original article

Demand management and optimization of clinical laboratory services in a tertiary referral center in Saudi Arabia

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BACKGROUND: Demand for clinical laboratory services in our institution has increased by 7% each year in the past 5 years, while the amount budgeted for services has remained fixed. To address the issue, we conducted a pilot study to curb inappropriate demand by implementing a minimum retest interval (time-based restrictions on the ordering certain tests) and thus reduce costs.

OBJECTIVE: Explore the impact (financial and work volume) of restricting overuse of laboratory tests that add to costs but provide no additional clinical value.

DESIGN: Pilot study of means to reduce costs and workload.

SETTING: Clinical laboratory that provides diagnostic support to a tertiary care center specializing in transplantation and oncology.

METHODS: With the engagement of clinical colleagues, we selected 13 tests characterized by high volume, high cost, or a perception of overuse that adds no clinical value. The selection was also based on established lock-out frequencies identified in a literature review. Data was captured on test numbers before and after initiating computer-based lock-outs along with the reference laboratory cost of these tests for the first 6 months of 2016 and 2017.

MAIN OUTCOME MEASURES: Alterations in testing patterns (mimimum retest intervals) and frequencies for tests.

RESULTS: The number of tests ordered during the 6-month period in 2017 were reduced by an average of 6.6% versus the same period for 2016, saving 2.03 million Saudi Arabian Riyals (SAR). Given a 7% annual growth in the preceding 5 years, the volume was reduced by 13% in real terms. The percentage reduction in number of tests ranged from as little as 0.2% for PT to 70.3% for an enzyme immunoassay. Savings were 1.4 million SAR in hematology and 0.36 million SAR in microbiology over the 6-month period.

CONCLUSION: Minimum retest intervals using computer-based rules are effective in supporting strategies to manage demand.

LIMITATIONS: This approach may not be applicable to all laboratory tests; however, the success of this pilot study would encourage more widespread use of this approach.

CONFLICT OF INTEREST: None.

The Department of Pathology and Laboratory Medicine (DPLM) provides diagnostic support to the clinical staff of King Faisal Specialist Hospital and Research Centre, a tertiary referral hospital that specialises in transplant and oncology in Saudi Arabia. With a 7% increase each year in testing volume with a fixed budget, it was time to review testing demand and to design strategies to protect limited resources. This article is the report of a pilot test of using "lock-out intervals" (time-based restrictions on the ordering certain tests) as an approach to manage demand. This approach was piloted with a set of tests from the chemistry, haematology, microbiology and cytogenetics sections of the laboratory.

Our premise is that demand management and test optimization are essential elements of a high performing laboratory culture. The literature shows that a plethora of initiatives and strategies have been explored to manage demand. These have included but are not limited to:

- Reducing or removing reimbursement for some tests,[1]
- Changing the format of laboratory tests to affect physicians behavior,[2]
- Enhanced use of IT solutions and clinical support tools,[3]
- Sharing knowledge by communicating requesting patterns and practices.[4,5]

The computer software in use in our hospital is Cerner Millennium, (Kansas City, MO, United States) which had not been configured for lock-out intervals for laboratory orderable tests. Therefore, we established a taskforce to explore the extent to which the system could be configured since this would be key to the implementation of a demand management strategy. Cerner Millennium can be configured with selective rules; however, this requires extensive computer programming and language skills, making rules difficult to build and maintain. As an alternative to reconfiguring rules, parameters can be set to check for order duplication; at the catalog type, activity type or orderable level. These parameters can either warn end users of order proximity, or reject an order entry if a new order collection data/time is "too close in time" to a completed order (for the same test), or future scheduled orders. Parameters can be independently set based on inpatient or outpatient settings and are much easier to build and maintain in comparison to rules. We worked with all relevant stakeholders to ensure alignment and to minimize issues once we went live with the lock-outs.

METHODS

Demand management and demand optimization strategies require a multi-faceted approach with buy-in of all stakeholders to ensure success. To that end, we established a task force that comprised members from the laboratory, medical specialties and administration to explore how to optimise services. After many months of focused literature review, scrutiny of our work volumes and growth rates (including perceived areas of overuse), we commenced an initiative to curb inappropriate demand by restricting certain tests within a repeat time window (a lock-out interval or implementation of time-based restrictions on the ordering certain tests). A review of the literature was undertaken and the testing frequencies recommended were compared to the local practices at our hospital. For the pilot implementation of lock-out tests, we chose tests that were: 1) high cost (such as BCR/ABL1 FISH), high volume (complete blood count) or considered overused and/or abused based on information in the literature (ESR, ova and parasite screening).

Data was extracted from the laboratory information system on 19 common tests, to compare before and after implementation of the time-based restrictions. For the purpose of this study, panels of tests were counted as one test. For example, the electrolyte panel contains five tests (sodium, potassium, chloride, creatinine and urea); this panel was counted as one test. The data was captured for the first 6 months of 2016 and 2017 (1 January to 30 June). The list of proposed tests and their minimal repeat intervals were presented to committees and appropriate internal forums to engage colleagues and to ensure that there was internal alignment. Due to the complexity of cases seen at this tertiary referral centre, it was important to ensure that there was medical agreement on the test frequencies, and that there was a common understanding of the medical value of the tests. The final list of tests was approved by the medical and clinical affairs administrators and a date was set to go live. As this was the first time that such an approach had been taken at this institution, it was imperative to engage all stakeholders. To that end, we worked closely with colleagues in the Health Informatics and Technology Affairs (HITA) to ensure robust validation of the new rules and to collaboratively create a newsletter to go to all clinical staff within the hospital. For technical reasons, we were not able to lock-out six of the tests (because there was a potential for a valid request to come from multiple sites such as wound swabs — and to lock-out the test would have restricted clinically valid tests). The tests selected for lock out were:

- 5 hematology (CBC, ESR, haemoglobin electrophoresis, PT and PTT)
- 6 microbiology (ova and parasites, CMV antigenemia by direct IFA, genital culture, respiratory culture and Gram stain, stool culture, viral acute diarrheal enzyme Immunoassay)
- 1 chemistry (electrolyte profile)
- 1 cytogenetics (BCR/ABL1 fluorescent in situ hybridization)

A safeguard was built into the pilot so that if a lock-out had to be removed for a clinical reason, a process was established to do this within 15 minutes. It was agreed that if a lock-out restriction were taken down for the purpose of the pilot study that it would not be reinstated. The process to unlock a test required the requesting physician to contact the DPLM medical section head to discuss the case. If approved by the section head, the lock-out interval would then be lifted by calling and requesting the change to be performed in the system by HITA staff. By implementing this process, it meant that we were able to minimise and mitigate any potential negative impact should the frequency of testing not support our patient population. We wished to ensure that our approach was conservative, met clinically justified needs and supported the ethos of 'the right test on the right patient at the right time'.

One of the key outcome measures were the testing patterns and frequencies of the tests both both before and after the lock-outs were implemented. This would allow for measurement of both the impact of these changes and associated cost reductions. To that end, data was captured on test numbers before and after lock-outs along with the reference laboratory cost of these tests. The department concurrently implemented a robust plan to systematically validate, using activity-based costing principles, i.e., the current DPLM cost to deliver the tests that were part of this pilot.

RESULTS

The laboratory has experienced a 7% year over year organic growth (**Figure 1**). We forecast that by the end of 2017 we will have produced 17.9 million test results across the 18 sections within the DPLM, which is manned by approximately 500 staff (comprised predominantly of medical staff, medical technologists, technicians and phlebotomists). The growth differential experienced across the sections ranged from anatomic pathology with flat growth (0.3%) versus molecular genetics growing by 58% (highest growth rate). The initial pilot focused on 19 tests from the biochemistry, hematology, microbiology and cytogenetics sections that were selected for lock-out based on our literature review. From these 19 proposed tests, 13 tests and panels were implemented as lock-outs (**Table 1**). To compare the increase in tests that were restricted to those that were not, data was captured from 2016 (before the

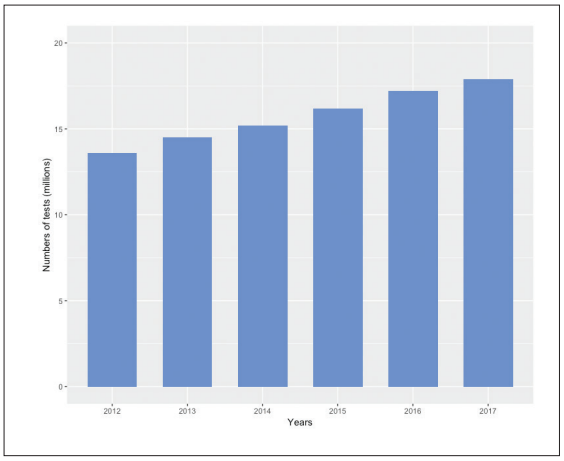

Figure 1. Numbers of laboratory tests from 2012 to 2017 demonstrating an annual increase of 7% from 13.5 million tests produced in 2012 to 17.9 million in 2017.

Table 1. Thirteen laboratory tests chosen for the pilot study.

Test name	Minimal re-test interval
CMV antigenemia, direct IFA	Every 72 hours
Stool culture	Every 72 hours
Ova and parasites	Once a week/not from inpatients after 3 days of admission
CBC	Every 2 hours
PT	Every 4 hours
Gram stain (genital) and culture	Once a week
Biochemistry profile[6]	Every 2 hours
Respiratory culture and gram stain	Every 72 hours
Viral acute diarrheal EIA	Once a week
BCR-ABL1[a] FISH[7]	Every 3 months
Hb electrophoresis	Every 6 months
PTT	Every 4 hours
ESR	Daily

[a]Philadelphia chromosome; CMV: cytomegalovirus, IFA: indirect immunofluorescence assay, CBC: complete blood count, PT: prothrombin time; PTT: partial thromboplastin time, EIA: enzyme immunoassay, FISH: fluorescent in situ hybridization, ESR: erythrocyte sedimentation rate.

lock-outs were implemented) and 2017. The locked-out tests reduced the number of tests by an overall average of 6.6% versus the previous year (**Table 2**), and saved 2.03 million Saudi Arabian Riyals (SAR) during the 6-month period.

The reduction in testing volumes ranged from 0.2% to 70.3% (**Figure 2**) and based on total test numbers this represented an overall reduction in testing volume for the 6 months of 6.6%, while other tests, not restricted, grew overall by 7%. This means that the testing volume reduced by approximately 13% in real terms for all tests. The cost saved in hematology was 1.4 million SAR over a 6-month period (**Table 2**), with an overall reduction of 6.2% in testing volume. The cost saved in microbiology was 0.36 million SAR over a 6-month period, with an overall reduction of 11.7% in testing volume.

DISCUSSION

Our premise is that demand management and test optimization are essential elements of a high performing laboratory culture. We have a duty to ensure that the right tests are performed on the right patients at the right time to drive optimal outcomes. Published reports state that 20% to 50% of laboratory testing may not be appropriate (not clinically relevant nor supported by evidence based practice[1-14]). Our hospital is transforming to a new not-for-profit commercial entity and the DPLM was tasked with ensuring the appropriateness (clinical utility) of testing.

In our review of the literature, we initially focused on tests that were high volume, high cost or perceived to be overused at our hospital. In comparison with other institutions, our organic growth rate (7% year on year) was similar (others reported increases of 5 to 10% year on year[8]). Rao et al[8] described three developments that are positioning providers to rationalize the services that they provide by 1) increasing computer links for requesting tests and reviewing results, 2) allowing evidence-based medicine to drive a willingness to review testing, and 3) greater recognition of the importance of multidisciplinary teams working towards the development of care pathways.

Our experience indicates that these developments are necessary to implement demand optimization, but in addition we would add 1) engagement of all relevant stakeholders, including executive sponsorship to drive the initiative forwards, 2) optimize test requests using rules and algorithms that are IT-based, and 3) reinforcing

Table 2. Numbers of tests and costs before and after implementing a minimum retest interval.

Test name	2016 number of tests	2017 number of tests	Percentage difference	2016 cost (in SAR)	2017 cost (in SAR)	Difference in cost (SAR)
BCR/ABL1 for t(9;22), FISH	352	268	23.9	594880	452920	141960
CBC	198890	186733	6.1	9944500	9336650	607850
CMV antigenemia, direct IFA	2954	2433	17.6	1255450	1034025	221425
Electrolyte profile	1805	1057	41.1	351975	206115	145860
ESR	15121	12850	15.0	2268150	1927500	340650
Genital culture	800	756	5.5	140000	132300	7700
Hemoglobin electrophoresis	1989	1915	3.7	618579	595565	23014
Ova and parasites	1776	1484	16.4	310800	259700	51100
PT	74656	74507	0.2	3732800	3725350	7450
PTT	74377	66350	10.8	3718850	3317500	401350
Respiratory culture and gram stain	3860	3668	5.00	598300	568540	29760
Stool culture	2464	2163	12.2	300608	263886	36722
Viral acute diarrheal EIA	64	19	70.3	20800	6175	14625
Total	**379108**	**354203**	**6.6**	**23855692**	**21826226**	**2029466**

the coaching and value-added service that pathologists are able to provide by training (and re-training) users on the appropriateness of testing.

Toolkits have been created for demand management that to seek to reduce inappropriate testing,[9] but the widespread uptake of these strategic approaches is not evident. The landscape of inappropriate utilization varies by clinical setting with some over 21% and some under by 45%.[10] The focus of our pilot study was to understand the impact of overutilization of tests. Our results demonstrate a reduction in testing volume of 24 905 tests during a 6-month period. A large medical laboratory in the US described saving US$2 million over a 3 year period (7.5 million SAR) by implementing time-based rules.[11] Our experience, with a limited pilot program has saved 2.03 million SAR in a 6-month period (over 4 million SAR projected annually). Others have achieved better financial improvements,[12] but nonetheless, they demonstrated management of test ordering by means of frequency filters. The impact of the lock-outs in our experience varied; for example, the reduction in inappropriate testing in hematology was 6.21%, saving 1.38 million SAR, while in microbiology, the testing was reduced by 11.7% but the savings was less (0.36 million SAR). This approach is limited in that it may not be applicable to all laboratory tests; however, the success of this pilot study would encourage a more widespread use of this methodology where applicable.

There is broad agreement on the benefits from optimizing laboratory tests,[13] but few authors have looked at the patient impact[14] and population level studies.[15] We are of the opinion that this is an area of healthcare delivery that needs to be thoroughly explored with sharing of best practices. The lack of continuous education is cited as one of the drivers for inappropriate testing[16-19] and our experience suggests that robust demand management requires strong medical leadership, coaching and education. The concept of locking-out tests has been well received by hospital administration, but had some initial resistance from clinicians. However, after personal communication with senior clinicians involved in the process along with a hospitalwide newsletter describing the rationale for the lock-outs this resistance soon disappeared. There is a demonstrable reduction in work volume with associated cost avoidance; importantly, this will reduce the number of blood samples collected from patients that add no clinical value. Minimal re-test intervals using computer-based rules are effective in supporting strategies to manage demand. Due to the success of this pilot study, we will continue to develop and add more tests to create more minimal retest interval rules in the computer system to manage demand and ensure that we use our resources wisely.

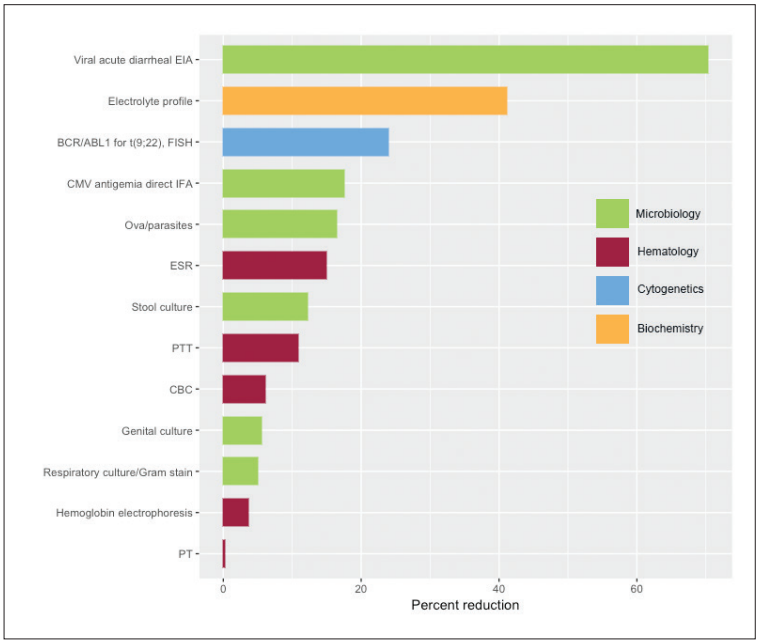

Figure 2. Percentage reduction in workload volume for the 13 tests subject to time restrictions on ordering. CMV: cytomegalovirus, IFA: indirect immunofluorescence assay, CBC: complete blood count, PT: prothrombin time; PTT: partial thromboplastin time, EIA: enzyme immunoassay, FISH: fluorescent in situ hybridization, ESR: erythrocyte sedimentation rate.

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