Interpretative commenting: A tool for improving the laboratory–clinical interface

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A B S T R A C T

The clinical interpretation of laboratory results is an integral part of laboratory services. However, while many clinical laboratories provide comments of some form or other in their reports, this provision varies from one country to another, and between laboratories in a single country. Over the last decade, the focus on medical errors and patient safety has spread worldwide, involving all medical disciplines, including laboratory medicine. While available evidence demonstrates that in recent decades an impressive reduction has been achieved in the rates of analytical errors in clinical laboratories, the pre- and post-analytic phases of the testing cycle are still error prone and, even more dramatic, affected by errors that could translate into harm and adverse events for patients. Interest in post-analytic errors, in particular, has increased the identification of problems not only before and during the reporting of laboratory results, but also in the physician’s reactions to the transmission of data, their interpretation, and the appropriate action to take for the patient. Therefore, greater efforts should be made to facilitate the review, interpretation and utilization of test results. The continuation and expansion of interpretative commenting, part of a broad strategy to improve the transmission and communication of laboratory results, appear to be favored by several factors, including the introduction of new and complex tests, clinical and regulatory guidelines, data on clinicians’ satisfaction and the impact of interpretative comments on patient outcomes. The appropriate training and education of laboratory professionals is a fundamental component in assuring quality and safety of interpretative comments. Moreover, quality assurance programs and an appropriate clinical audit are required to evaluate and improve upon this activity.

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1. Introduction

Medical error continues to capture the attention of the medical profession, policymakers, and the public. Most data available on errors in health care focus on medication-related errors, particularly in hospitals, and related adverse events [1–3]. However, in recent years, large-scale surveys have demonstrated that patients and physicians perceive that diagnostic errors are common, and are a matter of concern [4]. Indeed, throughout the last decade, diagnostic errors have become the most prevalent cause of malpractice claims in the US [5,6].

Recent reports on missed and delayed diagnoses both in ambulatory and emergency department settings underlined that the leading breakdowns in the diagnostic process were the failure to order and the incorrect interpretation of diagnostic tests, including those from laboratories [7–11].

While it has been demonstrated that in the last few decades an impressive reduction has been achieved in analytical error rates, the pre- and post-analytic phases in the testing cycle are still error prone; they are, moreover, vulnerable to errors that could translate into harm and adverse events for patients. Increasing interest has been shown in post-analytic errors, the sources of problems being identified not only before and during the reporting of laboratory results, but also in the physician’s reactions to the transmission of data, their interpretation, and the appropriate action to take for the patient. It has also been demonstrated that laboratory information is only partially utilized: past studies showed that physicians ignored or overlooked 25 to 60% of abnormal routine tests [12] and, more recently, it was demonstrated that 45% of the results of urgent laboratory tests requested by the emergency department were never accessed [13]. In addition, one study established that 3.5% of abnormal blood calcium results were not recorded in the patient’s medical record [14], that there was no follow-up for abnormal TSH results in ≥2% of patients [15] and that potassium supplementation was prescribed in a significant percentage of patients with increased serum potassium concentrations [16].

Several strategies have been developed and implemented to improve upon performance in the post-analytic phase. In particular, the provision of interpretative comments on reports has been advocated as an effective tool for adding value to laboratory services and for improving the interpretation and utilization of laboratory results [17]. However, while interpretative commenting is considered an important aspect of laboratory medicine, the practice of attaching comments to laboratory reports varies widely among countries, and even among clinical laboratories within the same country; the clinical usefulness of this practice is also debatable. Currently, some factors might favor the expansion of the practice of adding comments to the
report. Here I review available knowledge on interpretative comments, underlining the advantages and disadvantages of this practice, and discuss current drivers and forces able to make this practice an effective tool for improving laboratory services in a patient-centered scenario.

2. The starting point

As pointed out by Lundberg several years ago [18,19], at the end of the testing cycle the laboratory information provided should assure a better clinical outcome than that which would otherwise be obtained. Under this perspective, we have to review and evaluate all variables of potential value in providing information enabling optimal quality of care (i.e., patient management), diagnosis and treatment. In addressing the issue of the clinical usefulness of interpretative comments, we can envisage two different scenarios, in which the requesting physician is a) familiar with, or b) is not familiar with, the test required. Clearly, several different clinical situations lie between the two extremes.

a) When the requesting clinician is familiar with the test and aware of its quality specifications and diagnostic effectiveness, all s/he may require is result which, if reliable, can be put to fully effective use. However, it has been demonstrated that the provision of a “simple” analytical result does not enable the clinician to put the laboratory result to full use as information. The variations between the units used by different laboratories in reporting results have caused confusion among receiving clinicians and have raised the possibility of medical errors. This, well demonstrated in reporting units for therapeutic drug monitoring [20], may affect many other parameters. An even more serious concern is variations in analytical performance characteristics; for most laboratory tests, the method used markedly affects the relationships between the analytical result and the appropriate reference range, the diagnostic cut-off, and the clinical validity of the test itself (diagnostic sensitivity, specificity, positive and negative predictive values). Moreover, analytical quality specifications of many laboratory tests change over time, thus affecting the related comparative values (reference ranges and decision limits). Available evidence from external quality assessment (EQA) schemes demonstrates that while, in recent decades, analytical results have become more comparable, this has not been achieved for reference ranges [21]. Thus, in many circumstances, the same analytical result may be interpreted as “normal” or “abnormal” depending on the relative reference values used. The more relevant the test for clinical decision-making, the more delicate the relationship between the analytical result and the appropriate reference range and/or diagnostic cut-off. The prototype of this type of laboratory test is cardiac troponin, particularly cardiac troponin I, whose results should be interpreted only if the appropriate decision limit is used. Current guidelines recommend the use of the 99th percentile as a diagnostic threshold even if some analytical goals (CV<10%) should be assured at that concentration [22]. Since the diagnostic cut-off is method-dependent, the report of each and every clinical laboratory must include information on the decision limit appropriate for the diagnostic system used. A further example, CRP measurement to identify cardiovascular risk, has a decision limit significantly different from the limit used when the protein is measured to diagnose and monitor systemic inflammatory diseases [23]. It is extremely important, in many instances, to specify the reference range as well as the analytical result also because the individual physician may receive laboratory results from different laboratories and therefore have to cope with differences between results and their interpretation due to the unsatisfactory standardization and harmonization of laboratory results. The proposal that I have made, designed to improve upon the communication of laboratory results, specifies that the report should include information on the total error and/or of the reference change value if the test is performed for monitoring purposes and serial data are/will become available [24,25].

b) Clinicians can often request laboratory tests that they are not necessarily familiar with. In his seminal paper published in the nineties [26], Challand underlined the formidable changes that had taken place in laboratory practice over a few decades. In particular, the increased workloads, the shift towards primary care and the reduction in time “to go to the ward and discuss results and further investigation directly with the clinician responsible” were cited by the Author as the main drivers for the inclusion of interpretative comments on reports. Challand also maintained that, while it was widely assumed that hospital clinicians knew how to interpret laboratory data, General Practitioners welcomed advice on interpretation and further investigation or action. Since then, the number of laboratory tests and their complexity have steadily increased, the reporting via computerized systems and other electronic communications has replaced and/or integrated the traditional paper format, and the number of individuals requesting, and receiving, laboratory reports (nursing and midwifery staff, and patients) has grown enormously. Overall, these changes appear to offer the opportunity to provide interpretative comments and services in day-to-day practice. Moreover, the instances in which the value of a laboratory result can be considerably enhanced by an accompanying written comment include cases in which: a) the result is unexpected, particularly if the laboratory has identified the possible cause (e.g., macroamylase, other macromolecules such as macroprolactin) [27,28]; b) an interference (e.g., from heterophilic antibodies in immunossays) [29] has been identified and the analytical result amended; c) a test panel is measured and the evaluation of possible patterns adds value to the single result of each analyte (e.g., serum electrophoresis, panels for gastric and liver diseases) [30]; d) a specific question has been posed but it is not clear whether the results provide the answer; e) the clinician has posed a question without requesting a test, and the laboratory has activated a series of interrelated measurements; g) results show that a decision on patient management or treatment is indicated, but advice is needed to ensure that the information provided is used in the best possible way [31–33].

None of the above can be considered novel circumstances, but currently some factors favor the continuation, or even expansion, of the practice of adding comments to laboratory reports [34], as shown in Table 1.

2.1. Introduction of new and complex tests

The extensive development of specialized sectors in clinical laboratories and the correlated increase in the number of tests and their complexity have highlighted the difficulties in data interpretation encountered by general practitioners and physicians receiving laboratory tests outside their own specialty area. The prototype of this situation, the “autoimmunology laboratory”, has undergone considerable growth in recent years thanks to new discoveries in physiopathology, target antigens

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and diagnostic tests. Autoantibody tests, in fact, comprise a set of procedures that differ considerably in method, diagnostic specificity and sensitivity, and clinical correlation. According to Tonutti et al. [35], in view of this complexity, interpretative comments on autoantibody tests are required in the following circumstances:

a) positive finding for autoantibody, with low or unexpected clinical correlation;
b) finding of inconsistent results when two or more methods are used to determine the same antibody;
c) independent performance by the laboratory of further tests either on the basis of screening test results or in response to specific clinical queries;
d) chance finding of an antibody not requested, particularly when using methods able to detect multiple antibody specificities (e.g., microarrays).

Some guidelines on autoantibody assay recognize the need for interpretative comments, and a consensus on specific comments has been achieved. This applies to the consensus guidelines on anti-beta glycoprotein 1 (β2GPI) testing [36]. When IgG anti-β2GPI is positive, the following comment is considered appropriate: “The combination of positive aCL and anti-β2GPI antibodies is relatively specific for the anti-phospholipid antibody syndrome (APS), but needs to be interpreted in the context of the clinical scenario. However, positive tests for both antibodies have been described in some infections (including leprosy, parvovirus B19, syphilis, HIV, and acute Q-fever). Recommended repeat testing after 12 weeks to determine antibody persistence. (Testing for lupus anticoagulant is recommended)”.

Vice versa, when the result is negative, the following statement is considered appropriate: “IgG anti-β2GPI are less sensitive than IgG aCL for the anti-phospholipid antibody syndrome. Therefore, some patients with APS may have positive aCL but negative anti-β2GPI test results (Testing for lupus anticoagulant is recommended)” [36].

Other examples of complex diagnostic testing are those for coagulation disorders, allergic diseases and serum protein analysis. Regarding the latter, the typical interpretative comment is indicated when a band of restricted mobility is found to migrate in the gamma region. In addition to the concentration of the band, if the band has not been previously characterized the addition of an immunofixation test should be either made on the spot, or recommended [37].

Genetic tests give rise to particular concerns and the issue of appropriate requesting and interpretation of genetic tests is currently a hot topic in the scientific debate [38]. David Melzer et al. underlined the risk that “some laboratories only want to report assay results, without making clinical claims” [39]. Pre- and post-analytical counselling is mandatory for translating discovery into evidence-based practice. Although major scientific progress has been made in the genomic contribution to several human diseases, clinical applications are still largely unclear and, therefore, analytical data are not self-explicative. Interpretative comments, a fundamental tool in allowing the correct interpretation of laboratory results, should be considered a key component in clinical counselling.

2.2. Physicians’ satisfaction and its impact on clinical outcomes

In their survey on clinicians receiving coagulation interpretations, Laposata et al. investigated “customer satisfaction” regarding the interpretative service: 98% of physicians interviewed described the service as “useful” and, according to 55% of them, interpretation reduced the time to diagnosis; 72% claimed that it allowed a reduction in the number of laboratory tests performed, and prevented misdiagnosis [40]. In a more recent survey in the UK, Barlow observed that the feedback was positive regarding thyroid tests (considered helpful or very helpful by 93% of physicians and nurses interviewed), other hormones (FSH, LH, estradiol, testosterone, cortisol) and glucose tolerance tests (almost 90% of nurses and general practitioners considered the comments provided very useful or useful) [41]. Lim et al. observed that “attaching a comment adds value to the report and is appreciated by junior hospital doctors and general practitioners and even specialists may be helped especially on test results outside their specialty” [34]. Finally, 90% of physicians judged as useful the interpretative comments in hematological reports in the University-Hospital of Padova [42].

Regarding the influence of interpretative comments on clinical outcomes, Kilpatrick reported a 22% reduction in the number of general practitioners samples indicating thyroxine under-replacement in the three years following the introduction of interpretative comments [43]. Laposata et al. reported a significant reduction in errors in test requisition following an interpretative service of 2.5 years’ duration [40], and also described some clinical cases in which the interpretation significantly changed and improved the clinical outcome. Cunney et al. described the actions taken in response to interpretative comments introduced in the report of sputum, urine and wound microbiological cultures and, in particular, their effects on antibiotic therapies [44].

2.3. Clinical and regulatory guidelines

Assessing and reporting on the quality of health care has become a fact of life. In particular, the external assessment of the quality of services delivered by clinical laboratories, introduced some decades ago, aims to provide an objective tool for assessing and improving everyday practice. The currently available specific International Standard (ISO 15189:2007) for the assessment and accreditation of medical laboratories specifies requirements for competence and quality that are peculiar to medical laboratories and is a widely accepted standard for the accreditation of clinical laboratory services. For the post-examination procedures, specific requirements for the interpretation of results are recommended “where appropriate” [45]. A more comprehensive description of these requirements is given in the “Standards for the Medical Laboratory” released by the Clinical Pathology Accreditation (UK). Regarding the “clinical advice and interpretation” four requirements are included in section G (the post-analytical phase) of the document, after the following statement “the provision of interpretive comments in reports is an essential role of the laboratory service [46]. The frequency of such comments may vary between specialties”. The four requirements concern: 1) the availability of advice and interpretation of results to meet the needs of users; 2) some characteristics of the comments, which should be clear and succinct; 3) the proviso that comments should be provided only by authorised personnel with appropriate training; 4) systematic communication between laboratory and clinical staff that should promote effective utilization of laboratory services.

Moreover, recently developed and released clinical guidelines recommend the use of interpretative comments to improve the utilization of laboratory data. In addition to a previously reported example [36], the consensus guidelines on anti-cardiolipin antibody testing [47], and on tumor markers [48] should also be cited.

The document entitled “Guidelines for the Provision of Interpretative Comments on Biochemical Reports” released by the Royal College of Pathologists in 1998 [33], a milestone in approaching this issue, states that whether a comment is required will depend on:

a) the clinical details provided;
b) the clinical implication(s) of the results;
c) the likely familiarity of the requesting clinician with the test and their interpretation.

Moreover, the guidelines suggest some situations in which comments might be appropriate (e.g., when a decision on management or treatment is indicated, a result is unexpected, a specific question has been made to the laboratory and/or when the physician is not very familiar with the test requested [33]).
2.4. Increased communication of electronic data

The widespread use of electronic systems for the reporting and review of laboratory data has significantly improved the communication of laboratory information, particularly by reducing and avoiding any delay between the production of analytical results and their effective availability at the point-of-care. However, for optimal communication of information, the laboratory must be involved in the formatting of electronic reports to minimize the risk of results being misunderstood or misinterpreted. In fact, the already large volume of laboratory data to be reviewed by requesting physicians, namely general practitioners is becoming even larger. Previous estimates indicate that a typical primary care physician may have to review up to 800 data points from chemistry and hematology reports, 40 radiology reports, and 12 pathology reports per week [49]. A recent analysis of malpractice cases by a large insurer showed that about one quarter of diagnosis-related malpractice cases can be attributed to failures in the follow-up system [50]. Boohaker et al. found that less than one fourth of physicians had a reliable method for identifying patients overdue for follow-up after abnormal test results had been obtained [51]. These Authors also reported that three fourths of physicians did not routinely notify patients of normal test results and that up to one third of physicians did not always notify patients about abnormal test results. The increased electronic data communication will require clinicians to cope with this traffic and increase the desirability of interpretative comments, in addition to some innovative tools to facilitate test result review, patient–physician communication, tracking of test orders and correct interpretation of results, particularly when they play a key role in patient management.

2.5. Competition between clinical laboratories

Changes in the delivery of health care services and in the reimbursement systems have increased the competition between clinical laboratories. Competition, moreover, is prevalently based on costs. Other variables considered in evaluating the quality of the service provided, are turnaround time, analytical reliability, and the reputation of the institution. The availability of an interpretative service should be considered an “added value” in improving the appropriateness of the test request, allowing an effective cost reduction, and maximizing the utilization of laboratory information [52].

2.6. Increasing use of expert systems and interpretive algorithms

Great steps have been made forward in the development of information technologies and their use in laboratory medicine. The rational combination of laboratory tests, particularly those expressed in the form of diagnostic ratios or scoring systems, or linked through mathematical models (e.g., stepwise and artificial intelligence algorithms) significantly improves the diagnostic accuracy of single tests. In particular, in recent years, combination panels of biomarkers have been evaluated and introduced in clinical practice as non-invasive, less expensive and effective markers for the diagnosis and monitoring of patients with chronic liver diseases and dyspepsia [30].

While liver biopsy is still the gold standard for evaluating the presence, type and stage of liver fibrosis, a body of evidence has been accumulated to demonstrate the limitations of this technique, including inter- and intra-observer variations, sampling errors and variability [53]. Algorithms based on the sequential combination of biochemical biomarkers have a high diagnostic accuracy. This, in turn, translates in a reduction by more than 50% of the need to take liver biopsies. Likewise, a biochemical panel including the measurement of serum pepsinogens I and II, gastrin G-17, and anti- H. pylori antibodies, the so-called GastroPanel has, due to its high negative predictive value, been proposed as a valuable approach to screen dyspeptic patients younger than 55 years and with no alarm features, assuring safety and cost-effectiveness [33,54]. In these cases, a mathematical algorithm and/or an expert system allows the elaboration of single results and the provision of an overall score. However, an interpretative comment seems mandatory to enable physicians to correctly understand and utilize the laboratory information provided. In fact, some explanatory remarks and comments add value to the pure score or index provided and released by the computer or obtained through the mathematical elaboration of raw data.

2.7. Need to provide improvements in the quality of care

According to Laposata, the need for advice on laboratory test selection and result interpretation is being driven by some major issues, including the need to reduce medical error and to improve the quality of care [55]. The patient safety agenda are gaining momentum in the health care systems of all developed countries and laboratory medicine must play a role in reducing medical error. After nearly 10 years of generating narrative interpretation, Laposata et al. demonstrated the usefulness of this service in order to save improve diagnostic accuracy while saving time and reducing cost of care [56]. Currently available evidence underline the importance of decreasing the error rates in test request and result interpretation. In fact, while a dramatic reduction in analytical errors has been achieved in the last decades, the pre- and post-analytic phases are much more vulnerable to errors and, therefore, many efforts should be made to improve these steps of the total testing process [57–59].

3. Open questions

Open questions regarding interpretative reports are related in particular to: a) the nature of the training required for the provision of clinically useful interpretative comments; b) quality assurance for this provision; c) the way in which this activity should be audited.

Interpretation of laboratory tests is a complex post-analytical activity calling for the understanding of the analytical processes involved in generating results and therefore the knowledge of performance characteristics of the method used, recognition of potential pre- and intra-analytical errors, and correlation of results with the clinical status of the patient. In theory, because a full knowledge of, and expertise in, all the above aspects of the testing cycle cannot be gained by any single individual, the interpretation of results is the paradigm of a collaborative activity with inputs both from clinicians and laboratory professionals. In practice, this collaboration is impossible for each and every test generated because of the huge number of tests performed, nor is it necessary in the vast majority of cases [26]. Nor can interpretative comments replace regular contact between laboratorians and clinicians working together to develop and improve upon the dialogue concerning appropriate testing, developing diagnostic profiles and algorithms, agreeing on test protocols as well as diagnostic criteria. In addition, feedback on the comments included in laboratory reports might be more informative than the comments themselves.

However, whenever they are called for, interpretative comments may be entrusted to pathologists and scientists with the appropriate professional qualification, who are accredited for being specifically trained in providing comments in specialized areas of laboratory medicine. While the definition of standards assuring the appropriate qualification and training for performing this activity is the responsibility of the top management of the individual laboratory, it must be borne in mind that any interpretation provided by laboratory professionals with inadequate expertise can be clinically dangerous [34].

As yet there is no gold standard for assessing the quality of interpretative services. However, External Quality Assurance Schemes (EQAS) examining the interpretation of laboratory tests have been introduced in the last decade, particularly in the UK and Austrálasia.
These programs aim not only to evaluate the quality of comments provided but, first and foremost, to play a useful role in continuing education and in improving upon the practice of delivering comments. However, while the Australasian scheme utilizes an expert panel working together to produce a pooled view, the UK scheme uses assessors scoring independently from each other to produce an arithmetically pooled view. Both systems have advantages and disadvantages, but no quality control system can improve quality by working solo: quality will be improved only if the laboratory personnel responds to the evidence provided by EQA results and makes all necessary changes to laboratory procedures and processes. Therefore, the lesson we have learned is that EQAS should encourage the active participation and involvement of professionals in understanding results and, where necessary, activating corrective measures.

A consensus exists on the evidence that, in addition to formal training, personnel making interpretative comments need to regularly audit their activity and continually acquire appropriate professional development. Participation in relevant EQAS is part of continuing professional development. In addition, the clinical audit of interpretative comments released should be performed in each institution, thus allowing laboratory professionals and clinicians to verify the quality of the interpretation service provided by using, whenever possible, clinical outcomes as the gold standard.

3.1. To pay or not to pay? This is the question

Another intriguing issue regarding interpretative commenting is payment for the interpretation itself. From a general viewpoint, it is evident that if interpretative commenting is of added value, it should be reimbursed. On the basis of their US experience, Michael Laposata et al. stressed two fundamental points regarding this issue. In the US, payment made for a clinical laboratory interpretation can be considered “modest” when compared with the payment made for an anatomic pathology interpretation. However, in the States, the payment can effectively be obtained if the requirements of the payer are understood. In addition, currently in the US no reimbursement is made for narrative interpretations provided by qualified PhD clinical scientists, and this is a further barrier to the expansion of interpretative services. Finally, as Laposata et al. stressed, administrators represent barriers to the development of this service because any savings to the budget achieved by improved test selection and interpretation do not come from quantifiable cost centers, and may therefore be invisible to hospital administrators. As yet few experiences on reimbursement have been reported by teams elsewhere, and differences between countries in their management of the delivery of health care services and related payment mechanisms must be taken into consideration. Further studies on this issue are therefore required, worldwide.

4. Interpretative comments: when and how?

The provision of interpretative comments on reports varies widely between laboratories. It may be determined by the management philosophy as well as by the complexity of the tests requested. Interpretative comments were first included in laboratory reports on paper and in print. With the increasing availability of electronic reporting, it has been suggested that clinicians’ interpretation might be facilitated by offering hyper-linking to knowledge resources (e.g., guidelines, laboratory handbooks available on the intra- or internet, specialized websites, such as labtestsonline) rather than as added comments. These sources of knowledge at the point-of-care, however, cannot replace interpretative comments and the two approaches are not mutually exclusive. In particular, while hyperlinks allow clinicians to navigate in order to find the information they require in real time, they call for additional time, and the will to search for general information. Interpretative comments, vice versa, take into account specific clinical context, patients and methods and provide information on particular rather than generic questions or clinical situations.

Furthermore, as underlined above, interpretative comments cannot replace face-to-face contact between clinicians and laboratory professionals, whether in the form of regular and systematic visits or occasional visits to the respective departments. The practice of medicine, the provision of patient care and awareness of clinical needs are changing at a spectacular speed. The only possible way for laboratories to preserve and improve upon the quality of their services is to guarantee continuous communication and to work in close collaboration with clinicians.

Regarding appropriateness, the proposal is to add interpretative comments:

a) always — for particular tests/test panels that cannot be interpreted by numeric data alone (e.g., serum electrophoresis);

b) in patient-specific situations — when a particular laboratory finding has been obtained and there are additional explanatory comments, particularly in some diagnostic areas such as allergy, autoimmune and coagulation testing;

c) when requested by clinicians — when a specific clinical question is asked on requesting a laboratory examination, and after receipt of the laboratory report.

5. Conclusions

The clinical interpretation of laboratory results, an integral part of laboratory services, has a long-standing history, but some factors, improvement to information technology in particular, may favor its continuation and expansion. The translation into everyday practice of new research insights, “omics” techniques and more complex laboratory tests are key drivers to the wider use of interpretative services in clinical laboratories. However, for interpretative comments, as for any other step of the testing process, the medical dictum “first do not harm” should be applied. Safety and quality of interpretative comments hinge upon on the training and education of laboratory professionals performing this task. Appropriate quality assessment programs should be implemented and the regular auditing of this activity should be performed in close collaboration with clinicians.

Finally, interpretative comments should be viewed as a fundamental part of a strategy devoted to improving the post-analytical phase of laboratory testing, which should be further improved by providing an appropriate report form, with the safe and rapid transmission of data to clinicians, and in reporting critical values in real time. The ultimate goal is to assure the appropriate interpretation and utilization of laboratory information for an effective clinical decision-making process and valuable patient management.

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