

# Facilitating Access to Laboratory Guidelines by Modeling their Contents and Designing a Computerized User Interface

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**Abstract.** Laboratory tests are not always prescribed appropriately. Guidelines for some important laboratory tests have been developed by expert panels in the Parisian region to maximize the appropriateness of laboratory medicine. However; these recommendations are not frequently consulted by physicians and nurses. We developed a system facilitating consultation of these guidelines, to increase their usability. Elements of information contained in these documents were identified and included in recommendations of different categories. UML modeling was used to represent these categories and their relationships to each other in the guidelines. We used the generated model to implement a computerized interface. The prototype interface, based on web-based technology was found to be rapid and easy to use. By clicking on provided keywords, information about the subject sought is highlighted whilst retaining the entire text of the guideline on-screen.

**Keywords.** Test ordering, Laboratory medicine, Prescription appropriateness, Guidelines, Modeling, User interface

## 1. Introduction

The use of diagnostic tests has increased over the past decades, and 60 to 70% of the most important decisions concerning admission, discharge and medication are based on laboratory test results [1]. Various international studies have suggested that up to 67% of laboratory test requests in healthcare are inappropriate and can be called into question [2-3]. Various strategies for changing the test-ordering behavior of medical practitioners, including education programs [4], redesigning the request form [5], feedback on the number or rational basis of tests prescribed [6], informing requesters about the costs of the tests requested [7], and the use Computerized Decision Support Systems (CDSS) [8], have been proposed in the literature.

The implementation of guidelines, which are becoming more and more common in medical practice, and compliance with guidelines in daily practice, remain problematic areas [9]. A lack of awareness of the content of a guideline and a lack of familiarity or agreement with these recommendations are the reasons for not using or following practice guidelines by physicians [10]. Furthermore, guidelines may be difficult to

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obtain at the appropriate moment and identifying the information required can be laborious as guidelines are usually written in a purely textual format.

The expert panels of the public hospital system of the city of Paris and its suburbs (AP-HP), the largest hospital system in Europe, recently formulated evidence-based laboratory guidelines for improving test ordering, specimen collection and handling procedures for about 30 common laboratory tests. Unfortunately, it became evident that these recommendations were not frequently consulted by physicians or by the nurses responsible for specimen collection and handling procedures under appropriate conditions. We hypothesize that the contents of these documents might be used more effectively if a computerized interface was developed to facilitate access to these recommendations and to make them easier to read. The main aim of this study was therefore to develop and evaluate a new presentation of the information of these laboratory guidelines, based on a model derived from an analysis of their contents.

## **2. Materials and Methods**

We studied 22 evidence-based laboratory guidelines formulated by expert panels of the AP-HP. These documents appeared to be very heterogeneous in structure, as the topics were different (either a pathology or a test), and they were written by different panels.

### *2.1. Modeling the Content of the Guidelines*

In order to identify the elements of information contained in the guidelines, we first randomly assigned them to two groups. The first group, the study group, containing two thirds of these documents, was used to structure a model. The remaining third was used to validate the model obtained. We then listed all the different headings present in the study group. For each section, we studied the relevant text in each document (when available), and broke it down into recommendations (some sections contained several independent recommendations). We then analyzed the recommendations, to identify the various elements of information within them. For example, an indication for the rescription of a test may have conditions such as persistence of the underlying disease, inefficacy of the treatment and/or a time limit between two prescriptions. Whenever an information element did not match a type already encountered, a new information element was added. The information elements found in each recommendation were therefore listed incrementally, as they were discovered. Unified Modeling Language (UML) was used to model the categories of information. Once the model had been developed, it was validated with the documents of the second group.

### *2.2. Designing and Evaluation of the Interface*

The next step was to develop a web-based interface to facilitate the consultation of guidelines, providing faster access to the information within them. The documents were restructured according to the model constructed. This restructuring involved the grouping of individual recommendations into the categories and subcategories of recommendations defined in the model. We extracted headings and keywords from categories of recommendations and from the information elements in these recommendations, and presented them in the left margin of each document. The categories of recommendations correspond to section headings in the restructured

document: Prescription, Represcription, etc. It is interesting for the user to have information not only about the types of information present in a document, but also about the types of information not present. For example, if the physician sees that there is no recommendation concerning the writing of requests for a specific test, he or she saves the time that would have been wasted searching the entire document in vain. We used a color-coding system to indicate to the user whether information about a category or subcategory of recommendation is present in the document. We tried then to make the interface interactive by using HTML language to make it possible to click on these headings. When the user clicks on a heading in the left margin, the corresponding text is highlighted in the main document.

A satisfaction survey was carried out, by asking physicians and nurses to score the interface on an analogic scale questionnaire. The physicians and nurses were already familiar with the original guidelines and were asked to complete the questionnaire after handling the interface.

### 3. Results

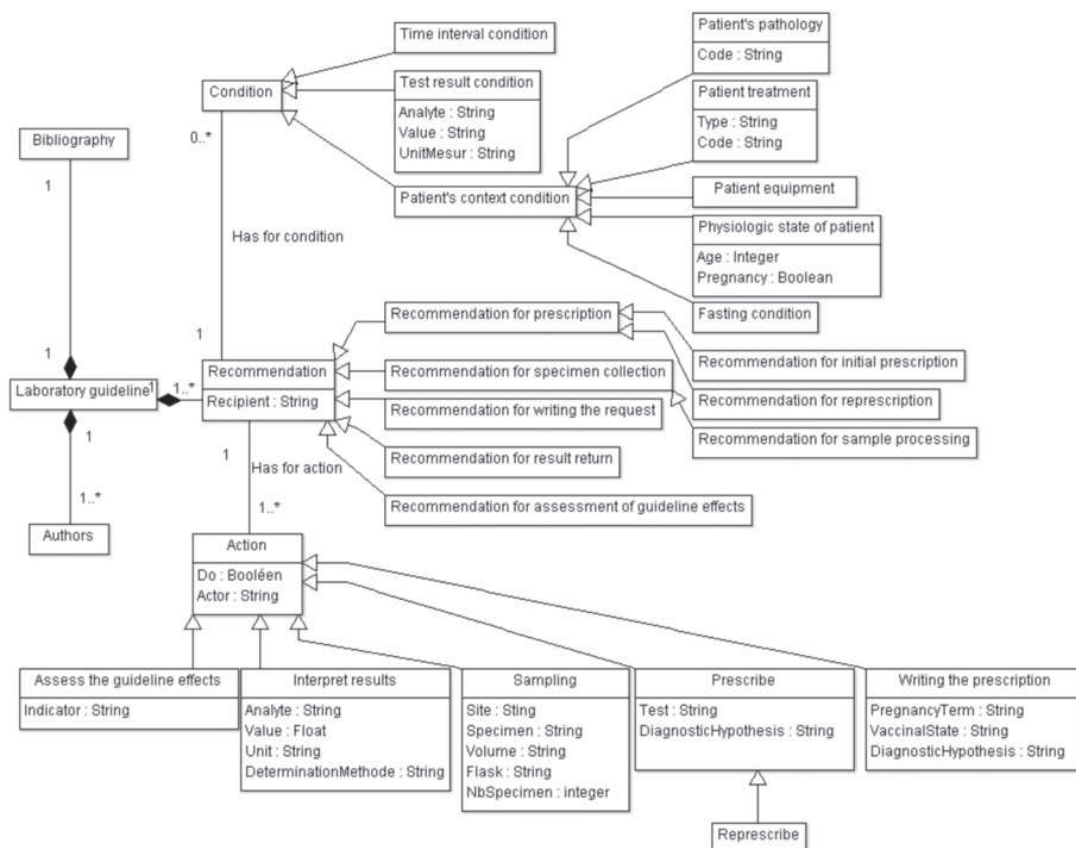
In total, 15 different topics were found in all 22 original guidelines. Some topics appeared in several guidelines, whereas others were specific to some guidelines only. These documents were heterogeneous, with the same section in different guidelines containing different information. Despite the differences between sections and contents, each laboratory guideline consisted of several recommendations, and listed bibliographic elements and authors. A list of the various recommendations and their frequency in the guidelines is presented in Table 1.

All the information found in these guidelines is represented in our UML model in Figure 1. Each recommendation has one or more conditions determining the application of the recommendation and leads to one or more actions that an authorized actor should do or not do. A recommendation may also relate to: a) A test prescription. This may be a recommendation for the initial prescription or represcription (for example, 24 hours after the first series of two samples, if endocarditis is suspected, the represcription of blood culture is recommended). b) The collection of a specimen (for example, the collection of 15 ml of blood by puncture). c) The return of the result (for example, the result must include the electrophoresis layout). d) An assessment of guideline effects (for example, a decrease in the number of blood cultures per patient).

This model was developed from two thirds of the guidelines and was validated on the remaining third. The validation showed that the model was able to represent all the recommendations contained in the remaining third of the guidelines.

**Table 1.** Recommendation categories and their frequency in the guidelines

| Recommendation categories                          | Number of guidelines (%) |
|--|--------------------------|
| Recommendation for prescription                    | 22 (100)                 |
| Recommendation for represcription                  | 22 (100)                 |
| Recommendation for specimen collection             | 16 (73)                  |
| Recommendation for interpretation of results       | 7 (32)                   |
| Recommendation for writing the request             | 11 (50)                  |
| Recommendation for assessment of guideline effects | 16 (73)                  |



**Figure 1.** UML diagram describing the organization of information elements in laboratory guidelines

The model served to rearrange the elements of the guidelines. It was used to design the web-based interface, to reorganize the recommendations present in each guideline according to an identical section structure for all documents. The user clicks on a heading (listed in Table 1) in the left margin and corresponding text is highlighted in the main document, providing direct access to required information without the need to read the entire document. When an element of information is not present in a guideline, the heading is shown in gray, indicating that the information sought is not available. A “Specific clinical context” section is provided for each guideline, enabling the user to identify rapidly information applying to a particular patient context, e.g., “suspicion of anaerobic bacteremia” in the guideline for blood culture.

We asked 21 physicians and 14 nurses from three university hospitals in Paris to consult the original documents and then to manipulate the web-based interface. Table 2 shows the results of the evaluation.

**Table 2.** Interface evaluation results

| Question  | Mean | Standard deviation |
|---|------|--------------------|
| Compared to the initial presentation, the order of presentation of information seems better/worse (0 for the worst and 100 for the best)              | 74   | 19                 |
| Compared to the initial presentation, the headings seem more/less comprehensible (0 for the least understandable and 100 for the most understandable) | 80   | 18                 |
| The clickable menu in the left margin seems hard/easy to use (0 for difficult to use and 100 for very simple)   | 77   | 15                 |
| Do you find the possibility of selecting “Specific clinical contexts” useful? (0 for not at all useful and 100 for very useful)                       | 96   | 6                  |
| Overall, access to the information is/is not better (0 for has no improvement and 100 for considerable improvement)                                   | 74   | 15                 |

#### 4. Discussion and Conclusion

The consultation of laboratory guidelines should lead to rational and appropriate requests for testing. However, if guidelines are to be useful, the user must be able to search for the necessary information rapidly and to find it in a non ambiguous context [11]. In this study, we proposed a model for structuring the contents of laboratory guidelines. The integration of recommendations into a web-based interface made it possible to provide a contextual menu that facilitates reading. For example if the user seeks the indications for prescription of a laboratory test, he clicks on “Indications” in the right menu and finds them rapidly, as the information is highlighted on the screen. A quick glance at the menu provides the user with a concise overview of the contents of the page. An evaluation of satisfaction with this interface gave promising results.

Further evaluation of the model, by other users than developer team, is required to confirm its generic nature. Although our preliminary evaluation showed that the interface was favorably received by physicians and nurses, a quantitative evaluation of the impact of the interface in terms of the behavior of physicians and nurses (e.g. their test-requesting behavior) would be of considerable interest.

A model of this type can pave the way to many other possible applications for improving the quality of laboratory medicine. These applications may be based on decision trees, graphical approaches, or alert systems when a physician prescribes a test that is not in accordance with the recommendations. Automatic assessment of the effects of guidelines is feasible based on the indicators described in the guidelines. This model may also be useful for improving the formulation of future laboratory guidelines and designing a useful knowledge base containing the entire body of knowledge about the laboratory tests available.

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