Dr. Krasowski

By Matthew D. Krasowski, MD, PhD

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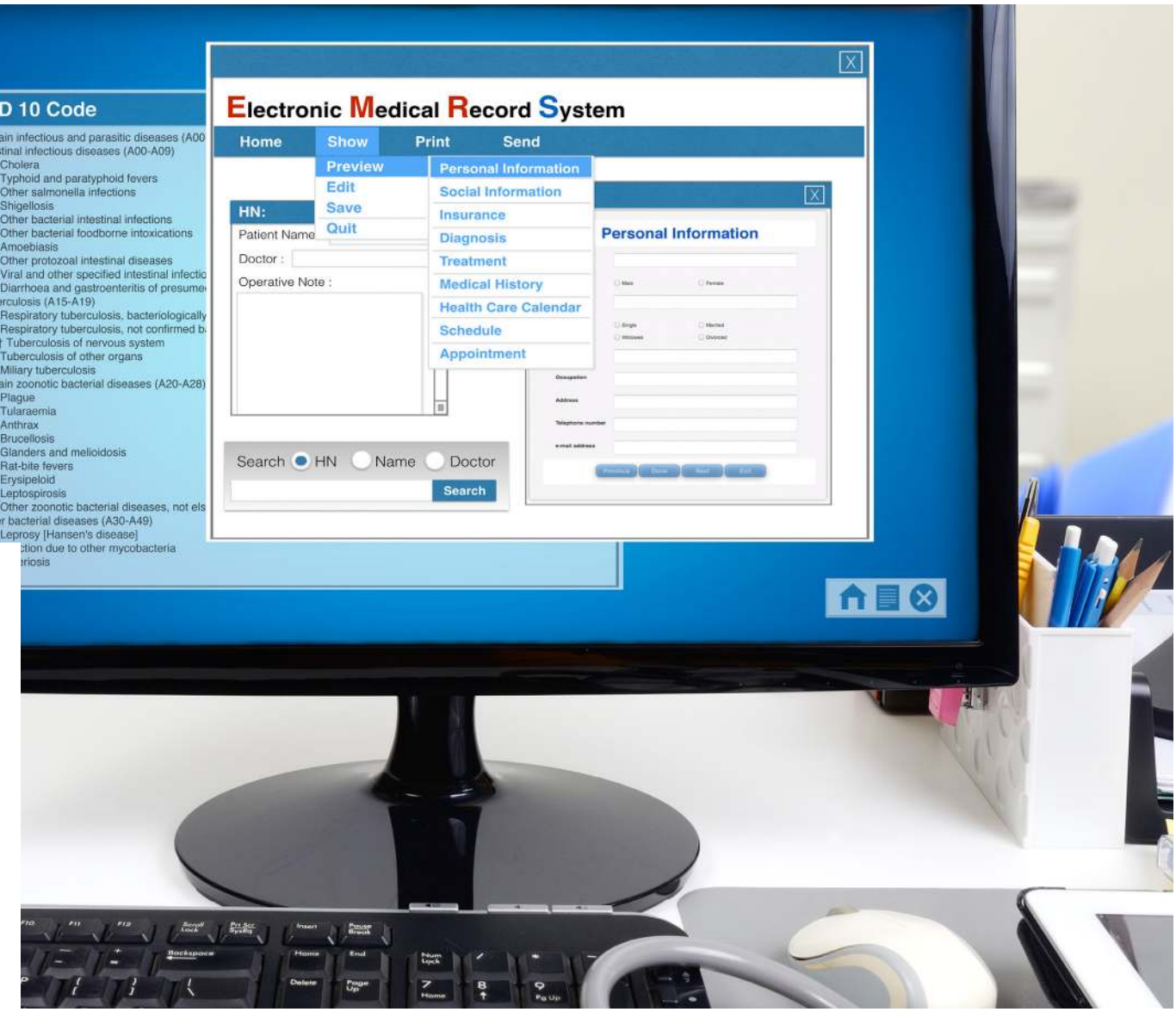
Data Mining to Improve Laboratory Utilization and Patient Care



Laboratory testing is an integral part of modern medicine, with results influencing diagnosis, prognosis, and therapy. A number of published studies have focused on problems with laboratory utilization ("mis-utilization") and interventions to improve test ordering,[1,2] including over-utilization (ordering too many tests), under-utilization (not ordering clinically indicated testing), and ordering incorrect testing. Inappropriate test utilization can have a variety of adverse consequences, including iatrogenic blood loss, missed diagnoses, patient anxiety, unnecessary referrals, need for additional diagnostic tests, and patient financial liability for unreimbursed test costs. With a growing focus on healthcare costs, clinical laboratories are often tasked with improving laboratory utilization, while also remaining conscious of ensuring patients receive the appropriate testing for optimal patient care.

The focus on laboratory test utilization has primarily been on two major categories of testing.[1] The first is high-volume, automated tests such as complete blood count and routine chemistry tests. Common interventions to tackle over-utilization of high-volume tests include limits on repetitive ordering, providing information to providers on ordering patterns and costs, and posting price information for tests in the electronic health record (EHR). The second category of testing that is often targeted is low-volume but very high-cost orders such as panels of genetic tests. These tests may have direct costs of thousands of dollars and sometimes poor reimbursement by health insurance. Frequent strategies for managing high-priced esoteric testing include requiring pre-approval prior to ordering (by pathology or other designated group) and limitation of certain tests to specific medi-

cal specialties. Some institutions have developed "laboratory test formularies" (following a model commonly employed by pharmacies), with a formal process for placing tiered restrictions on specific tests.

Getting the Data

Hospital EHRs and laboratory information systems (LISs) contain large amounts of data that can potentially be analyzed to improve utilization of laboratory testing. Yet, a major challenge is the availability of tools that can mine data from the EHR, LIS, and other data sources. Commercial EHR and LIS software typically has modules for performing queries of data, although these can vary greatly in functionality and ease of use. With respect to laboratory data, common applications include determination of test-ordering patterns (e.g., "who is ordering specific tests and from what clinical areas") and turnaround time for testing. Clinical laboratory staff and management might not have direct access to EHR and LIS query tools or be required to request specific queries from informatics staff. Most EHR and LIS reporting tools work well for relatively simple requests, but more complicated queries can exceed the ability of standard reporting tools, particularly when questions involve the intersection of laboratory testing with other data (e.g., admission/discharge/transfer records, medical diagnoses, radiology results, and medication records).

Over the past five years, pathologists and laboratory management within the Department of Pathology at the University of Iowa have been involved in multidisciplinary efforts at the University of Iowa Hospitals and Clinics (UIHC) to improve laboratory test utilization.[3] To this end, we have extensively utilized tools from the EHR, LIS, and, more recently, a data warehouse to identify mis-utilization that may be amenable to interventions. With respect to high-volume tests, analysis of ordering patterns using the EHR indicated that there was substantial over-utilization on inpatient units. Two of the clearest examples were serum albumin and erythrocyte sedimentation rate (ESR), laboratory parameters that change relatively slowly (albumin over several weeks and ESR over days). Nearly 20 percent of albumin orders were repeats within 24 hours of a previous order. Similarly, 25 percent of ESR orders were repeats within 48 hours of a previous order. Modifications to the maximum repetitive order frequencies available in a single electronic order by provider had dramatic impacts of test volumes for albumin (36 percent decline), ESR (17 percent decline), and a number of other common chemistry and hematology tests. Overall, the order volume of high-frequency tests (adjusted for patient days) declined by 8 percent.[3]

As an example of incorrect ordering, we saw fivefold increases in test volumes for 1,25-Dihydroxyvitamin following implementation of a new EHR for UIHC in 2009.[3] The routine test for assessment of vitamin D nutritional status is 25-hydroxyvitamin D, whereas 1,25-Dihydroxyvitamin D has much narrower clinical indications and is not a good marker of nutritional status. An analysis of test-ordering patterns indicated that increased orders were coming from multiple clinical areas and patient populations. Investigation revealed that a major problem was that dozens of electronic order sets had the wrong vitamin D test inserted in the transition to the new EHR. Correction of these order sets, coupled with education of ordering providers, reduced 1,25-Dihydroxyvitamin D ordering to the previous baseline. Following this issue, all electronic order sets involving laboratory testing now undergo review by pathology prior to being loaded into the EHR production system.

We also found other examples of mis-ordering between tests with similar names ("look-alike" tests). One striking example was mis-ordering of serum manganese for magnesium.[3] Prior to any intervention in the EHR, approximately 10

percent of manganese orders appeared to be mis-orders in which magnesium was the intended order. Introduction of a warning prompt and "hard stop" in the EHR when a provider attempted to order serum manganese reduced mis-orders to a very low percentage (less than 1 percent).

The utilization examples above were addressed using standard reporting tools in our EHR and LIS. In these examples, knowledge of ordering patterns that included basic information such as ordering providers, clinical area, and patient demographics were sufficient to identify the problems. Limited chart review further defined the issue where needed.

Use of a Data Warehouse

Nevertheless, we realized that some questions simply could not be readily addressed with our existing EHR and LIS tools. Fortuitously, our medical center had been investing in a collaboration with a private company to create a 'data warehouse' that combined data from the EHR, hospital admission/discharge/transfer, pharmacy systems, and billing records.[4] The software has a graphical interface that allows users to generate queries without having detailed knowledge of computer code. The queries have a built-in Health Insurance Portability and Accountability Act log-in step, with data access logs capturing interrogation of patient data. With this system, we began to tackle more difficult questions.

One example was the issue of how often serum angiotensin converting enzyme (ACE) levels (typically ordered as part of the workup for possible sarcoidosis) were ordered in patients on ACE inhibitor drugs.[5] It was well known in the literature that ACE inhibitors profoundly lower ACE levels (and thus make them unreliable for sarcoidosis workup); however, many providers might be unaware of this interaction. To identify how often ACE levels are ordered in patients on ACE inhibitor therapy is not easy in standard EHR reporting tools. In our own EHR, there were more than 100 ACE inhibitor varieties (different drugs, doses, combination of drugs) in the pharmacy formulary, each of which would comprise a separate search item in the reporting system, leading to very long search times. In the data warehouse, the search was much simpler. Pharmacy data could be searched with a standard nomenclature (SNOMED), with a single search item capturing all ACE inhibitor formulations. Once completed, a query covering five years of data took less than a minute and revealed that nearly 10 percent of serum ACE orders occurred in patients on ACE inhibitors at UIHC. Collaboration with a national reference laboratory identified that a similar percentage of mis-utilization applied to samples for ACE level analysis from hospitals throughout the United States. Education of healthcare professionals and interventions in the EHR dramatically lowered the incidence of ACE level ordering for patients on ACE inhibitors.[5]

Further use of the data warehouse has assisted us with other difficult queries, such as estimated number of patients with positive blood cultures in the setting of neutropenic fever. This type of query involves several areas of clinical and laboratory data (e.g., fever from flow sheet records, neutropenia, timeframe, and laboratory diagnosis of pathogens filtering out contaminants). Searches using the EHR alone are very time-consuming and difficult.

Involvement of Pathology Residents and Fellows

Lastly, we have found that pathology residents and fellows are very helpful in projects involving laboratory test utilization. Many of the projects cited above were part of management/quality improvement projects for our trainees.[3-5] Our residency curriculum now includes sessions on data mining, spreadsheet analysis, and analyzing research data. Residents and fellows can be invaluable in data analysis and also the more time consuming task of chart review. Although data mining tools can be powerful, many questions still require some degree of chart review.

It is important to keep in mind that the most important goal is to provide the appropriate testing for optimal patient care. Eliminating unneeded tests can minimize iatrogenic blood loss, unnecessary work-up of false positive results, and patient anxiety. Preventing mis-orders or under-utilization can maximize chance of accurate diagnosis and management. Utilization interventions should be accompanied by monitoring of quality measures (e.g., length of stay, mortality, adverse events) to identify and avoid unintended consequences. Overall, it takes a coordinated effort to detect mis-utilization and implement strategies to improve use of laboratory testing. Clinical laboratory professionals are in a unique position to work collaboratively as leaders in utilization management.

References

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Dr. Krasowski is a Clinical Associate Professor and Director of Clinical Laboratories in the Department of Pathology at the University of Iowa Hospitals and Clinics, Iowa City, Iowa.