

ORIGINAL PAPER

A Map for Clinical Laboratories Management Indicators in the Intelligent Dashboard

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ABSTRACT

Introduction: management challenges of clinical laboratories are more complicated for educational hospital clinical laboratories. Managers can use tools of business intelligence (BI), such as information dashboards that provide the possibility of intelligent decision-making and problem solving about increasing income, reducing spending, utilization management and even improving quality. Critical phase of dashboard design is setting indicators and modeling causal relations between them. The paper describes the process of creating a map for laboratory dashboard. **Methods:** the study is one part of an action research that begins from 2012 by innovation initiative for implementing laboratory intelligent dashboard. Laboratories management problems were determined in educational hospitals by the brainstorming sessions. Then, with regard to the problems key performance indicators (KPIs) specified. **Results:** the map of indicators designed in form of three layered. They have a causal relationship so that issues measured in the subsequent layers affect issues measured in the prime layers. **Conclusion:** the proposed indicator map can be the base of performance monitoring. However, these indicators can be modified to improve during iterations of dashboard designing process.

Key words: Map, Clinical Laboratory, Information Dashboard, Key Performance Indicators, Laboratory Management.

1. INTRODUCTION

Clinical laboratories have an important role in the future of healthcare (1). However, laboratory managers are faced with the challenge of increase revenue in conditions that reduce spending and utilization management while maintaining quality is a complicated issue. It is more complicated for educational hospital clinical laboratories in universities that faced to steadily increasing costs, limited resources and funding, and increasing pressure to reduce spending while maintaining quality (2). Researchers believe that innovation plays a leading role in the reform of laboratory management (3). Innovation requires that managers use new approaches and tools for management (4). In particular, tools are required that can help in utilization management and intelligent decision making on the managing of costs, orders, time, human resources etc.

Utilization management means the reducing of over-utilization, and under-utilization of laboratory tests (13) and main motivation for it is to reduce the costs (5). Hence, utilization management has attracted increasing attention in clinical laboratory management. Managers should consider solutions and programs that not only will reduce the number of inappropriate laboratory utilization, but also will increase the revenue. In this context, they must monitor the laboratory performances, identify bottlenecks and finally decide what program is needed in order to reduce inappropriate laboratory utilization and spending and increase revenue. In addition, it is essential that the running programs be evaluated with indicators and their efficiency and effectiveness be measured.

It is obvious that for all these tasks should data be gathered. However, laboratories usually faced with problems in data gathering and processing for monitoring the performances, because, required data have scattered between multiple systems or stored in different formats (6). Also, there is a question that what is the most useful way to display the data? Because, how to visualize data and indicators, will affect on the understanding of the current performance, the identifying of causes of problems and decision-making.

Today, laboratory Information System (LIS) operates as a tool for facilitating and safety assurance of the most of "total testing process" (TTS) phases includes pre-analytical, analytical and post-analytical phases (7, 8). Well-designed laboratory information systems through embedded intelligent agents will have potential to reduce laboratory errors and specimen rejection rates in pre-analytical phase (7, 8), which includes ordering, specimen collecting, identifying and labeling, handling and transporting (9). However, laboratory information system has limited capabilities for the management decisions (7).

Therefore, in addition to these systems, managers should use other tools for business intelligence (BI), such as information dashboards (10) that provide a proper environment for intelligent decision-making and problem solving.

The dashboard will enable managers to monitor the performance of clinical laboratory through key performance indicators and identify the causes of the problems such as increased costs; increased turnaround time etc. It helps to answer to the question that what program or intervention is proper for uti-

lization management.

According to Few (11, 12), “a dashboard is a visual display of the most vital information needed to achieve one or more objectives, combined and organized on a single screen so that information can be monitored at a glance” (13). In other words, it is a user interface which presents key performance indicators (KPIs) in a readable format, so that the user can see useful information at a glance (6). Dashboards widely used for monitoring and analysis of business process in organizations (14). According to Nicoleta, “dashboard, a modern managerial instrument, efficiently presents an assembly of relevant information to beneficiaries in a domain in synthetic form and helps to managers gradually follow the way of objectives are being fulfilled and make decisions about these” (15).

Ability to identify trends, problems and improvement strategies in little time, all is some benefits of using dashboards. They are capable of connecting to different systems for pulling of needed data and also calculate and display indicators by graphics or gauges. Drill-down into different levels of information or indicators and customization for different users are other capabilities of dashboards. If permanent connection is established between dashboards and information systems, real-time monitoring of performance is possible. Likewise, for clinical laboratories dashboards can be designed and integrated into the laboratory information system and the hospital information system.

In healthcare, different units of health care facilities include emergency departments (16), nursing (17, 18), intensive care units (ICUs) (19), radiology (20) have been employed dashboards. In addition, various health specialties for example neonatology (21), dental care (22) and public health (23) have efforts for develop dashboard.

Design of dashboard is an incremental process. It begins with defining objectives and determining key performance indicators. Next steps include determining the underlying relationship between the indicators and their mapping, data gathering, data loading on dashboard software and dashboard visual design.

However, it said that the success of dashboards often depends on the indicators that are defined for monitoring (23, 24). Scholars stated that the key elements of a dashboard include the summarization and integration of indicators. In addition, according to Pauwels, the modeling of the underlying relationship between the indicators or metrics moves the dashboard from a simple presentation of information to a deeper understanding of the business and a decision support system (25). Therefore, the fact is substantial that how to model the causal relationships among these indicators. That is indicators mapping. The resulting map is a mental model. Now, we want describe in this paper that how we model the map for laboratory indicators for clinical laboratory dashboard system.

In this paper has been described formation process of the indicators map, which is the critical element to develop a clinical laboratory dashboard.

2. METHODS

2.1. Study design

The present study is one part of an action research that begins from 2012. It aims to design national model of hospital

laboratory dashboard in the context of HAKIM innovation model that proposed by innovation initiative of Tehran University of Medical Sciences. In present study, the main map of indicators was determined. Setting of the project was one of the educational hospitals of Tehran University of Medical Sciences that was a 350-bed hospital. The laboratory department of the hospital provides pathology, microbiology, serology, urinalysis, parasitology, biochemistry, hematology and coagulation, hormonology, Enzyme Linked Immunosorbent Assay (ELISA), Electrophoresis and other laboratory services. The average number of laboratory and pathology requests during 2009-2014 was 636,195 and 5,573 respectively in the selected hospital.

The study conducted in several steps. For first step, which was the determining of clinical laboratories challenges and problems in educational hospitals, the brainstorming and mind mapping techniques were used. To draw a mind map of challenges and problems, Freeplane software, java version 1.6.0 used. In brainstorming sessions, eight people participated that six people from whom were active in laboratory and pathology departments and others were staff of other department such as nursing and emergency departments. Problems identified and grouped during several sessions.

In the second step, key performance indicators (KPIs) and other indicators that are important for monitoring of laboratory performances and in future, evaluating of the proposed plans efficiency and effectiveness. This performed through focus group discussion about clinical laboratory management that guided by an expert leader with experience on clinical dashboards implementation field. Finally, based on the results that obtained, clinical laboratory dashboard for the hospital designed and implemented. It is necessary be noted that designed dashboard is still continues developing and promoting to better recognize tests request patterns and achieving continues improvement in laboratory performance.

2.2. Research questions

There were two main questions include the following:

What are the challenges for clinical laboratory management, in particular, on order management to utilization management?

What are the KPIs that should be considered in the dashboard, which could help to the establishment of laboratory supplies order and test request protocol? In other words, what is the indicators map?

3. RESULTS

Step 1: Laboratory management challenges and problems

During brainstorming sessions, the challenges and problems related to management of clinical laboratories were specified and grouped with a focus on utilization management. The results have been shown in Table 1. This step helps to the identifying of bottlenecks, which have the potential for risk of inappropriate utilization and costs increase. In addition, with considering to the bottlenecks is that will be specified KPIs. However, in this phase, for each problem, possible consequences were determined and proper solutions were proposed. Solutions mainly are in the form of preventive plans.

Step 2: Indicators map

After determining problems, the KPIs, which should be

Problem groups	Problems	Possible Consequences	Proposed plans
Group A: problems in supplying of consumable materials, supplies and accessories	A1: High sensitivity to order of consumable materials	Increased cost	Protocols establishment for supply chain and materials or accessories ordering
	A2: Long order business cycle, from order to receive	Delay or interruption in analysis/ test error	
	A3: Delay in the procurement of materials needed	Delay or interruption in analysis/ test error	
Group B: problems related to Hospital Information System(HIS)	B1: lake of unique identifier for each patient and misidentification	Sample rejection, repeated requests, over-utilization of laboratory test	System promotion by application controls
	B2: Frequent communications interruptions between LIS and HIS	Interruption in pre-analysis or post-analysis phase/ delayed reports	
	B3: Deficiency in pathology request form, in particular in primary diagnosis field	Inappropriate request/ under or over-utilization of laboratory tests	
Group C: inappropriate interaction of other departments with clinical laboratory	C1: Repeated request for a sample	over-utilization of laboratory tests	Designing of the interaction model of departments
	C2: Failure to timely send the sample and autolysis	Sample rejection / test error/need for repeated sampling	
	C3: Antibiotic therapy for patient before test and create microbial resistance	Sample rejection/ test error/	
	C4: absence of label on sample or incomplete information on the labels	Sample rejection/ repeated sampling	
	C5: Mismatch between information on the lab request form and sample type	Sample rejection/ repeated sampling	
	C6: Unavailability of attending physician or his/her assistants to get needed information about the patient	Sample rejection/ repeated sampling	
Group D: insufficient education and experience	D1: Lack of awareness nurses from sufficient volume or how to obtain a sample and its send	Sample rejection/ test error/	Educational programs,
	D2: Lack of knowledge of assistants and medical students on diagnostic test indications	Inappropriate request/ under or over-utilization of laboratory tests	

Table 1. Problems related to management of hospital clinical laboratory

measured, was specified through focus group discussion. In this regard, key indicators must measure dimensions that will affect on costs and utilization. It was seemed that determination of KPIs in different layers of dashboard screen, which can follow different purposes, is more useful. The KPIs that will be presented on the main screen of dashboard (i.e. the first layer) are general indicators and measure overall performance results of department of laboratory and pathology in the hospital. In the second layer, there are more detailed indicators and to be reviewed by using of drill-down from the first layer into a second layer. In Table 2 have been shown KPIs in first and second layers.

Indicators in third layer are indicators that have been targeted the problems. They should be measured to determine the success rate of utilization management efforts. **Figure 1** shows the indicators map of the third layer and their relation

General Indicators (KPIs in the first layer)	KPIs in the second layer
Total cost separately for pathology and laboratory	Cost breakdown includes materials, salaries and so on
Total income separately for pathology and laboratory	Cost per test
Net income separately for pathology and laboratory	Profit per analysis or test
Total requests separately for pathology and laboratory	Highest volume tests
The number of customers (inpatient and outpatient)	Request number for each test per month
The number of provided services (tests)	Request per patient (inpatient and outpatient)
	The number of tests ordered per inpatient discharge
	The number of requests by each physician or by specialty
	Average of requests by each physician in year

Table 2. KPIs in first and second layer of dashboard

to problems and possible consequences.

Step 3: Clinical laboratory dashboard design

Following the results of the previous stages of the research, data sources for measuring these indicators must be specified. The main source of data required was hospital information system and its laboratory and pathology subsystems. Data extracted from HIS and transmitted to dashboard software in real-time. In dashboard system, indicators and their formulas defined and proper layout of each sheet designed to present each indicator with consider to its type through existing objects such as charts, tables, graphs and lists. Figure 2 shows a view from the main screen of designed dashboard.

4. DISCUSSION

As results shown, the most important issues about the management of clinical laboratories in the hospital are sample rejection, inappropriate request and inappropriate laboratory utilization. Issues that, according to many researchers, have received increasing attention internationally (26). According to the results of our study, cases of sample rejection were unsuitable specimens from aspect of volume, sampling method, identification and transfer time. The results of this study are consistent with previous studies. Findings of a literature review performed by Codagnone and et.al (27), indicated that inadequate samples, delays in transport or inappropriate storage, illegible requisitions, inadequate instructions to patients (as to previous fasting, special diet, medicine use, etc.), incorrect identification of samples and insufficient sample volume are usually lead to sample rejection (28, 29). Another study has similar results (30). However, latter two issues (i.e. inappropriate request and inappropriate utilization) are intertwined together. In addition, cases of inappropriate requests

and inappropriate laboratory utilization can be more complicated and may be due to problems beyond the problems identified in this study (i.e. insufficient experience and lack of coordination). For example, in a study, it stated that uncertainty in medical practice, fear of litigation, lack of accepted protocols and in academic hospitals, supervisor pressure for test request can be considered as causes of unnecessary requests and subsequent unnecessary utilization (2, 31). However, it should be noted that inappropriateness in utilization includes over, under and misuse. Hence, utilization management is complicated and to determine indicators for monitoring of it is difficult. Anyway, according to Huck and Lewandrowski, it is clear that basic step in utilization management is to understand what tests are being ordered, in what volume, by which clinicians and for what purpose (26). In the study also, indicators defined in the second layer (e.g. the request number for each test per, the number of tests ordered per inpatient discharge, requests by each physician or by specialty and so on) represents test volume, clinicians who ordered and their specialty. In a similar study by Kim and et al, selected metrics for utilization management were tracking numbers of specific tests, tracking the test volume of specific services, and tracking the total number of tests per inpatient discharge (32). Therefore, the results of present study are consistent with previous studies. In the third layer, there are KPIs that closely and exactly show the problems and changes of their values will affect on the values of other indicators in the second and first layers. Generally, indicators in it reflect the rate of turnaround times(TAT), errors, duplication and other issues that lead to inefficient and ineffective performance. Hawkins in his article explicitly stated that turnaround time reflects laboratory service and is often considered as a key performance indicator of laboratory performance, because, delays are major factors for unsatisfactory from laboratory services(33). Although, we only used the average time (mean) to measuring TAT, but in other study, the performance of the mean, median, 90th percentile, and outlier rate for TAT studied (34).

5. CONCLUSION

The proposed indicator map can be base of monitoring performance through dashboards. But, as said before, designing dashboard is an incremental process with multiple iterations. Some of the iterations can be in the phase of setting indicators. Thus, over time, these indicators can be modified to improve. Collectively, it seems that the map be first and useful step to utilization management efforts.

Greater steps in utilization management are to monitor test ordering behavior and patterns and also to determine baseline or criterion for overuse and under use, which is the most challenging aspects of controlling utilization (26). Nonetheless, given the capabilities of dashboards, it seems that, they can be helpful for identifying of ordering behavior and patterns and establishing of ordering protocol. However, more studies are needed to prove this hypothesis. We offer it as a suggestion for future studies.

CONFLICT OF INTEREST: NONE DECLARED.

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