

## Original Article

# Overview of laboratory data tools available in a single electronic medical record

Neil R. Kudler<sup>1</sup>, Liron Pantanowitz<sup>2</sup>

Departments of <sup>1</sup>Clinical Informatics, and <sup>2</sup>Pathology, Baystate Medical Center, Tufts University School of Medicine, Springfield, MA, USA

E-mail: \*Liron Pantanowitz - [lpantanowitz@hotmail.com](mailto:lpantanowitz@hotmail.com)

\*Corresponding author

Received: 07 April 10

Accepted: 07 April 10

Published: 26 May 10

DOI: 10.4103/2153-3539.63824

J Pathol Inform 2010, 1:3

This article is available from: <http://www.jpathinformatics.org/content/1/1/3>

Copyright: © 2010 Pantanowitz L. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### This article may be cited as:

Kudler NR, Pantanowitz L. Overview of laboratory data tools available in a single electronic medical record. J Pathol Inform 2010;1:3

Available FREE in open access from: <http://www.jpathinformatics.org/text.asp? 2010/1/1/3/63824>

## Abstract

**Background:** Laboratory data account for the bulk of data stored in any given electronic medical record (EMR). To best serve the user, electronic laboratory data needs to be flexible and customizable. Our aim was to determine the various ways in which laboratory data get utilized by clinicians in our health system's EMR. **Method:** All electronic menus, tabs, flowsheets, notes and subsections within the EMR (Millennium v2007.13, Cerner Corporation, Kansas City, MO, US) were explored to determine how clinicians utilize discrete laboratory data. **Results:** Laboratory data in the EMR were utilized by clinicians in five distinct ways: within flowsheets, their personal inbox (EMR messaging), with decision support tools, in the health maintenance tool, and when incorporating laboratory data into their clinical notes and letters. **Conclusions:** Flexible electronic laboratory data in the EMR have many advantages. Users can view, sort, pool, and appropriately route laboratory information to better support trend analyses, clinical decision making, and clinical charting. Laboratory data in the EMR can also be utilized to develop clinical decision support tools. Pathologists need to participate in the creation of these EMR tools in order to better support the appropriate utilization of laboratory information in the EMR.

**Key words:** Decision support, EMR, flowsheet, health maintenance tool, information system, laboratory

## INTRODUCTION

Laboratory information is a key driver of evidence-based clinical care and medical decision analysis.<sup>[1]</sup> Timely (turnaround-time based) availability of this information at the point of service is crucial in an increasingly complex medical environment. Furthermore, the ability to mine for data in order to monitor the health of condition-specific populations and to meet the call for quality reporting relies on a sophisticated repository system that is accessible and flexible, yet secure and in compliance with regulatory requirements. A well-

integrated laboratory information system (LIS) is part of the bedrock of a successfully implemented electronic medical record (EMR).<sup>[2]</sup> Laboratory data are said to account for the bulk (around 70%) of data stored in any given EMR.<sup>[3]</sup> Such laboratory data populating an EMR include both quantitative results (i.e. numerical values) and qualitative information (e.g. formatted pathology reports that contain predominantly text).

Optimal use of laboratory data in the EMR requires careful consideration of electronic laboratory result formatting and display in the EMR.<sup>[4]</sup> The meaningful

configuration of laboratory data is critical to the success of the burgeoning EMR technology. With laboratory data included in the EMR, users can begin to benefit from decision support tools that capitalize on this data (e.g. lab-drug-related e-alerts).<sup>[5]</sup> In its current state, EMRs can display laboratory data in the form of tables, spreadsheets, group listings, or graphs. This allows users to rapidly search, view, sort and pool laboratory information to support trend analyses and their clinical decision making process. However, to best serve the user, electronic laboratory data need to be flexible and customizable. Our aim was to determine all the various ways in which laboratory data get utilized by clinicians in our health system's EMR.

## METHOD

### EMR Design

All the laboratory data from our different LISs (Sunquest version 6.2, CoPath Plus version 3.1, Mediware HCLL) are transmitted electronically in HL7 and/or RTF format to the enterprise EMR (Millennium v2007.13, Cerner Corporation). The *Enhanced View* version of the EMR provides both a *table of contents* menu and a labeled *tab (electronic folder)* layout that together facilitate viewing of all result types. Currently, there are discrete menu bars within the EMR for all results (including vital signs, radiology, pharmacy information, and laboratory results), laboratory results only, microbiology results, and anatomical pathology reports. To account for the complexity of the medical record, there is a drop down menu that provides nearly three dozen custom flowsheets based on specialty and/or administrative needs. Not only are data presented for discursive viewing, but also they are linked to a defined set of rules and internal feeds that generate decision support alerts, trigger automated health maintenance reminders, and can be used to populate clinical notes and EMR-generated letters.

### EMR Evaluation

The authors were involved in the customization and maintenance of several tools within their enterprise EMR over a 5-year period. During this time period, the aforementioned electronic menus, tabs, flowsheets and subsections within the EMR were explored to determine how clinicians utilize laboratory data. The results of the authors' experience from observations, training, user feedback, and management of issues related to laboratory data in the EMR are described.

## RESULTS AND DISCUSSION

Both clinical and anatomical pathology laboratory data in the EMR were utilized by clinicians in five distinct ways [Table 1], viz., within flowsheets, their personal inbox (EMR messaging), with decision support tools, in

the health maintenance tool, and when incorporating laboratory data into their clinical notes and letters.

### Flowsheets

Laboratory data presented as a flowsheet is similar to a spreadsheet with columns and rows. Results reside within cells of the table. Data within small preset cells (that do not autosize to fit the result) may cause results to be hidden or truncated. Hidden data require users to perform an additional right-hand click to display this information. Nevertheless, this is often the default format of many EMRs. Default settings frequently require customization for each user, which means training of the users is required. Depending on the number of results and time range selected, users may need to scroll down and across the screen in order to view all results. Data may be missed when rapidly scanning large tables. Looking over many blank cells without any data is also a waste of time. Results in this format can be easily sorted (e.g. by specified date range). By arranging laboratory data into a list or group of tests, users can rapidly view all the results obtained for a given day on their patient. Specialty flowsheets (e.g. diabetes, heart failure, HIV infection view) can be customized to group relevant laboratory results [Figure 1] to assist in disease-specific management. For example, physicians providing care in the acute hemodialysis unit select the renal flowsheet for immediate viewing of salient results. Data can then be selected for graphical display of trends across custom timeframes. In the ambulatory setting, ready access to condition-specific flowsheets assists in the surveillance of preventive and maintenance measures necessary both for optimal patient care and quality reporting. For example, the HIV infection flowsheet displays relevant routine laboratory results (e.g. complete blood count, metabolic panel), related results (annual STD screening, hepatitis antibody status) and HIV-specific results (T-cell subsets, HIV RNA viral load assays). Printing laboratory results in draft format from flowsheets may fail to incorporate pertinent data (e.g. reference ranges).

### Inbox Results (EMR Messaging)

For laboratory tests that are ordered by health care

	2/25/2009 14:41	2/25/2009 14:40	3/23/2008 18:24	3/25/2008 9:38	3/25/2008 9:36
Alkaline Phosphatase	64	66		71	
Amylase		101 H			
Lipase		43			
AST (SGOT)	20	34			35
ALT (SGPT)	27	40			50 H
Bilirubin, Total	0.2	0.3			0.3
<b>MICRO-VIROLOGY - HIV VIEW</b>					
Hepatitis C Virus Genotyping					2* (m)
Hepatitis C Virus Genotyping Interp					TEST PERF
HIV RNA Ultrasensitive					HIV1 RNA NK
HIV RNA Ultrasensitive Interpretation					FOR LABCOF
<b>FLOW CYTOMETRY - HIV VIEW</b>					
% Cd4+ T Lymph		21 L			23 L
Abs Cd4+ T Lymph		427 L			389 L
% Cd8+ T Lymph		54 H			56 H
Abs Cd8+ T Lymph		1,097 H			946 H
Cd4/Cd8 Ratio		0.389 L			0.411 L

Figure 1: Screenshot showing portion of an HIV flowsheet in the EMR with laboratory data in a table format

**Table 1: Summary of laboratory data utilization in our EM**

Cerner Millennium tool	Availability of the tool	Utilization by clinicians	Positive features	Negative features
Flowsheets	All enterprise settings	All	Lab data can be viewed in multiple formats Data can be easily sorted Data can be viewed during the time period set by the user Graphs can be easily created for trending Customization of specialty flowsheets Data can be printed directly from the EMR with reference ranges	Difficult to identify an ideal default setting to present data Lengthy time to view large amounts of data Need to scroll up and across screens to view large data sets Results can be missed Result details within small boxes may be hidden or truncated Additional right-click required for some information (e.g. comments) Flagging results is restricted to the use of symbols (e.g. H, L, ↓, ↑) and/or colors Second tier "discoverable" data may not get printed from the EMR Unable to import/store outside lab data within flowsheets
Personal Inbox/EMR messaging	All enterprise settings	All	Secure communication between users Delivery of all results (lab, radiology, and ancillary) Results are sent to the ordering provider Creation of reminders and messages to oneself or other users Forward capabilities of documents for review or co-signature Ability to generate electronic consult requests High priority setting available Return receipt tools available Easy access to patient charts from inbox	Limited adoption by users Occasional difficulty identifying the correct provider to notify Results can be sent to the wrong clinician Poorly formatted inbox can cause results to be lost or not seen Irrelevant messages create noise Messages require frequent review and can accumulate Limited user interface Result refusal process is suboptimal Potential medicolegal liability for unread messages
Decision support tools	All enterprise settings	All	Identify drug–drug interactions Identify any drug–condition interactions Therapeutic drug monitoring Identify drug allergy prior to use	Workflow interruption May not be relevant in all situations Requires custom builds Manual management "Alert fatigue" No distinction between true allergy, intolerance, side effect, etc.
Health maintenance tool	Mainly ambulatory environment, but available across the enterprise	Primarily PCPs and their staff	Monitor preventive and condition-specific measures Interface to use lab results possible Direct data feed to registries for quality reporting and care management	Requires custom builds Lab values are not included or accessible Practice guidelines need to be kept updated Requires users to interact with the tool
Clinical notes/letters	All enterprise settings	All	Letter writing can be done in tandem with results review Documents can include lab data as needed Templates facilitate incorporating lab data Text explanations for patients about specific tests can be included	Reference ranges are not available in documents and letters Risk of adding incomplete or inaccurate lab data to reports Technically possible for a nonpathologist to modify reports by adding an addendum

PCP: Primary care provider.

providers in the ambulatory setting, results not only post to the flowsheet in the patient’s chart, but also get routed using the EMR messaging system to the ordering provider’s inbox. However, this requires that the correct provider is identified to be notified. Within the inbox, these results are stratified into three categories: normal, abnormal, and critical. The inbox has limited user interface. For example,

each result needs to be individually opened in order to see if it is normal or abnormal. The critical results folder is highlighted in red and duplicates direct telephone alerting to the ordering clinician. The delivery of results to the inbox allows the clinician to track those results that were recently ordered. The results arrive as they are statused and can be acted upon in a timely fashion as determined

by the ordering clinician. Results within an inbox can be endorsed, deleted, forwarded, and/or set up to be handled by a proxy.

### Decision Support Tools

Laboratory data in our EMR have also been used in the design of rules and alerts that are fundamental to clinical decision support. Specifically, certain laboratory results have been associated with medication order entry so as to generate drug-related alerts that interrupt workflow. For example, ordering a potentially nephrotoxic drug in the EMR triggers the automated scanning of laboratory results' tables for creatinine values. If appropriate (e.g. there is an abnormal creatinine value), an interruptive alert is sent to the clinician recommending a drug dose reduction. On the other hand, the posting of a high potassium result yields a non-intrusive message that is sent to the ordering clinician's inbox if he/she ordered a medication known to raise the risk of hyperkalemia. Also, when laboratory values undergo *post hoc* modification or updating in the LIS, an alert message is sent to the provider's EMR inbox notifying him/her of this changed result [Figure 2]. Although critical laboratory test results are electronically reported to providers' inboxes, as a redundant mechanism, laboratory personnel still make telephone calls and/or page providers to verbally communicate such critical results.

### Health Maintenance Tool

An added advantage of an enterprise EMR is that data can be accessed as well as fed to a variety of care enhancement tools. In our EMR laboratory information gets posted not only to flowsheets, but also to a health maintenance tool that is customized and based upon the latest clinical practice guidelines. For example, Pap test results, lipid panel findings, and glucose test results all populate this health maintenance tool [Figure 3] once they are transmitted to the EMR. This assists the clinicians in their efforts to perform comprehensive preventative care in a timely fashion. Moreover, the health maintenance tool is used to assist in the monitoring and tracking of disease-specific testing. We have linked results of biannual hemoglobin A1c and annual urine evaluation for microalbumin, low-density lipoprotein (LDL), and creatinine to the diabetes mellitus module within the health maintenance tool. Similar modules have been designed to effectively manage patients with heart failure, cerebro- and peripheral vascular disease, and coronary artery disease.

### Clinical Notes and Letters

We found that many clinicians incorporate laboratory results, often without the accompanying data elements (units, reference ranges, comments), into their clinical notes. For example, the author of an inpatient progress note can select relevant values (e.g. white blood cell

count, Blood urea nitrogen (BUN)/creatinine) to populate their note. An electronic consultation request within the EMR can also be generated to include laboratory values that are germane to the question at hand, and thus expedite the consultant's ability to discern the details of the clinical case. Moreover, laboratory data were also included within EMR-generated letters to patients [Figure 4]. Letter templates that reside in the EMR foster quick, yet complete, communication with patients, and they include laboratory results. While numerical results (e.g. a lipid panel) get automatically entered into such letter templates, they are associated with clear explanations

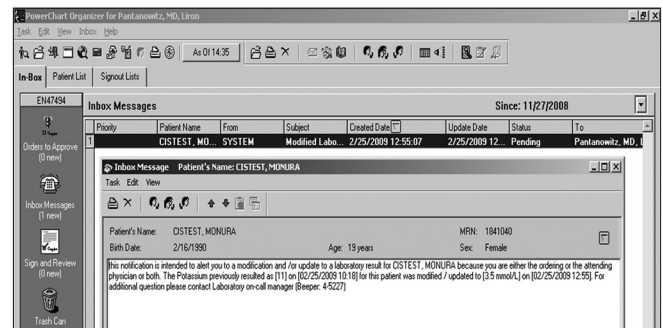


Figure 2: Screenshot of a user's EMR inbox messages showing an automated e-alert informing them that a potassium result was modified from 11 to 3.5 mmol/L

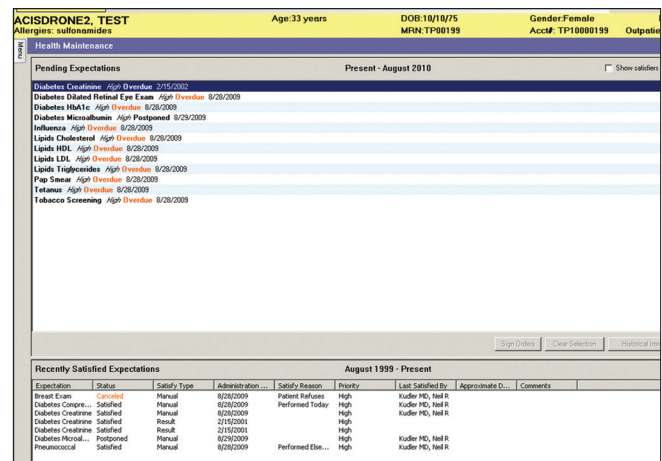


Figure 3: Screenshot of the EMR Health Maintenance view populated with pending expectations for the user to act on

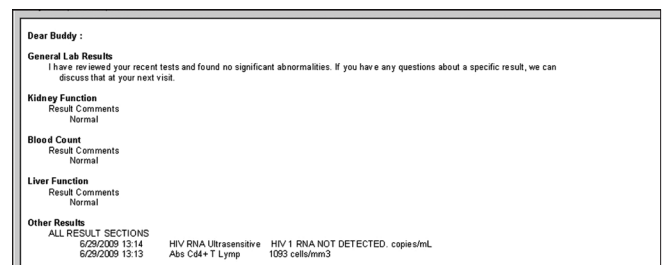


Figure 4: Example of an EMR-generated letter by a physician to his/her patient including laboratory results and interpretation comments for the patient



from the clinician along with additional advice and treatment targets. In addition, these *ad hoc* letters have served as laboratory requisitions for follow-up testing when required. In such cases, clinicians simply included the specific test requested and an associated diagnostic code to facilitate billing.

## CONCLUSIONS

Flexible electronic laboratory data in the EMR have many advantages. As we discovered, laboratory data in our EMR were being utilized by clinicians in a number of ways. The positive and negative features of utilizing the laboratory data in different EMR tools are summarized in Table 1. It should be noted, however, that our findings are based upon the evaluation of a single institution's proprietary EMR (Cerner Millennium), with certain tools specific to this EMR. While it is acceptable to have laboratory results within an EMR be displayed in several ways, these data should not be permitted to be edited by users. Allowing laboratory results viewed within an EMR to be customized, as was evident in our EMR with different flowsheets, meets the needs of many users and specialties. Rather than force all users to view data in the same manner, such customized screens (dynamic displays, dashboards, or flowsheets) can be created. Moreover, countless test results on a computer screen can be distracting and is a waste of time for busy users to search through. Honing into these flowsheets hides distracting test results that are not relevant to the clinical scenario or decision-making process on the screen for users. By collating only relevant data and focusing attention on important data, customized displays have been reported to assist users in clinical decision making.<sup>[6,7]</sup> Because printing laboratory results directly from the EMR in draft format may not incorporate pertinent data, for medicolegal purposes users are required to use an alternate medical record publishing (MRP) format. The MRP version, however, takes significantly longer to print out results.

All laboratory data in the EMR are posted in the aforementioned flowsheet format. Depending on the location of clinical care, this may be optimal. However, the practice between inpatient and ambulatory services differs. Laboratory tests that are ordered and resulted during a hospital encounter post to the results flowsheet. This fits well into the traditional workflow of the hospital-based clinician. In this practice setting, the flowsheet is routinely viewed in the midst of hospital rounds and is accessible when required. For laboratory orders that are ordered in the ambulatory setting, while results still post to the flowsheet, they have been found to be most helpful to users when they are also sent to the clinician's EMR inbox. New or outstanding lab results for review are displayed in the inbox. In this way, the EMR

provides added value by decreasing the risk of a lost or overlooked result. Furthermore, the clinician is afforded the opportunity to both review the relevant data and electronically immediately document any necessary action taken. Utilizing the EMR messaging system thereby facilitates a paperless environment, eliminating the need to also deliver printed pathology reports to patients' providers. The EMR messaging system has several other advantages such as displaying new or updated chart information for sign off and facilitating communication (e.g. send reminders, request information, forward instructions) among clinical colleagues. However, poorly formatted inboxes may cause important results to be missed. Given the potential for medicolegal liability of missing results in one's inbox, there is some concern about relying solely on an EMR messaging system.

Clinical decision support systems allow the EMR to more actively contribute to the clinical care process. Available data suggest that decision support tools not only improve the efficiency of patient care (e.g. lower the misuse of tests), but also may enhance outcomes (e.g. reduce the incidence of adverse events).<sup>[8,9]</sup> These tools can also support mundane administrative duties (e.g. automated coding) and promote best-practices (e.g. practice guidelines and protocols). They can include alerts (e.g. pop-up screens), reminders, calculators, order sets, and embedded educational content in the EMR. Often, such tools require custom builds and ongoing updates. Alerts may be interruptive (i.e. an action is required by the user) or non-interruptive (i.e. no user action is needed). Alerts may certainly be a hindrance when they interrupt user workflow and with overuse they may result in "alert fatigue" causing users to ignore, delete, or override them. Modified, abnormal and/or critical laboratory results within the LIS can even be used to trigger a timely message to automatically alert clinicians via a cell phone, pager, e-mail, or the EMR inbox.<sup>[10,11]</sup> At our institution, we also invested in building more complex EMR tools that link laboratory data and information about medications. They may generate at the time of online order entry or trigger when laboratory data are resulted. Linking laboratory results and pharmacy data has been shown to help with drug choices (e.g. laboratory-based indications and contraindications), drug dosing (e.g. renal or hepatic values, blood level-guided adjustments), drug monitoring (e.g. laboratory signals of toxicity), and broader quality improvement (e.g. surveillance for unrecognized toxicity).<sup>[5]</sup>

Computer-based reminders to prompt physicians to implement preventive and other services have been available since the late 1970s.<sup>[12]</sup> Several EMRs now have the so-called health maintenance tools available. Studies have reported improvements in the delivery of preventive services (e.g. vaccination) using automated reminders.<sup>[12,13]</sup> By virtue of the automated delivery of

results to a health maintenance tool, the clinician is afforded a highlighted alert that particular testing is either imminent or past due. Laboratory data such as Pap test results posted to the health maintenance tool in our EMR were used to generate reminders, prompting physicians to perform a Pap test on their patient if indicated. Unfortunately, researchers have shown that many clinicians neither pay attention to these reminders nor do they even regularly review the health maintenance needs of their patient before the clinical encounter.<sup>[14]</sup> Perhaps what is required is not just a tool to remind providers of needed preventive services, but a system to ensure optimal delivery of preventive services.<sup>[12]</sup>

As a result of this study, it was apparent that clinicians frequently cut and paste or “pull” laboratory data from the “source of truth” into their clinical notes and letters. This cut and paste mechanism can be utilized by clinicians to quickly summarize other clinical data (e.g. radiology interpretations) in addition to laboratory data. The ability to pull laboratory data into clinical documentation certainly enhances communication, not only between referring and consulting physicians, but also between the clinician and the patient. This feature, however, is not without risk,<sup>[15]</sup> as it has the potential for users to misreport data if incomplete or incorrect data are pasted or moved. Guidelines (e.g. CLIA 493.1109 standard) exist regarding the specific data elements that should be incorporated in laboratory reports. When appropriate, laboratory reports (i.e. paper and potentially electronic) are required to include the following data elements: unique patient identification, name and address of the performing laboratory, report date, test(s) performed, specimen source, result, units of measure, reference range as determined by the laboratory performing the test, and information regarding specimen(s) that do not meet acceptability criteria. All of these additional data elements, although present in the EMR, are not included when clinicians cut and paste laboratory data into their notes and letters. Users need to be aware of the data they are omitting. According to the College of American Pathologists (CAP) checklist question GEN.41067 (*Does an individual meeting CAP laboratory director qualifications review and approve the content and format of paper and electronic patient reports at least annually?*), the laboratory director must approve the content and format of laboratory patient reports, including computer screen images, to ensure that they effectively communicate patient test results.<sup>[16]</sup> Pathologists should assume responsibility for the data supplied by their laboratory that get cut and pasted into clinical EMR notes and letters, and accordingly, should

have a role in the design and/or utilization of this feature in their EMR.

In summary, flexible electronic laboratory data in the EMR have many advantages. Users can view, sort, and pool lab information to support trend analysis and clinical decision making. Laboratory data can also be used to trigger clinical decision support systems such as alerts and reminders. Future studies could survey clinicians to better assess their needs and determine which tools they find most valuable. It may also be of interest to compare and contrast similar tools in other EMRs. Pathologists need to start participating more actively in the creation of many of these EMR tools in order to support the appropriate utilization of laboratory information in the EMR.

## REFERENCES

1. Marchevsky AM, Wick MR. Evidence-based medicine, medical decision analysis, and pathology. *Hum Pathol* 2004;35:1179-88.
2. Hoyt R, Sutton M, Yoshihashi A. Medical informatics. Practical guide for the healthcare professional. Pensacola, FL: University of West Florida Press; 2007. p. 26-51.
3. Pantanowitz L, Henricks WH, Beckwith BA. Medical laboratory informatics. *Clin Lab Med* 2007;27:823-43.
4. Pantanowitz L, Brodsky V, Aller R. Laboratory reports in the electronic medical record. *Lab Med* 2007;38:339-40.
5. Schiff GD, Klass D, Peterson J, Shah G, Bates DW. Linking laboratory and pharmacy: opportunities for reducing errors and improving care. *Arch Intern Med* 2003;163:893-900.
6. Gierl L, Feistle M, Müller H, Sliva K, Varnholt D, Villain S. Task-specific authoring functions for end-users in a hospital information system. *Comput Methods Programs Biomed* 1995;48:145-50.
7. Young KM. Informatics for healthcare professionals. Philadelphia: FA Davis Company; 2000. p. 89-111.
8. Kuperman GJ, Teich JM, Gandhi TK, Bates DW. Patient safety and computerized medication ordering at Brigham and Women's Hospital. *Jt Comm J Qual Improv* 2001;27:509-21.
9. Hanson CV. Healthcare Informatics. New York: McGraw-Hill; 2006. p. 123-34.
10. Piva E, Sciacovelli L, Zaninotto M, Laposata M, Plebani M. Evaluation of effectiveness of a computerized notification system for reporting critical values. *Am J Clin Pathol* 2009;131:432-41.
11. Setia N, Lareau W, Pantanowitz L. Utilization of an electronic alerting system for critical and corrected laboratory results. *Am J Clin Pathol* 2009;132:451-2.
12. Frame PS. Automated health maintenance reminders: tools do not make a system. *J Am Board Fam Pract* 2003;16:350-1.
13. Shea S, DuMouchel W, Bahamonde L. A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting. *J Am Med Inform Assoc* 1996;3:399-409.
14. Schellhase KG, Koepsell TD, Norris TE. Providers' reactions to an automated health maintenance reminder system incorporated into the patient's electronic medical record. *J Am Board Fam Pract* 2003;16:312-7.
15. Gaffey AD. Communication and documentation considerations for electronic health records. *J Healthc Risk Manag* 2009;29:16-20.
16. College of American Pathologists. Laboratory general checklist. 06/15/2009 Revision. Available from: <http://www.cap.org> [last accessed in 2010]