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Reducing Unnecessary Laboratory Testing Using Health Informatics Applications: A Case Study on a Tertiary Care Hospital

Mohamed Khalifa, MD * and Parwaiz Khalid, PhD

King Faisal Specialist Hospital & Research Center, Jeddah 21499, Saudi Arabia

Abstract

BACKGROUND: Like many healthcare resources, laboratory testing has been over-utilized for years with a huge number of unnecessary lab tests being done. The elimination of unnecessary laboratory testing is becoming more and more important in the control and management of the rapid growth of healthcare costs. OBJECTIVES: To develop a quantitative tool to identify unnecessary laboratory tests, based on quantitative over-utilization, and recommend a plan of control based on results and findings. METHODS: The study used the data warehouse of a tertiary care hospital to extract relevant information about laboratory tests ordered over a specific period of time then used statistical analysis to detect frequency of ordering lab tests to highlight both tests and users who are adding loads to the laboratory testing process and are potential for improvement with different methodologies and approaches. RESULTS: The study identified that more than 11% of ordered tests are repeated, over-utilized and simply unnecessary and could be eliminated. 3 tests only; Complete Blood Count, Renal Profile and Blood Glucose constitute 35% of all hospital inpatient lab tests. 10% of ordering physicians were responsible for the actual over-utilization of the lab testing. RECOMMENDATIONS: The study recommended two types of approaches; a user approach and a system approach, where user approach includes different types of orientation, education and training of physicians and other users on the importance and ways of decreasing unnecessary lab test ordering, mainly through avoiding unnecessarily repeated tests, while system approach includes the implementation of different computerized clinical decision support interventions that would help during the order entry process to alert and remind users with the potential of ordering an unnecessarily repeated lab test.

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Keywords: Health Informatics; Reducing Unnecessary Laboratory Testing; Laboratory Over-utilization; Hospitals

* Corresponding author. Tel.: +966564520916; fax: +966126677777.
E-mail address: khalifa@kfshrc.edu.sa

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1. Introduction

Like many other healthcare resources, laboratory testing has been over utilized for many years with a huge number of unnecessary lab tests being done routinely in many healthcare settings. The elimination of unnecessary laboratory testing is becoming more and more important in the control and management of the rapid growth of healthcare costs [1]. Population worldwide are getting older with a growing need for more sophisticated healthcare techniques, in addition, technology innovations are leading to new and expensive diagnostic and therapeutic methods and options which will lead eventually to a greater rise in healthcare costs [2], this is why the burden of health care expenditure on national budgets for most world countries has increased dramatically over the last ten years [3].

There are widely variable test ordering patterns at different sites for similar patient populations. Several studies had observed that test ordering sometimes varies by the day of the week even though the patient population remains constant and that there is also some variability in individual physician test ordering or to determine the number of tests necessary for diagnosis and patient management. Further complicating this issue is the apparent lack of agreement about what constitutes appropriate laboratory testing [4,5].

Physician ordering practices have been analyzed extensively in many studies, the inappropriate test ordering found to be a primary reason for increased laboratory use [6]. Over ordering may be the result of healthcare professionals' inexperience or lack of knowledge about the appropriate use of tests [7], failure to check previous results due to huge or messed-up patient files [8], test ordering routines that are difficult to change due to a non-user-friendly electronic medical record system, or fear of errors of omission and litigation [9]. Moreover, patients actively ask for tests and often attach greater value to test results than is justified [10].

World-wide attempts to cut unnecessary laboratory testing have not documented sustained results. Several measures can help to reduce unnecessary laboratory testing, among these; studies confirmed that advising doctors about rational use of clinical laboratory is effective but not sufficient [1]. Educational efforts directed at changing physician practice have clearly demonstrated a 25% or smaller decrease in laboratory test ordering, although such decreases are transient and time-limited [11]. Changes in requisition design have had a more durable effect but are labor-intensive to design and require dedicated subspecialty expertise [12].

The challenges are actually found in all of the stages and domains of this improvement project, starting from identifying what we do really mean by unnecessary laboratory testing and setting criteria to identify, evaluate and highlight those tests, which have no direct positive impact on patient outcomes. We need to set standards for the proper testing and the proper frequency of repeating tests, depending on the specialty of medicine and also on the patient's clinical condition and case severity [13]. Then we need to go through suggesting and planning different approaches and methodologies to manage these unnecessary tests, mainly by using health informatics applications and clinical decision support systems, and finally we need to implement such methodologies and measure their short-term as well as long term results in the form of achievable reduction of such tests [14].

In this case study at King Faisal Specialist Hospital and Research Center, Jeddah, Saudi Arabia, about one million laboratory tests were done in 2012 and a larger number, about 5 to 10% more, was expected to be ordered by different hospital departments and services by the end of 2013. This rate was actually increasing over the last few years by 5 – 10% each year, which evoked the necessity to study laboratory test ordering behaviors and patterns. One of the critical issues in this increasing rate is the pattern of utilization of different tests; such as increased frequency of ordering of tests, repeating some tests and test over-utilization. This is why the focus of the study was mainly on the quantitative over-utilization; unnecessarily repeating tests. The study focused on using health informatics applications in two phases; first discovering unnecessary laboratory tests based on quantitative analysis of increased frequencies of test ordering, identifying quantitative over-utilization, and percentages of contribution of ordering physicians, then suggesting a plan to reduce those tests according to the discovered patterns or potential reasons behind repeating unnecessary tests.

2. Methodology

To collect the study data, we needed to generate a joint table from the data warehouse using multiple database components to cover and enumerate all ordered and performed lab tests over a selected period of time, which was the first six months of 2013 as a sample data at the time of conducting this study in July 2013. This table included mainly basic data elements about lab tests such as lab test type, order date, order time, ordering department, ordering physician, encounter type, patient medical record number and patient encounter number. In addition to many other data elements, these main elements were prepared for the statistical analysis.

We needed to study the pattern of repeated tests to identify tests that were more frequently ordered and repeatedly performed, for example, we needed to know how many CBC – Complete Blood Count – tests were ordered for the same patient over a specific period of time, for example during the whole inpatient encounter. We needed to identify departments and physicians who are ordering repeated tests for the same patient more frequently than other departments or physicians to understand the factors that might contribute to the differences among departments and physicians in test ordering behaviors. It is expected that some medical specialties, such as critical care for example, could have a higher frequency in ordering certain tests, such as monitoring tests, since the condition of the patients in these specialties are more severe than the others [15]. We also needed to identify test types that are more frequently ordered by these departments or physicians.

We needed to set some comparison criteria or standards against which we can judge the level of over-utilization, or otherwise under-utilization, of each test type, since some physicians might repeat certain tests many times during the same inpatient encounter despite that none of these repeated tests, not even the first one, showed abnormality [16]. Like many other studies, the decision was made to use our own data to set these standards for each test type and for each department or medical specialty [17]. So an ordering index was developed and calculated for each test type, medical specialty and physician, it was a ratio that could reflect the utilization level of each lab test by different departments and physicians, it was used to compare departments, sections and physicians to each other. The ordering index was calculated by dividing the total number of tests performed by the total number of patients who had their encounters during the studied period of time.

We also needed to identify if this over-utilized test or repeated test order was done by the same physician for the same patient or done by another physician for the same patient, since this will have an impact on the plan and suggested actions to decrease the frequency of ordering, because some studies confirmed that timely presentation of previous test result to physicians, can easily reduce the re-ordering of those tests [8]. Was this repeated order done for the same patient during the same encounter or during a different subsequent encounter, another inpatient or another outpatient encounter? Outpatient tests should not be ordered for inpatients. What is the general average of repeating tests for each test that we have considering one patient? Most of these questions were answered during the analysis of the data.

3. Results

Data were retrieved according to the research criteria, cleaned and validated for any redundancy or bad content. Descriptive statistical analysis was performed on the collected data elements and results were generated in the form of tables and reports. 537,177 laboratory tests were ordered and performed during the studied period of time, six months, from January to June 2013. Inpatient encounters were responsible for ordering 52.8% of these thousands of tests, while outpatient encounters were responsible for about 37.3% and emergency department was responsible for about 8.8% of laboratory tests. Only 305 test types were ordered. Since the major portion of tests has been ordered for inpatient encounters, and since inpatients have a higher potential for repeating lab tests over their long inpatient days of stay, and for the purpose of simplifying the analysis, we decided to focus mainly on analyzing and calculating inpatient lab tests ordering; outpatient and ER test ordering were postponed to a later study.

Table 1. Laboratory tests order source.

Encounter Type	Number of Tests	Percentage	Cum Percent
Inpatient	283,627	52.8%	52.8%
Outpatient	200,267	37.3%	90.1%
Emergency	47,358	8.8%	98.9%
Others (e.g. Home Healthcare, Radiology …etc.)	5,925	1.1%	100.0%
Total	**537,177**	**100.0%**	**100.0%**

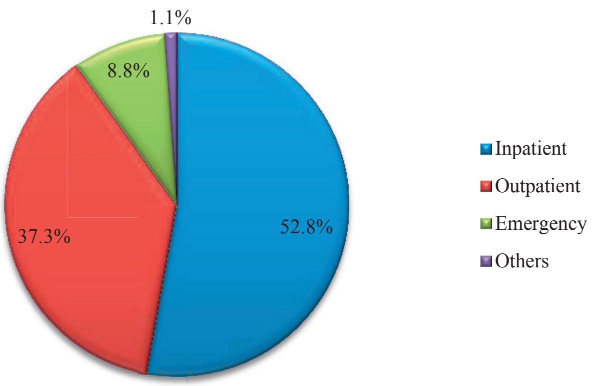

Fig. 1. Laboratory tests order source.

Three test types (CBC, Renal Profiles and Random Glucose Level) were responsible for about 35% of the total lab workload for inpatient encounters, seven test types were responsible for 60%, twelve test types were responsible for 70%, eighteen test types were responsible for 80% and 34 test types were responsible for 90% of the total lab workload. This sets priority when planning to focus on the most important tests, to start with the vital few!

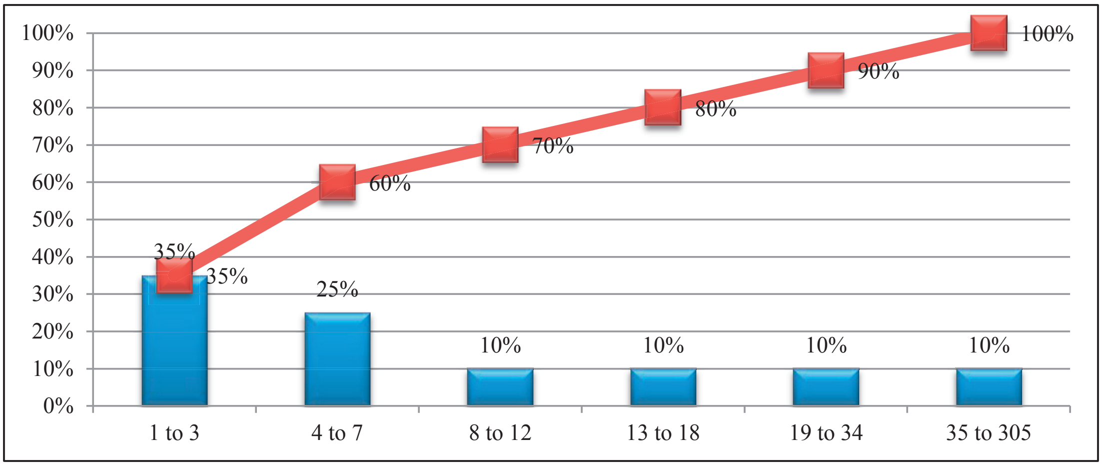

Fig. 2. Cumulative inpatient test numbers and percentages.

The analysis showed that 3,694 patients had inpatient encounters, some more than one, during the six months of the study, with 283,627 lab tests ordered and performed, some patients had more than a thousand tests of course during their long inpatient encounters, so the average of number of tests ordered for each patient was 76.8. Only 20% of patients exceeded this limit, these are mostly patients in the critical care and surgical specialties. The total of 283,627 tests performed were ordered through 62,035 test types for all inpatients, with a general ordering index = 4.6 for each test type, which means that on average any test is being ordered 4.6 times for the patient during his/her inpatient encounter, but not necessarily all patients had the same mix of lab texts ordered.

So, if a test ordering index is near to 4.6, it means that it is on a balanced utilization, but if the test type is ordered in an index much higher than 4.6, it means that the test type is being over utilized compared to other test types. Of course test types are not equally utilized in hospitals, some tests need to be ordered much frequently than others, since their resulting and monitoring values are changing physiologically and pathologically more than other tests. Some tests are needed to be done every 10 or 15 minutes in certain patient conditions, but at least this can give us an idea about the tests that we should focus on to achieve better utilization.

A test that has a high frequency of ordering and a high ordering index is the optimal target for this project, we should begin with these. E.g. a “Capillary Blood Gas” test had an ordering index of 14.6 (done 1,449 times for 99 different patients) is actually much less important than “CBC” which actually had an ordering index of 9.2 (because it was ordered 31,918 times for 3,452 different patients). Any effort done on large number tests will achieve significant results.

Table 2. A sample of calculations of test ordering index for different test types that are above the hospital average test ordering index.

Test	Patient Count	Test Count	Percentage	Ordering Index
Blood Gas, Capillary	99	1,449	0.5%	14.6
Renal Profile	3,256	33,375	11.8%	10.3
Glucose, Random	3,257	33,299	11.7%	10.2
Bone Profile	2,170	20,874	7.4%	9.6
CBC	3,452	31,918	11.3%	9.2
Blood Gas, Arterial	874	7,097	2.5%	8.1
CSA Level	33	241	0.1%	7.3
FK506 Level	128	934	0.3%	7.3
Total Plasma Exchange	14	100	0.0%	7.1
Albumin Level	1,655	11,231	4.0%	6.8
Alkaline Phosphatase	1,645	11,137	3.9%	6.8
WBC Differential	2,215	14,969	5.3%	6.8
Methotrexate Level	13	87	0.0%	6.7
Platelet Pheresis Unit	122	817	0.3%	6.7
PTT	2,873	18,670	6.6%	6.5
PT	2,872	17,954	6.3%	6.3
Blood Gas, Venous	519	3,184	1.1%	6.1
Hepatic Profile	2,279	13,331	4.7%	5.8
Total	**62,035**	**283,627**	**100.0%**	**4.6**

Tests that have high ordering index, above the hospital average, but still have a small percentage of contribution to the total inpatient ordered tests should be excluded from being a good candidate for a CDS rule, e.g. “Total Plasma Exchange” and “Methotrexate Level” both have a high ordering index but were ordered less than a 100 times each; with less than 0.1% contribution. Tests that have a high ordering index, above the hospital average and, at the same time, have a high percentage of contribution to the total inpatient ordered tests are very good candidates for developing a specific CDS rule to remind or alert users about their high ordering frequency, e.g. “Renal Profile”, “Glucose, Random”, “Bone Profile” and “CBC”. Some tests showed under-utilization, with a low ordering index, this might need future analysis. To keep the focus on the simple quantitative analysis, the study did not include the qualitative dimension of considering test cost, which might have a significant positive impact on reducing tests that are very expensive even if they are not ordered very frequently. This objective has been planned into a later study.

Using a type of Pareto analysis to see which department, specialty or physician should be approached first; results showed that 10% of physicians significantly exceeded their department/specialty ordering index for tests, through comparing the ordering index of each physician to the average and median ordering index of his/her colleagues in the same medical specialty. Again, it might be by chance or due to certain preferences or experience differences that certain level of patient condition acuity or severity are selected by or for certain treating physicians, so it is just a rough estimate to say that a certain physician is ordering more laboratory tests for his patients than another physician at the same department. A second phase of analysis can demonstrate which specific tests are repeated more by which physicians; studying only the high index physicians for their detailed pattern or repeating tests. This might help to explain why certain tests are ordered more often and/or why certain physicians are ordering more often.

Now we have the 5% most frequently ordered tests and the 10% most frequently ordering physicians, who are actually increasing the hospital lab work by 11%, if we assumed that they were ordering lab tests the same rate like their department colleagues, third of these physicians (3.3%) are responsible for 7% increase in the lab workload, these are our target users. We can now work on ideas and solutions to reduce unnecessary lab tests.

Table 3. A sample table to compare ordering index of the top ordering physicians to their specialties, showing percentage of increased tests and calculated over-utilization above the average for their specialties.

Section	Index	Physician	Patients	Tests	Physician Index	Increase	Unnecessary Tests
Medical Oncology	18.9	Physician 1	110	3,251	29.6	56.6%	1,175
Adult Critical Care	16.2	Physician 1	72	2,463	34.2	111.1%	1,296
		Physician 2	84	2,859	34	109.9%	1,497
Neonatology/Perinatology	12.6	Physician 1	62	1,422	22.9	81.7%	640
Internal Medicine	12.2	Physician 1	246	5,421	22	80.3%	2,415
		Physician 2	195	4,133	21.2	73.8%	1,755
Pediatric Hematology	12	Physician 1	37	3,428	92.6	671.7%	2,984
		Physician 2	29	2,325	80.2	568.3%	1,977
		Physician 3	39	3,039	77.9	549.2%	2,571
		Physician 4	33	2,490	75.5	529.2%	2,094
		Physician 5	7	375	53.6	346.7%	291
		Physician 6	28	648	23.1	92.5%	311
		Physician 7	27	529	19.6	63.3%	205
Cardiac Surgery	11.7	Physician 1	102	2,625	25.7	119.7%	1,430
Nephrology	9.4	Physician 1	102	1,713	16.8	78.7%	755
Gynecology/Gynecologic	8.9	Physician 1	75	1,712	22.8	156.2%	1,044
General Pediatrics	8.5	Physician 1	161	2,667	16.6	95.3%	1,301
Adult Cardiology	8.3	Physician 1	219	2,948	13.5	62.7%	1,136
Reproductive	8.2	Physician 1	30	373	12.4	51.2%	126
Neurosurgery	7.2	Physician 1	67	864	12.9	79.2%	382
		Physician 2	133	1,447	10.9	51.4%	491
All Hospital	**10.8**	**All**	**21,801**	**235,440**	**10.8**	**11%**	**25,876**

4. Recommendations

Laboratory tests are being ordered through the hospital information system and the computerized physician order entry systems available for the users, this leads the planning into two approaches; one from the user side, the ordering physicians, and the other from the system side, the hospital information system and the computerized order entry system. Both approaches could be implemented simultaneously. Base line measurements are already provided and a monthly measurement – for comparison and monitoring of the effects – should be made after the implementation of the suggested approaches, to see if the solutions are effective and to what extent and rate.

4.1. User Approach

This approach depends mainly on modifying user's behavior regarding ordering tests in general or ordering specific tests through highlighting physicians who have the highest ordering index and the highest patient and test numbers; those are the top priority users. In phase one, we should approach the top 3.3% of ordering physicians and phase two should approach the top 10% of ordering physicians. Target physicians should be approached for orientation and education about the importance of eliminating unnecessary laboratory testing and the impact of this over-utilization on both the managerial and the clinical sides of the healthcare process, such as the implications of unnecessary testing on the quality of care, which proved effective in some studies [18], or by directly educating physicians about the costs of the unnecessary repeated tests that could have been avoided [19], physicians should always keep in mind the value of the diagnostic tests, which means to assess whether a test provides healthcare benefits that are worth its costs or harms [20]. User approach should also include using printed and/or electronic materials sent to the users, department chairmen involvement through meetings departmental meetings, grand rounds and individualized meetings, orientation and training sessions conducted for target users. A general hospital orientation campaign could also be very helpful.

4.2. System Approach

This approach will depend mainly on two tasks; the first will be implementing specific computerized clinical decision support interventions and system alerts, since the implementation of specific clinical decision support interventions in the CPOE can help to reduce unnecessary lab testing through enhancing the appropriate use of laboratory tests and other diagnostics studies [21], to alert the users when they are re-ordering a specific test again or when they are ordering this test more than the average frequency exceeding their own specialty, department or section average ratio or the specified pre-determined ratio. The second task will include suggestions to change existing system components to help decreasing ordering group tests and frequent re-ordering of tests.

For the first task, a group of the medical informatics department was assigned to work on developing rules for the alerts of repeated ordering of tests based either on outside benchmarks; identified international standards, best practice or scientific evidence on literature or an inside benchmark; using average test ordering index for each specialty, department and section through available hospital data on data warehouse. The system should show the user the date and time of the last ordered and performed test of the same type when the user is ordering a new test. Decision rules to define appropriate intervals at which repeat tests might be indicated for commonly ordered laboratory tests have proved their success in safely reducing laboratory test over-utilization [22].

This CDS intervention implementation was planned to be phased according to the tests priorities and workloads as mentioned above; where phase one should include the top 3 tests, 35% of the total workload, phase two should include the top 12 tests, 70% of the total workload and phase three should include the top 34 tests, 90% of the total workload. User orientation about the newly implemented CDS intervention should be planned to make them aware of the functions and advantages of the new alerts and how to work with these alerts and use them properly.

For the second task, another group of the medical informatics department was assigned to work on conducting some system changes, mainly in the form of modifying test ordering screens to replace grouped test panels (Predefined Multi-Test Panels) with individualized test ordering check boxes and drop-down lists, which can have a great impact on reducing the number of unnecessary tests ordered through the panel [23]. Another modification was to use disease specific test ordering guidelines and ordering pathways, which can be effective in target areas or for target diseases, many institutes embedded specific disease treatment clinical guidelines into ordering pathways [24,25]. In case of ordering a repeated tests, or recently done test, a clinical justification, or rationale, text box is to be added to the order to make it done, otherwise the system would not allow the user to repeat or re-order the test, this helps the user to explain the reason behind re-ordering any test and will also help to minimize this type of orders.

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