Laboratory tests, interpretation, and use of resources

A program to introduce the basics

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Abstract

Problem addressed The overuse of laboratory testing has increased rapidly and is contributing to the financial strain on the health care system in Canada. Moreover, a substantial proportion of ordered tests are unnecessary. In a search of all the Canadian family physician residency programs, none lists laboratory training as mandatory or as an optional elective in its curriculum.

Objective of program To introduce family medicine residents to appropriate and efficient use of laboratory tests.

Program description The program was run as a series of identical 4-hour small group sessions to facilitate discussion and laboratory tours. The curriculum focused on 7 key topics: problems associated with laboratory testing, sources of laboratory errors, definitions of normal and abnormal test results, appropriate use of laboratory requisition forms, laboratory quality assurance methods, laboratory collection processes, and costs of common laboratory tests. Residents were taken to a patient specimen collection site for a tour and introduction, followed by approximately 2 hours of didactic sessions, and ending with a tour of a large tertiary care testing facility.

Conclusion The program was very well received by family medicine residents and resulted in a substantial increase in residents' self-assessed knowledge of the 7 topics covered in the curriculum. It is hoped that this program will fill an important gap in residency training and support residents' competency in the "selectivity" domain of training.

EDITOR'S KEY POINTS

- This collaborative educational program designed at the University of Calgary introduces family medicine residents to the basics of laboratory test ordering and interpretation. Education is a powerful tool that can help primary care physicians reassess and examine their laboratory test ordering and understand the tremendous and increasingly complex work that follows from those orders.
- The 7 components of the program (problems associated with laboratory testing; sources of laboratory errors; definitions of *normal* and *abnormal test results*; appropriate use of laboratory requisition forms; laboratory quality assurance methods; laboratory collection processes; and costs of common laboratory tests) address the issues that are important to meeting patient needs and improving the use of medical and laboratory resources.
- Residents completed surveys before and after the session. There was a significant ($P<.001$) increase in their self-assessed knowledge of all 7 topics after the session.

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Les examens de laboratoire, leur interprétation et leur impact sur les ressources

Un programme de formation sur les notions de base

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Résumé

Nature du problème On utilise de plus en plus d'examens de laboratoire, et cela contribue à augmenter le fardeau financier du système de santé canadien. On estime en outre que bon nombre de ces examens sont inutiles. Aucun des programmes canadiens de résidence en médecine familiale n'offre une formation obligatoire ou optionnelle ayant trait au laboratoire.

Objectif du programme Amener les résidents en médecine familiale à utiliser les examens de laboratoire de façon appropriée et efficace.

Description du programme Le programme consistait en une série de séances identiques de 4 heures en petits groupes afin de faciliter la discussion, avec des visites au laboratoire. Le contenu du programme était centré sur 7 sujets clés : les problèmes associés aux examens de laboratoire, les sources à l'origine des erreurs de laboratoire, la façon d'établir que les résultats sont normaux ou anormaux, l'utilisation appropriée des formulaires de demande d'examen, les méthodes d'assurance de la qualité utilisées par le laboratoire, les modes de collecte des échantillons et le coût des examens de laboratoire courants. Les résidents ont eu accès à un site de collecte des échantillons des patients, pour ensuite suivre une séance d'intervention pédagogique d'environ 2 heures et finalement visiter une grande unité effectuant des examens pour les soins tertiaires.

Conclusion Les résidents en médecine familiale ont accueilli très favorablement le programme, qui a eu comme effet d'améliorer considérablement l'évaluation qu'ils ont fait de leurs connaissances sur les 7 sujets couverts par le programme. Il est à espérer que ce programme comblera un important vide dans le programme de résidence et améliorera la compétence des résidents dans le domaine des « choix » de formation.

POINTS DE REPÈRE DU RÉDACTEUR

- Créé à l'Université de Calgary, ce programme de formation collaboratif fournit aux résidents en médecine familiale les notions de base nécessaires à la demande d'examens de laboratoire et à leur interprétation. Ce type de formation constitue un instrument puissant pour aider le médecin de première ligne à réévaluer et à revoir sa façon de demander des examens de laboratoire et à comprendre le travail énorme et de plus en plus complexe qui résulte de ces demandes.

- Les 7 composantes du programme (les problèmes associés aux examens de laboratoire; les sources d'erreur pour ces examens; la façon de déterminer si les résultats sont normaux ou anormaux; l'utilisation appropriée des formulaires de demande d'examen; les méthodes d'assurance de qualité utilisées par les laboratoires; les méthodes de collecte des échantillons; et le coût des examens de laboratoire courants) concernent des questions qui sont importantes pour répondre aux besoins des patients et mieux utiliser les ressources médicales et celles des laboratoires.

- Les résidents ont répondu à l'enquête avant et après la séance. Une augmentation significative ($P<,001$) de l'évaluation qu'ils ont faite de leurs connaissances sur les 7 sujets a été observée après la séance.

Cet article a fait l'objet d'une révision par des pairs.
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The overuse of laboratory testing has become a serious risk to the sustainability of the Canadian health care system, with estimates suggesting that 10% to 50% of laboratory testing might be unnecessary.[1] Excess testing can increase costs to the health care system and create medicolegal liability for practitioners through delayed diagnoses or missed or misinterpreted results. In many instances, excess testing stems from inadequate understanding of laboratory test ordering and interpretation; this is often recognized by physicians themselves. For example, in a 2002 British study, approximately 1 in 5 medical graduates self-identified as being "less than competent" in using laboratory testing.[2] Other drivers of increased use of laboratory testing in Canada include the increasing burden of disease in a rapidly aging population, complex comorbidities, complication rates with age requiring closer patient laboratory monitoring,[3] a lack of knowledge regarding the financial effect of laboratory testing on the health care system,[4] and the ever increasing test options available to clinicians.[3,5] Compounding these issues is a lack of knowledge of the preanalytic, analytic, and postanalytic laboratory errors required for accurate contextual understanding of every laboratory result. This has created a need for family medicine resident education that familiarizes trainees with the rationalization of investigations. To our knowledge, there are no introductory laboratory medicine curricula aimed at family physician residents published to date. As such, the components of the curriculum were derived from our laboratory physician experience relating to the common questions raised by community physicians and the consultations among laboratory physicians, as well as the goals and objectives of the family medicine residency program.

Program objective

The goals of this program are based on the College of Family Physicians of Canada evaluation objectives, particularly to support the emerging competency of "selectivity."[6] The main goal of the selectivity competency is that both in training and in practice, family physicians should not order investigations in a rigid or haphazard manner but should be "adaptable and selective in approach, modifying it to suit both the situation and the patient."[6] Specifically, they should be able to set priorities, focusing on the most important ones, and gather "the most useful information without losing time on less contributory data."[6] To improve the quality of resident test interpretation and reduce unnecessary test ordering, residents need to be provided with information about the sources of laboratory error, develop an understanding of normal and abnormal test results, and learn about the appropriate use of laboratory testing. The goals, then, of the program are to offer residents relevant procedural information related to laboratory requisition fields, collection processes, and quality assurance methods to make them familiar with laboratory work flow and provide them with skills that aid laboratory result interpretation.

Program description

In order to educate new family physician residents on how to effectively use laboratory services, an introductory program was developed by the general pathology laboratory medicine team at the University of Calgary and Calgary Laboratory Services in Alberta. Calgary Laboratory Services is a public laboratory and the sole provider of medical laboratory services to the 1.4 million residents of Calgary and the surrounding areas. This program was implemented as a single-day (4-hour) session for the residents, with instruction from a general pathologist (who incidentally is also a family physician) and 2 senior general pathology residents via facility tours and an interactive small group didactic session. Before their sessions, the family medicine residents were provided with a PowerPoint slide presentation that provided additional details supporting the discussions to follow. The 69 first-year family medicine residents participating in the 2012 session were divided into groups of 8 to 10 residents who rotated through the program over the course of a 2-week period.

The curriculum was delivered in 3 phases. The first phase consisted of a general introduction followed by a tour of a patient specimen collection (phlebotomy) site. Following this, there was an interactive didactic session, which covered the 7 components of the curriculum (**Box 1**). Phase 2 involved visiting our central laboratory for didactic sessions. Phase 3 consisted of a tour of clinical testing areas, with time dedicated for additional questions and discussion. The didactic materials are available upon e-mail request from the corresponding author (C.N.).

Both before and after the session, residents completed an anonymous survey that asked them to self-assess their knowledge of the curriculum topics.

Box 1. Components of the family medicine laboratory curriculum

Program components included the following:

- Problems associatied with the use of laboratory testing
- Sources of laboratory error
- Definitions of *normal* and *abnormal laboratory test results*
- Appropriate use of laboratory requisition forms
- Laboratory quality assurance methods
- Laboratory collection processes
- Costs of common laboratory tests

Program components

The following discussion outlines each of the 7 components of the program.

Problems associated with laboratory testing. As this topic was the basis of the educational session, it was the most extensive component of the program. This discussion reviewed the various reasons for ordering tests and how to justify those decisions; patient and system costs including unnecessary further investigations, referrals, or interventions; and patient anxiety. Examples of educational and administrative interventions were used to explain how Calgary Laboratory Services has instituted measures to become more cost-effective in performing tests. Further examples of how family physician residents can become more efficient and proficient at ordering patient bloodwork were also given, with a focus on evidence-based screening tests and guidelines.

Sources of laboratory errors. A misconception among medical professionals and patients is that most of the testing errors that occur are due to laboratory analytic fault. To provide residents with a better understanding of laboratory errors, we discussed 3 types of errors (preanalytic, analytic, and postanalytic) and the various reasons why they occur. Examples of preanalytic errors include incorrect test selection, specimen mislabeling, or providing inadequate material for examination. Postanalytic errors include results that never get back to the ordering physician or misinterpretation of the importance of the results by the ordering physician. Preanalytic and postanalytic errors are often influenced by the ordering health professional, whereas analytic errors occur within the laboratory and include errors resulting from equipment malfunction or reagent problems.

***Definitions of* normal *and* abnormal test results.** The most important concept introduced here was that an "abnormal" test result had a differential diagnosis, including a true positive, a false positive, and laboratory error. The order of these in the differential diagnosis is dependent on the specificity of the test, as well as the pretest probability of disease. This discussion led to a brief description of some statistical terms, such as *normal* and *reference intervals* and *critical values*.[7] Considerable time was then spent reviewing truth tables and explicitly explaining the importance of understanding the concepts of false-positive and false-negative results. Examples were used to help illustrate the common scenario of false-positive screening test results and the implications of overinterpreting results without the appropriate clinical context.

Appropriate use of laboratory requisition forms. Copies of the common community blood test and electrocardiogram (ECG) requisition were given to each resident and the instructor took the time to explain how to properly fill out the requisition form, paying close attention to the required information as per the provincial health regulations. Sample requisitions for microbiology, cytology, histology, acute care, standing orders, and mobile services were also presented; it was emphasized that some of these requisitions have special criteria that need to be satisfied before a test can be performed. Common themes that were addressed included ordering ECGs, stat specimens, and standing orders. These were discussed in regard to how to properly order the desired tests, when to order them, and how to receive the results. The microbiologists directly provided written information regarding when to order a culture, how to collect the best sample possible, and how to interpret the results. It was stressed throughout the discussion that if any concerns or questions came up, there was always a pathologist and microbiologist on call to answer questions and give pertinent advice.

Laboratory quality assurance methods. Laboratory quality assurance was discussed in the context of analytic errors and strategies for error reduction. Although not of direct clinical relevance, this section was meant to give family physicians background information on the reasons for test delays and cancellations due to quality assurance problems. Several different quality control measures were introduced, including the use of proper analyzer calibration, control samples, and Levey-Jennings plots. These points were repeated during the laboratory tour.

Laboratory collection processes. In this section, sample requisition forms were distributed and provincial department of health sample acceptance policies were reviewed. Common defects on requisition forms for chemistry, hematology, cytology, and anatomic pathology were reviewed. Residents were then introduced to the range of additional local services available to them and they learned how to access these services, including how to access mobile collection services, how to enrol patients in our standing order database, how to order ECGs (which are performed by the laboratory in Calgary), how to order stat tests, how to access on-call pathologists, and how to access the laboratory call centre for test results.

Costs of laboratory tests. Numerous tables were prepared illustrating the costs of a variety of individual tests to give the residents a clear visual assessment of the cumulative test costs and expenses charged to the health care system. Further discussions allowed the residents to explore the usefulness of particular tests.

Program evaluation

The first cohort of first-year family medicine residents completed this program in July 2012. A total of 69 residents completed the session, with program evaluations available for 68 of them. Overall the program was very well received, with a considerable increase in residents' self-assessment of their knowledge of all curriculum topics (**Table 1**).

Discussion

This new collaborative curriculum is unprecedented in regard to exposing family physician residents to laboratory services. A literature search failed to find any citations of published curricula with similar objectives or formats. For practising physicians, several other educational approaches to provide information on improved test-ordering practices have been explored.[8] For example, teaching by clinical pharmacists, managerial strategies, monetary incentives, and penalties have all been attempted with little effect.[9,10] Development and application of guidelines and laboratory use reviews have also been undertaken to no long-term avail.[8] In contrast, some successes were noted by removing tests from the requisition forms, limiting the number of tests residents can order, and obtaining peer comparisons and feedback.[8,11] Even though small improvements in test ordering were observed, overall these interventions were thought to be time-consuming, to be challenging to implement, and to interfere with physician judgment, as well as to be uncomplimentary to clinical conclusions.[10] Conversely, Attali et al developed a form that was met with much success for internal medicine physicians to reduce the number of tests ordered.[11]

The novel approach used in this study not only supports the residents' evaluation objectives, but also teaches them how to be efficient in ordering tests and encourages responsible medical resource stewardship among primary care physicians. The use of a small group format allowed for more tailored teaching toward those particular individuals based on concurrent feedback and questions. This encouraged more 2-way discussion and provided a more responsive and dynamic educational atmosphere. Because the sessions were held over a 2-week period, preceptors were able to identify patterns and address common questions up front with each successive group, continually improving the usefulness of each session. Additional take-home resources were provided to the residents in the form of PowerPoint slides.

Results of the before and after surveys of the 68 residents show statistically significant ($P < .001$) self-identified changes in levels of knowledge of the use of laboratory testing, sources of laboratory error, the definitions of *normal* and *abnormal laboratory test results*, laboratory quality assurance methods designed to minimize error, appropriate use of laboratory requisition forms, laboratory collection processes, and the costs of common laboratory tests. These issues are becoming increasingly important for continuing medical education, in order to better and more efficiently meet patient needs, and for improved stewardship of medical and laboratory resources. Ongoing funding and staffing shortage issues across Canadian laboratories[12,13] require dissemination of information to clinicians for improved use of laboratory testing in order for many laboratories to continue to meet clinical demands with high-quality laboratory results. Education is a powerful tool that can help primary health care physicians reassess and examine their strategies for ordering of routine laboratory tests and understand the tremendous and increasingly complex work that follows those orders.

Table 1. Survey results comparing residents' self-assessed knowledge of the curriculum topics before and after the session: *Responses were measured on a scale of 1 to 5, with 5 representing very high.*

TOPICS ON WHICH RESIDENTS RATED THEIR KNOWLEDGE AND A QUESTION	RESIDENTS' SELF-ASSESSMENT BEFORE THE SESSION, MEAN (SD)	RESIDENTS' SELF-ASSESSMENT AFTER THE SESSION, MEAN (SD)	*P* VALUE*
Please rate your knowledge of the following:			
• Problems associated with unnecessary use of laboratory testing	2.96 (0.70)	4.19 (0.60)	< .001
• Role of family physicians in preventing laboratory errors	2.90 (0.74)	4.31 (0.60)	< .001
• Definitions of *normal* and *abnormal laboratory test results*	3.47 (0.68)	4.16 (0.74)	< .001
• Appropriate use of laboratory requisition forms	3.13 (0.71)	4.34 (0.66)	< .001
• Principles of laboratory quality assurance	2.40 (0.74)	4.16 (0.59)	< .001
• Laboratory collection processes (eg, patient appointments, laboratory tests, ECGs, and mobile collections)	2.62 (0.93)	4.37 (0.67)	< .001
• Costs of common laboratory tests	2.29 (0.92)	4.07 (0.68)	< .001
Overall, was this session useful?	NA	4.54 (0.59)	NA

ECG—electrocardiogram, NA—not applicable.
*Statistical significance between self-assessments before and after sessions was calculated with the Wilcoxon signed rank test in SPSS, version 19 for Windows.

McConnell et al explain that a "frequency breeds carelessness" notion is most widespread among residents and upper-year medical students who can order common tests that are simple to perform, whereas many other complicated tests have a series of guidelines that must be followed in order to be performed, such as cytogenetics.[14] Unfortunately, "medical educators have attempted to incorporate cost consciousness into their teaching, but such efforts have been remarkably few, and curricula remain largely silent" in regard to diagnostic testing; this is the responsibility of the medical schools and residency programs.[8] This is a disadvantage to medical students and residents, as they should have opportunities to both observe and perform approaches to being cost-effective when ordering laboratory tests.[15]

The 7 components of the program (**Box 1**) were chosen to highlight common misconceptions about laboratory testing and consistent contributors to the misuse of laboratory services. Variation among doctors has been shown to be substantial and might be owing to physicians not assisting in developing guidelines or working in a multiphysician environment.[16] Both of these practices facilitate discussion among colleagues, leading physicians to reflect on their own test ordering behaviour.[16] One Ontario study reported that family physicians either had no indication of the cost of a test or they did not consider cost when ordering tests.[17] Other studies have found additional factors that might contribute to the overuse of laboratory testing: a lack of knowledge and education in laboratory errors and how laboratory results can aid in patient care; "defensive medicine"; doctors' lack of confidence or experience; research interests; institutional policies and procedures; and patient request and method of reassurance.[9,14] Factors that influence test ordering also include characteristics of the general practitioners, such as age, compensation, and habitual practice; or physicians introduce test ordering as a way to end patient conversations, believe that laboratory tests are cheaper and better technology is available, and overvalue the diagnostic yield.[8,9,14,17] Health care has always been a collaborative effort and any educational program that can help shed light on areas of medical care that are often ignored can serve a dual purpose of informing physicians in order to improve use of resources and fostering that collaborative model.

Limitations

A limitation of this study is the use of self-reporting in assessing the increased levels of knowledge from this experience. Future considerations might include direct comparison of responses to case scenarios between curriculum-exposed residents and unexposed residents to gauge curriculum effectiveness, or the incorporation of before and after objective examinations to measure individual resident knowledge improvement through this novel curriculum.

Conclusion

We present the curriculum for an introduction to laboratory medicine small group education program for family medicine residents. As the first such curriculum offered in Canada, it is hoped that this program will help to support the learning objectives of family medicine residents and serve as a template for similar programs at other teaching centres. Initial resident response from the first year of the program has been overwhelmingly positive.

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Contributors
All authors contributed to the concept and design of the study; data gathering, analysis, and interpretation; and preparing the manuscript for submission.

Competing interests
None declared

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