, control material, disposables, training, and a standard service agreement. For calculated cost savings, we only included laboratory cost savings using this cost-per-reportable value. Cost savings were calculated by determining the change in individual test volume relative to the test volume in 2011, the last year testing was done before implementation of the LES. However, these calculated cost savings assumed that test volumes would remain static after 2011. Projected cost savings for each test were also calculated using a best-fit regression line plotted against the yearly pre-LES test volume. Using this best-fit regression line, we then calculated the number of tests that would have been performed in the years following LES implementation. Projected savings thus take into account the projected increase in test volume that did not materialize due to implementation of the LES.

Results

Continued Feedback Resulted in Reductions in Exclusion Requests for Individual Patients

After triggering an LES rule for a test ordered on a specific patient, clinicians were allowed to contact the laboratory to request an exclusion for that patient. These exclusions were always granted. However, clinicians were tracked for the number of requested exclusions. This information was passed on to the clinician's service chief to allow for feedback on test ordering practice if necessary. Clinicians were initially allowed to ask for patient exceptions for an individual patient, which were granted for up to 7 days. This was then reduced to 3 days and finally to a single occurrence in 2014. This approach led to a decrease in the total numbers of exclusions requested as well as a decrease in the total numbers of clinicians with relatively large numbers of exclusion requests within a given year **Table 1**. In addition, the experience of our teaching facility was that most requests for multiday exceptions were initiated by resident physicians (Table 1).

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Table 1
Exclusion Requests by Providers for Individual Patients

Year	No. of Exclusions Granted	No. of Clinicians With ≥10 Exclusions	% of Clinicians With ≥10 Exclusions	
			Resident	Staff
2012	6,532	158	78	22
2013	4,058	103	62	38
2014	3,769	80	91	9

Implementation of the LES Resulted in a Significant Reduction in Testing Volume

In **Figure 1A**, we show the test utilization trends for total laboratory tests performed at the Indianapolis VA facility for calendar years 2004 to 2014. The number of comprehensive metabolic panels (CMPs), basic metabolic panels (BMPs), and CBCs were also assessed in the years leading up to the LES implementation in January 2012 and thereafter. Total testing from 2004 to 2011 had a statistically significant upward slope, as did pre-LES testing for CMP, BMP, and CBC testing. In contrast, the number of total tests performed as well as testing for all three common panel testing showed a reversal of the ordering trend line post-LES. In contrast, 10 high-volume tests that were not subject to LES frequency filter rules continued to show year-to-year (YTY) increases in test volume over the same time frame **Figure 1B**.

The above data strongly suggest that the LES system worked as intended and played a key role in suppressing unneeded testing. However, an alternative explanation for the observed changes in laboratory test frequency would be that these changes represented reductions in outpatient or inpatient census numbers. In **Figure 1C**, we show that there was no significant difference in the YTY change in outpatient visits when assessed before and after implementation of the LES (mean YTY change = 6.57% pre-LES relative to a 6.08% post-LES). Moreover, there was no change in bed days of care in the 2 years before implementing the LES relative to the first 2 years after implementing the LES **Figure 1D**. Thus, there is no evidence that changes in outpatient visits or inpatient occupancy rates were responsible for the post-LES decline in test ordering.

To verify that the testing volumes for both total tests and high-volume panel testing were significantly different between the pre- and post-LES periods of time, we plotted the mean YTY change in testing volumes for 5 to 8 years leading up to the LES implementation and the 3 years following **Figure 2**. Total testing volumes rose at a mean of 8.76% year to year before LES implementation but fell to a 5.68% YTY decrease after LES implementation Figure 2A. Likewise, similar YTY increases in testing volumes were noted for CBCs (Figure 2B: 9.30% mean YTY increase), CMPs (Figure 2C: 10.94% mean YTY increase), and BMPs (Figure 2D: 5.52% mean YTY increase) before implementing the LES. This was followed by a YTY reduction in post-LES testing volumes for all three high-volume test panels (–5.33%, –1.00%, and –12.75% mean YTY reductions for CBCs, CMPs, and BMPs, respectively).

Implementation of the LES Has No Measureable Effect on Inpatient Length of Stay

The LES rules that were developed for panel testing (CBC, CMP, and BMP) were designed to prevent repeated panel testing within a 24-hour period. Since repeat panel testing within the same day would be highly unusual for outpatient testing, the ability of these rules to reduce test panel utilization would be expected to be limited to inpatient laboratory testing. Since it is possible that overly vigorous cost containment measures could negatively affect patient care by preventing early recognition of a patient's change in health or treatment status, we also sought to assess whether the implementation of the LES altered the average length of stay for inpatients. We show there is no significant difference in the average length of stay **Figure 3** in the years following LES implementation. The laboratory also monitored incoming incident reports to determine whether any incidents could be directly tied to the implementation of the LES. There have been no incident reports received by the laboratory that would indicate that the LES resulted in a delay in diagnosis or treatment or resulted in any potential or actual patient harm.

Continued Revisions and Expansion of Rules Allowed for a Continued Decrease in Total Test Volume

Following implementation of a test frequency filter, it might be expected that the major decrease in test volume would be realized in the first year of implementing this type of utilization management tool. Thereafter, it might be expected that testing would revert to the previous YTY change in test order frequency. As seen in (Figure 1A), ordering for CMPs showed a pattern consistent with this idea. However, this pattern was not seen for total tests, CBCs, and BMPs. In these cases, we saw a continued reduction in test volumes through the first 3 years of LES implementation. This was particularly dramatic for total tests **Table 2**. Total tests, relative to calendar year 2011, were reduced by 5.07% in the first year, followed by more dramatic decreases of 12.37% and 16.11% in years 2 and 3 following implementation of the LES. However, it should also be noted that actual reductions in total laboratory testing relative to pre-LES numbers are somewhat misleading (Table 2). As shown in (Figures 1A and 2A), total testing volumes showed a consistent YTY increase before implementation of the LES. Thus, assuming that total test

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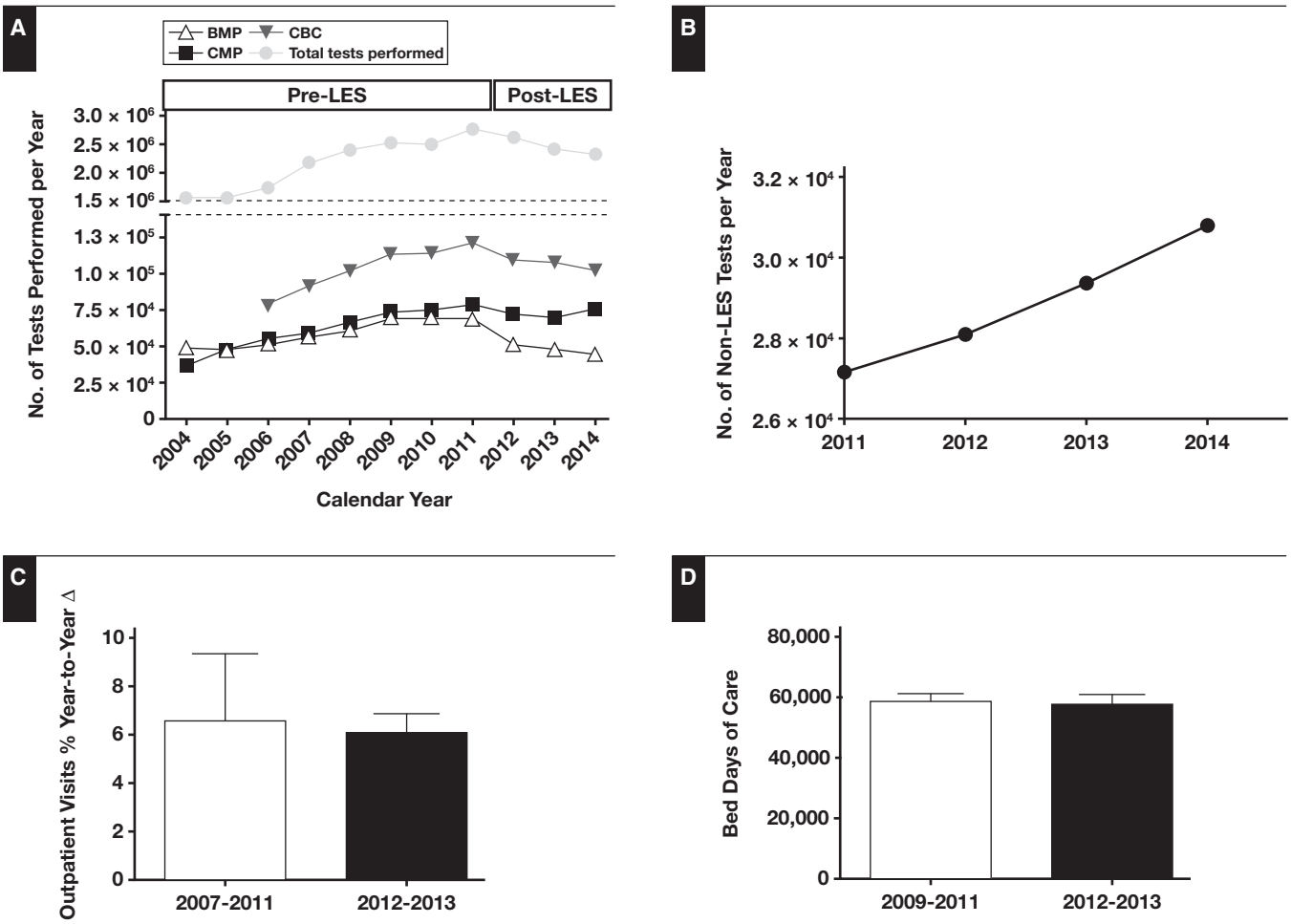

Figure 1 The laboratory expert system (LES) laboratory utilization management approach reverses a trend toward increasing total tests and specific high-volume panel testing over time that is not due to changes in outpatient visits or inpatient volume. **A**, The total number of laboratory tests (total tests), as well as the number of basic metabolic panels (BMPs), comprehensive metabolic panels (CMPs), and CBCs, performed by the Richard L. Roudebush VA Medical Center Clinical Laboratory is plotted per calendar year. The LES was implemented on January 1, 2012. Thus, pre-LES testing is plotted up until and including calendar year 2011. Post-LES testing included years 2012 to 2014. For the pre-LES years, the slope of the best-fit regression line for all tests was positive and significantly different from zero (no change in test volume: $P = .0001$ [total tests]; $P = .0011$ [CBC]; $P < .0001$ [CMP and BMP]). In contrast, the slope of the best-fit lines post-LES was negative and statistically different from the pre-LES best-fit lines for all tests: $P = .0012$ (total tests), $P = .00038$ (CBC), $P = .00012$ (BMP), and $P = .0012$ (CMP). **B**, The sum of total testing from 10 different high-volume tests not subject to LES rules is plotted for each calendar year from 2011 to 2014. The 10 tests included in this assessment were α-fetal protein, carcinoembryonic antigen, C-reactive protein, ethanol, ferritin, iron, ammonia, salicylate, total iron binding capacity, and valproic acid. **C**, The mean ± SD number of outpatient visits per year is plotted for the 5 years preceding the LES system implementation and the 2 years of complete data post-LES implementation. No significant difference was observed. **D**, The mean ± SD number of inpatient bed days of care for the 3 years leading up to LES implementation and the 2 years following LES implementation is shown. No significant difference was observed.

volumes would have increased at the 8.76% YTY rate observed before LES implementation, then our projected decrease in total test volumes would have been significantly higher (a mean of –19.80% YTY over the 3 years of the program relative to the mean –11.18% YTY reduction seen when reductions are assumed to be relative to a static baseline based on calendar year 2011 data).

Calculated Cost Savings

In **Table 3**, we show the calculated cost savings relative to 2011 that were realized by reductions in three high-volume panel tests (CBC, BMP, and CMP). These large panel tests were included because they are high-volume tests. Moreover, these test panels are highly unlikely to trigger test frequency filters for outpatient visits. Thus, the

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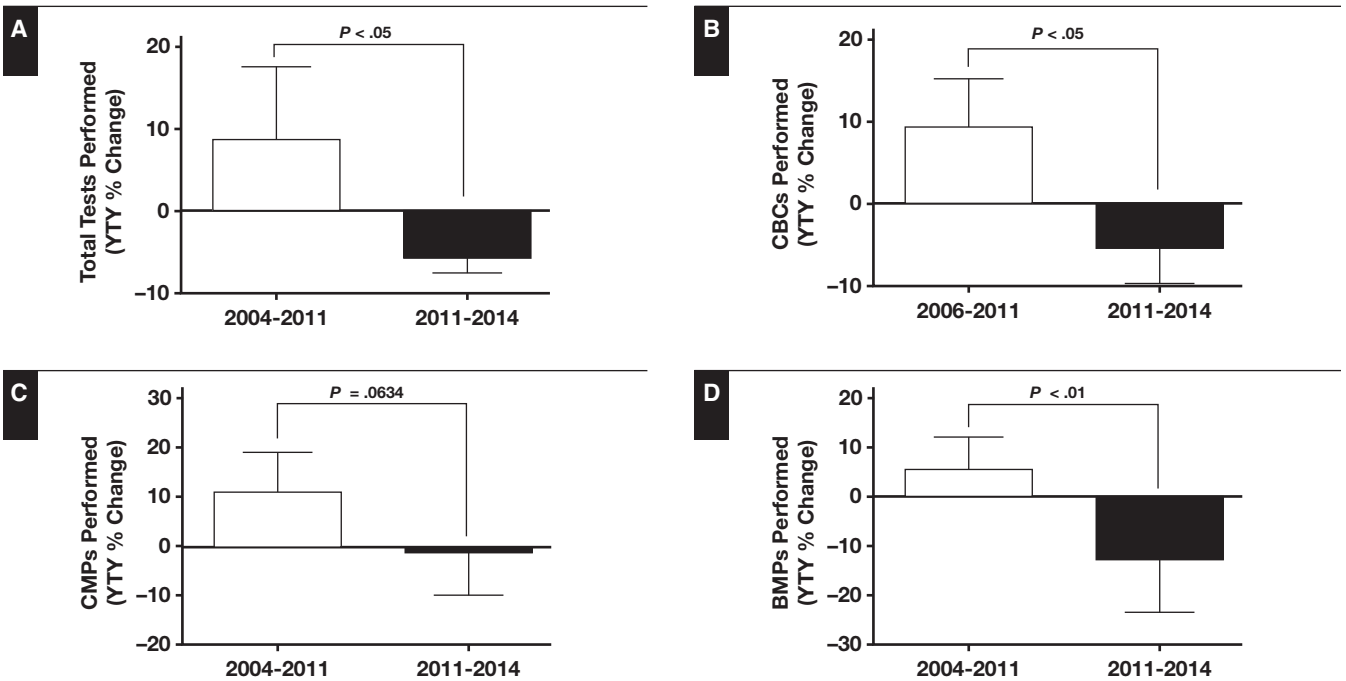

Figure 2 The effect of laboratory expert system (LES) implementation on mean year-to-year (YTY) change in total tests and high-volume panel testing. The YTY percent change in testing volumes was calculated for 6 to 8 years before implementation of the LES time period. The YTY change in testing was then calculated for the 3-year period following implementation of the LES. **A**, Mean YTY increase in total test volumes (8.76%) relative to a mean –5.68% reduction in YTY in total tests following LES implementation. **B**, CBC testing volumes rose at a 9.3% YTY mean increase before LES implementation compared with a –5.33% mean decrease from 2011 to 2014. **C**, Comprehensive metabolic panel (CMP) testing had a 10.94% mean increase per year over 2004 to 2011 but had a –1.0% mean decrease in testing volume per year after 2011. **D**, Basic metabolic panel (BMP) testing volumes changed from a 5.52% mean increase YTY relative to a –12.75% decrease YTY after implementation of the LES. All data are shown as the mean ± SD.

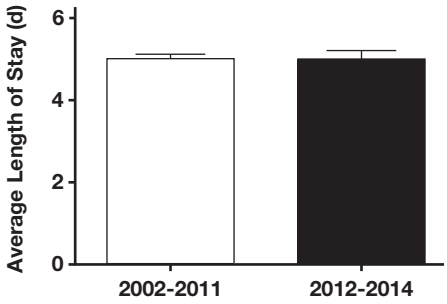

Figure 3 Implementation of laboratory utilization management had no significant effect on inpatient mean length of stay. For 2002 to 2014, we obtained the mean days of stay for each calendar year. For the 10 years leading up to laboratory expert system implementation (2002-2011), the mean length of stay was 5.01 ± 0.041 (mean ± SD) days. For 2012 to 2014, the mean length of stay was 5.00 ± 0.1 days ($P = .9142$).

changes in these high-volume test panels reflect the cost containment changes that might be expected for inpatient testing under existing diagnosis-related group (DRG) reimbursement schemes. Actual tests per year represent the actual number of tests performed in the given calendar year. The projected test numbers were obtained by fitting a regression line to the test volumes for each specific test panel before LES implementation. This linear equation was then used to project what test volumes for each test panel would have been for years 2012 through 2014.

Using actual test numbers, we calculated cost savings due to actual test numbers relative to the test numbers obtained in calendar year 2011, the last year testing was done without LES implementation. This was calculated from the contractually negotiated cost per reportable for each panel (CBC = \$1.75, CMP = \$2.58, and BMP = \$1.32). However, this number likely underestimates the true cost savings, since test volumes for all three panel tests had been increasing at a YTY rate of 5.52% to 10.94% (see Figure 2). Thus, using projected test volumes for calendar years 2012 to 2014, we estimated the cost savings that would have been realized if the projected increase in test volumes had occurred. This difference between projected and actual savings was dramatic. Using actual test volume numbers, the laboratory saved a cumulative amount of \$206,214 over the

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Table 2
Reduction in Total Tests Relative to 2011 and to Projected Increases

Calendar Year	Actual No. of TT/y	Projected No. of TT/y	% Reduction (TT/y) (Relative to 2011)	% Reduction Based on Projected Increase
2011	2,762,263	NA	NA	NA
2012	2,622,113	2,909,759	–5.07	–9.89
2013	2,420,469	3,071,404	–12.37	–21.19
2014	2,317,258	3,233,048	–16.11	–28.33
Mean (2012-2014)			–11.18	–19.80

NA, not available; TT, total tests.

Table 3
Actual and Projected Cost Savings for Selected Panel Tests

Calendar Year	Actual No. per Year	Projected No. per Year	Savings (Relative to 2011), US$	Savings Based on Projected Increase, US$
CBC				
2011	120,980	NA	NA	NA
2012	109,093	132,815	20,802	41,514
2013	107,302	141,258	23,937	59,423
2014	102,447	149,701	32,433	82,694
Total: 2012-2014	318,842	423,774	77,172	183,631
BMP				
2011	68,474	NA	NA	NA
2012	51,565	74,737	22,320	30,586
2013	47,724	78,213	27,390	40,246
2014	44,808	81,690	31,239	48,684
Total: 2012-2014	144,097	234,640	80,949	119,516
CMP				
2011	78,518	NA	NA	NA
2012	71,687	87,917	17,624	41,872
2013	69,633	93,753	22,923	62,231
2014	75,593	99,590	7,547	61,913
Total: 2012-2014	216,913	281,260	48,094	166,016

BMP, basic metabolic panel; CMP, comprehensive metabolic panel; NA, not available.

2012 to 2014 period due to reduced cost per reportables for these three high-volume panel tests. However, taking into account the trend for increasing orders for panel testing, cost savings were likely much higher (the estimated projected total savings from for the 3-year period following the LES implementation for these three commonly ordered test panels was $469,162).

Finally, we calculated total cost savings realized in each year due to reductions in testing volumes for all tests included in the LES. Relative to the test volumes observed in calendar year 2011 and assuming static total test volumes thereafter, the laboratory savings were calculated to be $151,814 for calendar year 2012 and $163,751 for calendar year 2013 (Supplemental Table 2). This corresponded to a yearly average reduction of our total test volume of approximately 11.3% per year (Table 2). Projecting cost savings due to historic YTY volume changes was not practical, since many of the tests are lower volume tests that exhibit higher YTY variances. However, as mentioned above, projected total test volumes were reduced by a mean of 19.8% YTY. Thus, it could be concluded that our true cost savings may have been approximately 75% higher than our calculated cost savings.

Discussion

In an attempt to safely reduce laboratory costs through the suppression of redundant or unnecessary testing, we report the implementation of a laboratory test utilization management system (LES) that assigned test frequency filters for commonly used laboratory tests and test panels. This system was designed to work at the point of test order through the VA VistA CPOE system. While no test was absolutely denied, the LES offered a significant roadblock to repetitive ordering: ordering clinicians were required to contact the laboratory to have a frequency filter lifted for a given patient. The gains realized through the implementation included a substantial cost savings for the clinical laboratory. Test reductions from all LES listed tests (Supplemental Table 1)

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resulted in an estimated $151,814 in savings during the first year of implementation and $163,751 in the second year (2.02% and 2.18% reductions in the total laboratory budget). This cost reduction was based on savings related to testing volume reductions from calendar year 2011, the last year in which the LES system was not used. Given that total laboratory tests had experienced a mean increase in test volume of 8.76% per year in the 8 years before implementing the LES, this savings estimate is likely considerably lower than the true reduction in laboratory costs. Considerable cost savings came from the reduction in testing using high-volume large panel testing (CBCs, CMPs, and BMPs). Additional significant cost savings came from applying test frequency filters for lower volume but high-cost tests (eg, hepatitis C virus viral load).

The continued YTY reduction in total tests and in specific test panels that we observed over a 3-year period was likely due to a number of factors. First, following implementation of the LES, there was an ongoing review of the data resulting in a number of refinements. Refinements included ongoing training for the ordering physicians by the chiefs of service, minor alterations in our test frequency filters, and reducing the ability of clinicians to exclude individual patients for multiple days. Reductions in total test volumes in the second and third years are also attributable to our expansion of the number of tests in which we instituted test frequency filters. It is expected that as we exhaust possible tests that can be incorporated into the LES, we will lose our ability to see continued reductions in test volumes and cost savings.

While volume reductions were noted for CBC, BMP, and CMP panel testing, this reduction was less marked for CMP testing. There are several possible explanations for this observation. First, as we have noted, outpatient testing would be infrequently associated with repeat testing that would trigger the frequency filter rule. In our experience, CMP testing is more frequently ordered on outpatients at our VA facility than CBCs or BMPs. Thus, there would be a smaller subset of inpatient CMP ordering that would be likely to trigger LES frequency filters. Second, CMPs provide more information than BMP testing, and thus CMPs may be ordered more frequently in metabolically unstable patient populations within the critical care units or emergency departments that were automatically excluded from the LES frequency filters. Third, the CMP testing may represent a workaround when BMP or renal panel testing is blocked.

Electronic laboratory utilization management approaches have been used with some success to limit redundant testing in US hospitals. In general, most published approaches have involved noninterventional alerts or alerts that require some action by the ordering physician at the level of the CPOE (eg, closing a pop-up alert) (reviewed in Baron and Dighe[12]). Systems that block order entry through the CPOE and require manual override at the level of the laboratory information system have also been described.[10,14,15] These have been limited systems that involve a relatively small number of analytes or high-cost send-out tesing.[10,14,15] One unique aspect of our utilization management approach was to initially target high-volume, low-cost test panels (eg, BMP, CMP, and CBC). Large test panels are very convenient for assessing a patient's global metabolic, physiologic, or hemodynamic status. However, these panels are very frequently overused in the inpatient setting.[6,7,14] The high rate of false positives associated with the ordering of a large panel of tests can also lead to unnecessary diagnostic testing, particularly by less experienced or risk-averse clinicians. This is particularly true if clinicians order a repeat panel to investigate an abnormal result for a small subset of analytes. Thus, while these panels are relatively inexpensive for the laboratory to run, we were able to obtain a significant cost savings by introducing frequency filters for large panel tests.

The drawback to such an approach is the interruption in clinicians' work flow, as well as the possibility of a delay in testing for a patient whose clinical status had changed rapidly. We therefore assessed not only cost reductions but also a critical measure of patient safety. There was no change in patient length of stay following the implementation of the LES. Moreover, the laboratory did not receive any incident reports indicating that the system resulted in patient harm. Finally, there were surprisingly few complaints from clinicians regarding the implementation of the system. This likely reflects the buy-in and active involvement of the various service chiefs.

In assessing cost savings accrued through the use of the LES, it should be noted that we only accounted for the cost savings from not performing the specific test on our analytical instruments (cost per reportable). We did not include cost reductions due to preanalytical variables (phlebotomy time savings, reduced test tube and needle utilization) or factor in savings due to reduced laboratory staff workload for analytical testing or for postanalytical verifications and reporting. In our study, total tests were reduced a mean of 11.27% per year relative to 2011 levels in the 3 years the LES has been in place. Thus, this reduction in testing would have resulted in reduced laboratory staff workloads. However, reductions in laboratory workloads were offset for the time needed for clinical staff to call in exclusions and for laboratory staff to execute exclusions. Nor did we factor in the time needed by both laboratory and clinical management teams to implement, evaluate, and refine the LES. However, laboratory utilization management at one facility produced considerable labor savings from reductions in phlebotomy services.[15] In this report, a similar frequency filter to limit unnecessary testing of five high-volume and

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overused tests was implemented at San Francisco General Hospital, a municipal teaching facility. They observed 41,765 fewer inpatient tests (6.9% reduction) that were directly attributable to the frequency filters in the first year after implementing this system. Importantly, this resulted in 17,207 (21.4%) fewer inpatient phlebotomies. Given that we saw a greater reduction in total test volumes (mean 11.27% reduction YTY), it is likely that there were considerable labor savings due to reduced phlebotomy services by the phlebotomy and nursing staff that we have not factored into the cost reduction analysis.

Redundant laboratory testing has been estimated to result in $5 billion in unnecessary laboratory costs annually.[9,12] Certainly, reductions in unnecessary laboratory testing are a financially sound approach for government-run hospitals. In contrast, for nongovernment US hospital systems, the clinical laboratories currently serve as revenue centers for outpatient testing. Thus, there is little financial incentive for initiating laboratory test utilization management controls for outpatient testing.[16] However, DRG reimbursement schemes result in clinical laboratories serving as cost centers for inpatient testing. Thus, there is a financial incentive for hospitals to reduce inpatient laboratory testing costs.[7,16-18] While it is difficult to extrapolate our cost savings to estimate the potential cost savings nationwide, a rough estimate could be calculated by our cost savings per patient days of care. For just high-volume panel testing (CBC, CMP, and BMP) that would largely affect inpatient testing costs, this cost savings averaged $1.17 per patient day of care if testing volumes were assumed to remain static at 2011 levels. If projected testing volume increases were factored in, the cost savings would have averaged $2.67 per patient day of care. In 2005, a total of 4,936 US community hospitals treated 39.2 million patients over 181.5 million days of care.[19] Thus, using our estimated actual or projected cost savings per inpatient day of care just for these three panel tests, a reduction of $212.4 to $484.6 million in nationwide laboratory direct testing costs could potentially be realized in the first year of implementing a similar system in US health care facilities. A number of other factors could also reduce or increase this estimate. Certainly, laboratory costs vary considerably depending on the specific DRG.[18] Thus, this estimate would fail to take into account differences in the mix of inpatient DRGs relative to other facilities. Additional cost savings would be likely from reduction in preanalytical testing costs and labor costs (eg, blood draws). However, it is also likely that diminishing cost savings would accrue after the first 3 to 4 years of implementing the system as clinicians incorporate the new ordering guidelines into their clinical practice.

Recently, the US Department of Health and Human Services has announced plans to speed up the introduction of value-based reimbursement schemes for all Medicare services.[20] Thus, it is likely that outpatient testing on a fee-for-service basis will eventually be phased out. This would have profound implications on laboratory utilization since it would force the conversion of hospital clinical laboratories from revenue centers to primarily cost centers. In this event, cost savings from the reduction of unnecessary or duplicative diagnostic testing will become a priority.

From a utilization management perspective, it should not be overlooked that the Richard L. Roudebush VA Medical Center is a teaching hospital. Redundant testing has been reported to be greater in teaching hospitals where inpatient laboratory tests are ordered by resident physicians.[15] Indeed, we have found that most clinicians' requesting exclusions were from resident physicians. Experienced physicians infrequently requested exclusions. After review by chiefs of service, requests for multiday exclusions for individual patients were found to be unnecessary. This resulted in the LES committee gradually reducing the ability to ask for an exclusion for a given patient from a maximum of 7 days to 3 days and finally to a single onetime exclusion. Thus, for nonteaching hospitals staffed largely with experienced clinicians, it is possible that a simple noninterruptive alert providing the physicians with the most recent laboratory data would suffice to prevent redundant orders. For training facilities such as ours, a more rigorous approach requiring active involvement of the laboratory may prove more useful.

It is important to note that the ability to implement the LES at the Indianapolis VA Medical Center is dependent on the VistA system used by all VA facilities. Thus, one considerable roadblock to implementation of a robust utilization management system is the necessity for a CPOE. While there has been considerable pressure on US health care facilities to adopt CPOE due to the Health Information Technology for Economic and Clinical Health Act of 2009, the independent research firm KLAS has estimated that only 21.7% of nonfederal US hospitals had fully adopted CPOE by 2011.[21] Certainly, additional hospitals have acquired CPOE since 2011, as hospitals adopting basic electronic health record systems have gone from 27.6% in 2011 to 59.4% in 2013.[22] Thus, it might be expected that a similar relative increase in CPOE adoption may have occurred. Nonetheless, adoption of CPOE is lagging due to several potential issues, not the least of which is the considerable cost to a hospital to adopt a CPOE system.[13] Thus, incorporating a laboratory utilization management system to reduce costs due to inpatient testing could be factored into the cost-benefit analysis for switching to CPOE systems.

Finally, the successful implementation of a test frequency filter for laboratory test utilization management is very heavily dependent on a strong working relationship between the laboratory, information systems specialists,

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hospital administration, and clinicians. Monthly meetings allowed for continued monitoring for efficacy as well as refinements to the frequency filters. This peer-based approach allowed for better acceptance from the clinical staff. Moreover, the early involvement of resident physicians in the initial training period and involvement of the clinical staff in providing appropriate feedback to the residents proved to be a crucial element to successful implementation.

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