Laboratory Medicine Quality Indicators

Shahram Shahangian, PhD, MS, and Susan R. Snyder, PhD, MBA

Key Words: Laboratory medicine; Quality indicator; Quality measure; Laboratory test utilization; Laboratory service delivery; Health outcome

Abstract

We summarize information on quality indicators related to laboratory testing from published literature and Internet sources to assess current gaps with respect to stages of the laboratory testing process, the Institute of Medicine (IOM) health care domains, and quality measure evaluation criteria. Our search strategy used various general and specific terms for clinical conditions and laboratory procedures. References related to a potential quality indicator associated with laboratory testing and an IOM health care domain were included. With the exception of disease- and condition-related indicators originating from clinical guidelines, the laboratory medicine quality indicators reviewed did not satisfy minimum standard evaluation criteria for quality or performance measures (ie, importance, scientific acceptability, and feasibility) and demonstrated a need across the total laboratory testing process for consistently specified, useful, and evidence-based, laboratory-related quality and performance measures that are important to health outcomes and meaningful to health care stakeholders for which laboratories can be held accountable.

Laboratory testing and services have an important role in the provision of health care and in utilization and reimbursement. Assessing the quality of laboratory services using quality indicators or performance measures requires a systematic, transparent, and consistent approach to collecting and analyzing data. A comprehensive approach would address all stages of the laboratory total testing process, with a focus on the areas considered most likely to have important consequences on patient care and health outcomes. Quality indicator data should be collected over time to identify, correct, and continuously monitor problems and improve performance and patient safety by identifying and implementing effective interventions and for the purpose of increased consistency and standardization of key processes among clinical laboratories. Certain laboratory medicine quality indicators have been advocated for use as internal quality assessment tools.

Quality Measures

Based on the Institute of Medicine (IOM) definition of quality of care as “the degree to which health care services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge,” a quality indicator is a tool that enables the user to quantity the quality of a selected aspect of care by comparing it with a criterion. A quality indicator may be defined as an objective measure that evaluates critical health care domains as defined by the IOM (patient safety, effectiveness, equity, patient-centeredness, timeliness, and efficiency), is based on evidence associated with those domains, and can be implemented in a consistent and comparable manner across settings and over time.
More specifically, the Agency for Healthcare Research and Quality (AHRQ) National Quality Measures Clearinghouse (NQMC), a public information database promoting widespread access to specifications and details on approximately 2,700 evidence-based health care quality measures (as of January 2009), identifies desirable attributes of a health care quality measure based on a comprehensive review of existing frameworks from national and international organizations committed to health care quality measurement and improvement. These criteria for quality indicators are widely adopted by many health care organizations, they do not vary with an indicator’s proposed use, and they are grouped into 3 conceptual areas: (1) importance, (2) scientific soundness, and (3) feasibility of a measure, each having detailed narrower categories as summarized in the following sections (from the AHRQ desirable measure attributes and based on reviews of quality measure frameworks from the National Committee for Quality Assurance [NCQA], the Joint Commission, Foundation for Accountability, IOM, US Department of Health and Human Services, Performance Measures Coordinating Council, Physician Consortium for Performance Improvement, Australia’s National Health Performance Committee, Britain’s National Health System, and German Agency for Quality in Medicine).

Importance

• Relevance to stakeholders: topic area is of interest and financially and strategically important to stakeholders (eg, businesses, clinicians, and patients)
• Health importance: addresses clinically important aspects of health, defined as high prevalence or incidence and significant effect on disease burden (ie, population morbidity and mortality)
• Equitable distribution: can examine whether disparities exist among patients by analysis of subgroups
• Potential for improvement: evidence indicates overall poor quality or variations in quality indicating a need for the measure
• Health care system influence: results can be improved by feasible actions or interventions under health care system control

Scientific Soundness

• Clinical logic: topic area is explicitly and strongly supported by evidence (ie, indicated to be of great importance to improving quality of care)
• Measure properties: reliable (results reproducible and the degree to which they are free from random error), valid (associated with what it purports to measure), allow for patient and consumer variables (stratification or case-mix adjustment), and comprehensible (understandable for users who will be acting on the data)

Feasibility

• Explicit specification: detailed specifications for the numerator, denominator, and data collection requirements understandable and implementable
• Data availability: needed data source available, accessible, and timely, and consideration given to whether the measurement costs are justified by the potential for improvement in care

Identification of Quality Indicators in Laboratory Medicine

This review is intended as a starting point that identifies and evaluates previously used laboratory medicine quality indicators. For laboratory medicine, quality indicators or performance measures may be developed to evaluate any stage of the total laboratory testing process, IOM health care domains, national health care priorities, and relevant testing environments (eg, hospitals and point-of-care settings). The results of this review are intended to identify gaps and needs related to adequate development and refinement of quality indicators for monitoring and improving laboratory service delivery and utilization.

Quality indicators were identified by using Internet searches and examination of peer-reviewed publications from January 1990 through July 2008. These sources included the following, among others: (1) AHRQ NQMC and National Guideline Clearinghouse (NGC) Web sites, (2) 2007 AHRQ National Healthcare Quality Report, (3) College of American Pathologists (CAP) Web sites for information on past Q-Probes (one-time assessments of laboratory issues) and ongoing Q-Tracks (quarterly monitoring program) studies, (4) Health Employer Data and Information Set measures provided by the NCQA, (5) the AHRQ-sponsored US Preventive Services Task Force, (6) Centers for Disease Control and Prevention (CDC) MMWR Recommendations and Reports, (7) CDC-sponsored US Task Force on Community Preventive Services, and (8) searches of the PubMed database using various terms for clinical conditions and laboratory procedures and general terms such as laboratory, health, quality, effectiveness, guideline, standard, and screening.

Two basic inclusion criteria were used. (These basic inclusion criteria are not as extensive as those used by the AHRQ NQMC because, with 1 exception detailed in “Test Order Appropriateness” [p 421], the laboratory medicine quality indicators included in this review have not met the NQMC inclusion criteria available at http://www.qualitymeasures.orge/about/inclusion.aspx. Updated January 19, 2008. Accessed January 24, 2008.) A quality indicator was required to be a previously used quantitative measure (1) associated
with laboratory testing or services and (2) having the potential to be related to at least 1 IOM health care domain.9 Indicators meeting the inclusion criteria were then categorized according to the following 6 stages of the total laboratory testing process1: (1) test ordering; (2) patient identification and specimen collection; (3) specimen identification, preparation, and transport; (4) analysis; (5) result reporting; and (6) result interpretation and ensuing action.

Laboratory Quality Indicators

The 14 laboratory quality indicators identified are grouped according to the stage of the total laboratory testing process. The indicators are listed in Table II, along with the related IOM domains.

The indicators identified span the stages of the total laboratory testing process; however, they do not provide comprehensive coverage. The stages with the least coverage based on the number and nature of the identified indicators are result interpretation and ensuing action, analysis, and patient identification and specimen collection. However, the general lack of reported use of all of the identified indicators may result in insufficient monitoring of all stages of the total testing process.

The indicators identified address multiple IOM health care domains, with safety, timeliness, effectiveness, and efficiency being the most frequent. Relatively few indicators were associated with patient-centeredness, and none of these indicators were associated with equity. Based on the relatively small number of indicators and their lack of widespread use in practice, the stages of the total testing process and IOM domains do not seem to be well covered.

The AHRQ NQMC categorizes measures into the following 7 primary domains: access, outcome (health state), patient experience, process, structure, use of service, and population health.17 All of the laboratory medicine quality indicators identified except one (patient satisfaction with phlebotomy) are process measures, compared with about half of the NQMC measures. (The NQMC health care measure domains relate to the following descriptions: [1] process: health care service provided to or on behalf of a patient appropriately based on scientific evidence of efficacy or effectiveness; [2] outcome: health state of a patient resulting from health care; [3] access: patient’s or enrollee’s attainment of timely and appropriate health care; [4] patient experience: patient's or enrollee’s report concerning observations of and participation in health care; [5] structure of care: feature of a health care organization or clinician relevant to its capacity to provide health care; [6] use of service: provision of a service to, on behalf of, or by a group of persons defined by nonclinical characteristics without determination of the appropriateness of the service; and [7] population health: state of health of a group of persons defined by nonclinical characteristics.) With the exception of test order appropriateness, none of the quality indicators identified in this review is listed in any form in the AHRQ...
Many laboratory test orders are not recommended for specific diseases and conditions (see its NQMC database; many involve laboratory tests recommended for screening, management, diagnosis, and monitoring of various diseases or clinical conditions consistent with guidelines. (2) Reduce wasteful and unnecessary testing.

Table 2

<table>
<thead>
<tr>
<th>Disease/Condition</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anemia</td>
<td>CMS (2004)</td>
</tr>
<tr>
<td>Chlamydia infection</td>
<td>NCOA (2005), USPTSF (2008)</td>
</tr>
<tr>
<td>Lead poisoning</td>
<td>Wisconsin Department of Health (2006)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>CMS (2005), Renal Physicians Association (2002)</td>
</tr>
<tr>
<td>Upper respiratory infection</td>
<td>ICSI (2003), NCOA (2006)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>ICSI (2004)</td>
</tr>
<tr>
<td>Venous thromboembolism</td>
<td>ICSI (2006)</td>
</tr>
</tbody>
</table>

BMA, British Medical Association; CDC, Centers for Disease Control and Prevention; CMS, Centers for Medicare & Medicaid Services; ICSI, Institute for Clinical Systems Improvement; NCQA, National Committee for Quality Assurance; PCPI, Physician Consortium for Performance Improvement; USPTSF, US Preventive Services Task Force; VHA, Veterans Health Administration.

NQMC and, based on the results of this review, the indicators do not seem to satisfy their inclusion criteria. In particular, one NQMC criterion for process measures requires that a current review of the evidence supports that the measured clinical process has led to improved health outcomes. Other potential US sources of quality indicators and guidelines for clinical laboratories (eg, regulatory, standard-setting, and accrediting organizations) were not included in the AHRQ NQMC and NGC clearinghouses.

Summarized information for each of the 14 reviewed laboratory medicine quality indicators is provided in the following format: definition, rationale (brief statement describing supporting health-related reasons), quality gap (AHRQ health importance and potential for improving health), and evidence base (AHRQ scientific soundness—clinical logic criteria associated with quality of care outcomes and interventions).

Test Ordering

Test Order Appropriateness

Definition.—Two types of quality indicators were identified. The first measures test order appropriateness, and the second measures inappropriateness: (1) Percentage of laboratory test orders that meet specific testing guidelines. A list of quality measures has been compiled by the AHRQ in its NQMC database; many involve laboratory tests recommended for specific diseases and conditions (see Table 2 for a selected list). Unlike this measure, which is based on laboratory test orders, the denominators for most of the measures in Table 2 are population-based, and they target not only improving health care quality but also public health. (2) Percentage of laboratory test orders duplicated within defined intervals.

There is no standard definition for what constitutes an inappropriate, incorrect, or duplicative test order.

Rationale.—(1) Assess appropriateness of laboratory tests ordered for screening, management, diagnosis, and monitoring of various diseases or clinical conditions consistent with guidelines. (2) Reduce wasteful and unnecessary testing.

Quality Gap.—Many laboratory test orders are not supported by guidelines or are unnecessary duplicate tests. These test orders add unnecessary costs and potentially contribute to delayed, inappropriate, and potentially harmful clinical decisions. On the other hand, evidence-based laboratory testing may be underutilized. Evaluating underutilization requires population-based measures. For many guidelines specifying appropriate use of laboratory tests, including those in the AHRQ NGC, there are no quality indicators, and there is a notable lack of guidelines and indicators related to anatomic pathology.

Evidence Base.—Principal sources of guidelines relating to utilization of laboratory tests are various health care, medical, and condition-specific organizations, many of which are listed in the AHRQ NQMC and NGC databases and identified in Table 2. Although a few studies have shown a significant decrease in hospital length of stay (LOS) associated with
greater test order appropriateness, \textsuperscript{24,25} most studies did not indicate an effect on outcomes. \textsuperscript{18,19,26-29} Underuse of recommended laboratory tests has been shown to have a negative impact in relation to specific conditions.\textsuperscript{30-33} Promotion of guidelines,\textsuperscript{18,34,35} and provision of education,\textsuperscript{18,36,37} periodic feedback,\textsuperscript{18,35,37-40} reminders,\textsuperscript{21,41} and electronic decision-support systems\textsuperscript{42,43} to clinicians and changes in laboratory requisition forms\textsuperscript{34} and in funding policy\textsuperscript{34} may decrease the number of inappropriately ordered laboratory tests, resulting in cost savings. Linking clinicians to electronic medical records may decrease errors of omission and improve adherence to practice guidelines.\textsuperscript{44}

**Patient Identification and Specimen Collection**

**Inpatient Wristband Identification Error**

**Definition.**—This indicator is the percentage of inpatients with absent or wrong wristbands, multiple wristbands having conflicting data, or wristbands containing erroneous, missing, or illegible data.\textsuperscript{45-48}

**Rationale.**—Inpatient wristband errors may lead to misidentification of a patient, which could result in inappropriate treatment.\textsuperscript{49} Inpatient wristband errors could be associated with incorrectly performed laboratory tests or mislabeled patient specimens, including blood specimens that could lead to a hemolytic transfusion reaction from an incompatible blood type.\textsuperscript{46}

**Quality Gap.**—Several studies have documented prevalence of wristband errors or, specifically, absent wristbands to be as high as 2.1% to 5.7%.\textsuperscript{45-48} However, a recent longitudinal study of wristband errors suggests the rate is close to 1%, with only 0.1% of these errors representing wristband mix-ups involving 2 patients.\textsuperscript{50} There are multiple published studies identifying some type of patient or specimen identification error as a major contributor to acute hemolytic reactions from infusion of ABO-incompatible blood, indicating that 40% to 50% of transfusion-related deaths result from identification errors\textsuperscript{49,51-54}; however, there is no information specific to wristbands. There are no consistent and reliable data on the frequency with which wristband and patient and specimen identification errors occur, let alone their consequences.

**Evidence Base.**—No published studies were found documenting a relationship between wristband errors and any process or intermediate outcomes of interest, nor were there published controlled studies with results demonstrating the effectiveness of interventions or practices at reducing inpatient wristband identification errors.\textsuperscript{52} Except for transfusion medicine, no direct evidence was found relating patient misidentification to any adverse impact on clinical, health, or cost outcomes. There is evidence for effectiveness of wristband monitoring to decrease patient misidentification during phlebotomy.\textsuperscript{46}

**Patient Satisfaction With Phlebotomy**

**Definition.**—This indicator is the percentage of patients satisfied with phlebotomy services. There is no standard definition of patient satisfaction with phlebotomy that has been assessed using questionnaires in several hospital-based outpatient\textsuperscript{55,56} and inpatient\textsuperscript{57} studies.

**Rationale.**—Specimen collection is one of the few areas of laboratory medicine that involves direct patient contact. As a result, phlebotomy services provide one opportunity to measure patients’ perceptions of their experience with laboratory services.

**Quality Gap.**—When asked if they were satisfied with their phlebotomy experience in a survey 2 days after the procedure, 15% of outpatients stated that they were not.\textsuperscript{58} However, an earlier similar study found patients far less frequently dissatisfied with the overall phlebotomy services.\textsuperscript{56} The limitations of these data are that they are dated, as no study published after 1996 was identified assessing patients’ satisfaction with phlebotomy, and no standard measurement tool has been proposed that would assess patients’ satisfaction with the specific aspects of the phlebotomy service.

**Evidence Base.**—Patient satisfaction with phlebotomy services has not been related to any other outcomes. No study could be found that demonstrated effectiveness of any intervention to improve patient satisfaction with phlebotomy services.

**Specimen Identification, Preparation, and Transport**

**Specimen Inadequacy and Rejection**

**Definition.**—This indicator is the percentage of specimens rejected.\textsuperscript{55,59-61} There is no standard definition or specific measure to assess the adequacy of specimens.

**Rationale.**—Specimen adequacy can affect the accuracy and usefulness of laboratory test results. Monitoring specimen acceptability may facilitate identification of quality improvement (QI) opportunities that could reduce rejection rates and improve patient care.

**Quality Gap.**—Programs to track laboratory quality have reported aggregated specimen rejection rates ranging from 0.3% to 0.8%.\textsuperscript{55,59-61} However, in a single-institution study, the proportion of specimens rejected was up to 2.2% in the emergency department (ED).\textsuperscript{59}

**Evidence Base.**—Although some form of this indicator has been used in several hundred hospital laboratories to estimate specimen adequacy,\textsuperscript{55,59-61} no systematic study has related it to any other outcomes. The type of specimen collection personnel impacted specimen rejection rates; nonlaboratory personnel were 2 to 4 times more likely to be associated with rejected specimens compared with laboratory personnel.\textsuperscript{47,48} Use of a QI monitor for specimen rejection did not result in better performance.\textsuperscript{50,61}
Blood Culture Contamination

Definition.—This indicator is defined as the percentage of positive blood cultures identified as contaminated.62 The term contaminated has not been uniformly defined.

Rationale.—Laboratory evaluation and clinical intervention associated with blood culture contamination consume substantial health care resources.63-70 Clinicians rely on blood culture results to diagnose and monitor febrile patients. When acting on a potentially contaminated blood culture, clinicians must choose to ignore a result that could be potentially life-threatening or take a conservative approach of fighting an infection that might not exist.

Quality Gap.—False-positive blood cultures lead not only to unnecessary repeated tests, but also to unnecessary drug use with potential harm to patients and significant downstream patient care costs. In 2 separate multi-institutional studies of inpatient blood cultures, one involving more than 600 hospitals and the other more than 300 hospitals, the median estimated blood culture contamination rates were 2.5% and 2.9%, respectively.52,68

Evidence Base.—False-positive culture results are costly because they are associated with increased hospital LOS, diagnostic testing, and antibiotic prescriptions.69,70 Patients with contaminated blood cultures compared with patients with negative blood cultures have had statistically significantly higher total hospital LOS (13.9 vs 5.5 days), postculture LOS (8.9 vs 4.6 days), postculture number of days of antibiotic therapy (5.9 vs 2.9 days), vancomycin use and postculture cost of antibiotics ($760 vs $120 in 1993 dollars), and postculture hospital cost per patient ($10,500 vs $4,200 in 1993 dollars).70 No evidence was found directly linking a reduction in the percentage of contaminated blood cultures to other clinical or health outcomes. Long-term monitoring and use of dedicated phlebotomy teams are interventions associated with sustained reductions in blood culture contamination rates.62,64,65,67-70

Specimen Container Information Error

Definition.—This indicator is the percentage of all specimens sent to the laboratory with inaccurate or inadequate information on the specimen container (eg, no label or illegible or missing patient information, clinical information, or tissue source for surgical specimens).71 There is no standard definition for what constitutes inaccurate or inadequate information.

Rationale.—Specimens with inaccurate or inadequate information may adversely impact test result reporting, delay patient diagnosis and treatment, negatively impact patient satisfaction with the health care system, and negatively impact the associated clinical, health, and economic outcomes.72

Quality Gap.—Studies have not been done that consistently measure the rate of inaccurate or inadequate specimen (labeling) information; however, rates have been reported between 0.01% and 0.03% for chemistry and hematology specimens50,55,60,61 and between 0.4% and 2% for surgical pathology specimens.71,73

Evidence Base.—Inaccurate or inadequate specimen information may impact clinical processes and/or outcomes50,61, however, no direct evidence was found relating this indicator to any outcome. Aside from whether personnel were from the laboratory or elsewhere,60,61 no interventions were identified that improved performance using this indicator.

Analysis

Proficiency Testing Performance

Definition.—This indicator is the percentage of correct proficiency testing (PT) results. Criteria for passing vary by analyte (eg, target value ± a fixed concentration limit, ± a fixed percentage, or ± 3 SD for results of a given laboratory group).74

Rationale.—There is some evidence that PT performance relates to performance using actual patient specimens75-78, however, there is no direct evidence to support it. The Clinical Laboratory Improvement Amendments of 1988 (CLIA) regulations have minimum PT requirements that must be met for US laboratories to be certified.74

Quality Gap.—Based on data collected from up to 7,000 physician office, clinic, and small hospital laboratories, PT failure (defined as unacceptable PT result for an individual sample as determined by CLIA criteria74) rates in 2004 for 8 chemistry and hematology analytes were 1.1% to 5.5% and were 2.8% to 7.3% for 3 positive culture tests and 0.6% to 1.9% for 3 negative culture tests.79 An analysis of the PT data from the Centers for Medicare & Medicaid Services for laboratories inspected by the CAP, the Joint Commission, the states, and the Commission on Laboratory Accreditation (COLA) during the 1999-2003 period showed PT failure (defined as unsatisfactory PT performance [4 of 5 PT samples with an acceptable result in a testing event as determined by CLIA criteria74] on 2 consecutive or 2 of 3 testing events) rates ranging from 4% to 6% (for CAP-inspected laboratories) to 11% to 13% (for COLA-inspected laboratories).80

Evidence Base.—Although PT performance has been positively correlated with performance in blind PT75,76 and with routine patient testing,77,78 there is no direct evidence that improved PT performance positively impacts actual test performance or any other outcome. There is evidence that PT failure rates decrease with increased experience performing PT. PT failure (defined as an unacceptable PT result for an individual sample as determined by CLIA criteria74) rates for chemistry and hematology decreased from 1994 to 2004 for 8 analytes most often tested in physician office and clinical laboratories79: 18.7% to 3.2% for cholesterol, 6.3% to 1.1% for potassium, and 5.7% to 2.4% for creatinine. In addition,
microbiology failure rates decreased for positive and negative cultures between 1994 and 2004. Similar downward trends for PT failure (defined as unsatisfactory PT performance [<4 of 5 PT samples with an acceptable result in a testing event as determined by CLIA criteria\(^4\)) on 2 consecutive or 2 of 3 testing events) rates were also observed using the 1999-2003 Centers for Medicare & Medicaid Services data for COLA-inspected laboratories (failure rate decreasing from 13% to 11%) and for state-inspected laboratories (from 9% to 8%).\(^8\)

There is no published evidence for the effectiveness of any intervention to improve PT performance. In one study of PT, despite consistent feedback on PT errors, there was no significant change in participants’ subsequent performance over time.\(^8\)

**Gynecologic Cytology-Biopsy Discrepancy**

**Definition.**—This indicator is the percentage of patients with discordant cervical cytology and cervical biopsy results\(^8\) for whom a Papanicolaou (Pap) smear was submitted within the previous 3 months.\(^3\) There are no standardized criteria or practices for measuring this discrepancy rate.\(^4\)

**Rationale.**—Cytologic-histologic correlation may be a useful tool to monitor performance and to identify specimen types prone to error.\(^4\)\(^,\)\(^8\) An annual evaluation of the number of gynecologic cases in which cytologic and histologic results are discrepant is required by CLIA regulations.\(^4\) Although sampling variables account for the majority of false-negative results,\(^4\)\(^,\)\(^8\)\(^,\)\(^5\)\(^,\)\(^6\) interpretation variability is substantial for all types of cervical specimens.\(^7\)

**Quality Gap.**—There seems to be great variability in practices and standards for identifying a discrepant pair of cytologic-biopsy results, and many laboratories have found that most cervical cytology-biopsy noncorrelation is the result of sampling problems.\(^3\)\(^,\)\(^4\) Institutional gynecologic cytologic-histologic discrepancy rates of 1.8% to 9.4% of all result pairs have been documented\(^8\); and one estimate of Pap smear discrepancies is that they occur in 0.9% of all cytologic specimens.\(^5\) One study of cervical cytologic-biopsy specimens revealed a predictive value for a positive cytologic result of 89%.\(^8\)

**Evidence Base.**—The percentage of cytologic-histologic gynecologic discrepancies that was deemed to result in severe harm (eg, loss of life or limb or long-lasting morbidity secondary to an unnecessary diagnostic test) ranged from 0% to 6% by site in a study done in 4 hospitals.\(^4\) Based on aggregate data from these hospitals, the frequency of physician-perceived severity for discrepancies was 46% for no harm to the patient, 8% for any harm avoided by addressing such discrepancies (ie, near misses), and 45% for any patient harm.\(^8\) No improvement trend was identified for hospital laboratories participating in a program monitoring cervical cytology-biopsy discrepancy rates.\(^3\) No evidence was found demonstrating that any intervention to reduce gynecologic cytology-histology discrepancy rates is effective or that this indicator is associated with any actual outcomes.

**Result Reporting**

**Inpatient Laboratory Result Availability**

**Definition.**—This indicator is the percentage of test results available for morning rounds as stipulated in the institution policy.\(^8\) There are no standard definitions for what constitutes compliance because this indicator is institution-specific.\(^8\)\(^,\)\(^9\)

**Rationale.**—If laboratory results are not available for clinicians’ morning rounds, there may be a delay in the treatment and diagnosis of a patient that may unnecessarily prolong the LOS. The objective of this measure is to assess the compliance rate for meeting morning test reporting deadlines, which may identify opportunities for improvement.

**Quality Gap.**—A survey of more than 300 hospitals found 10% of CBC and electrolyte tests were not reported on or before the reporting deadlines that the participating laboratories set for themselves.\(^8\) When more than 2,000 physicians from these hospitals were asked how often delayed morning laboratory test results contributed to delays in inpatient treatments or increased hospital LOS, only 1 in 4 indicated that delayed result reporting might contribute. There was no association between physician satisfaction and morning reporting compliance rates.\(^8\)

**Evidence Base.**—No published evidence was found relating this indicator to any outcomes or for interventions that are effective at improving performance.

**Corrected Laboratory Reports**

**Definition.**—This indicator is the percentage of specific laboratory reports corrected.\(^9\)\(^,\)\(^1\)\(^2\) There is no standard definition for the basis of correction of such laboratory reports.

**Rationale.**—This indicator may be used to determine causes of the corrections so that preventive actions can reduce the release of incorrect reports.

**Quality Gap.**—Aggregate mean and median rates of corrected reports were less than 2 per 1,000 cases based on a survey of more than 1.5 million surgical pathology specimens.\(^9\)

**Evidence Base.**—In one study of microbiology laboratory reports, clinician interviews revealed that 7% of 480 corrected reports were associated with an adverse clinical impact; of these 32 cases, 59% involved delayed therapy, 25% involved unnecessary therapy, and 25% were associated with inappropriate therapy.\(^9\) Most of these errors were considered amenable to laboratory-based interventions. No published evidence was found relating this indicator to any actual outcome or for interventions that are effective at improving performance.
Critical Values Reporting

Definition.—Critical values reporting is the percentage of all critical laboratory test results reported to a health care provider.93 Critical values are defined as those for which reporting delays can result in serious adverse outcomes for patients.94 There is no standard list of laboratory tests included in this indicator, nor are there standard critical value limits for specific laboratory tests.93,95-97 In part, this is because of variation in test methods, patient population, and individual patient characteristics. There is no widely accepted, standard method of reporting or the appropriate people who should receive these laboratory test results.97

Rationale.—Critical values reporting is considered an important laboratory process because it can impact clinical decision making, patient safety, and operational efficiency.94 Critical laboratory test results, by definition, represent potentially life-threatening situations98,99 and require rapid and timely evaluation by clinicians. Reporting of critical values is required by CLIA regulations,74 and the Joint Commission 2009 National Patient Safety Goals for hospitals include multiple requirements related to critical values reporting under the goal of improving the effectiveness of communication among caregivers.4

Quality Gap.—Reported occurrences of critical values ranged from 1 in 2,000 to 1 in 100 tests.96,100 In a survey of about 200 hospital laboratories self-reporting their unreported critical values, there was wide variation among hospitals, with the rate of unreported critical values of 6.6% or more for the 25% worst-performing institutions in 2001.93 The 25% best-performing hospitals had unreported critical value rates of up to 0.9%, and half of the institutions had unreported critical value rates of 2.3% or more.93

Evidence Base.—No studies were found relating critical values reporting to any outcomes; however, critical values have been found to influence patient care. In a survey of nursing supervisors and physicians, the majority of medical staff interviews (63%) and reviews of medical records (65%) indicated that critical values resulted in a change in therapy, and 95% of surveyed physicians indicated that critical laboratory results were valuable for patient care.96 No published studies were identified on any interventions that were effective in improving the rate of critical values reporting.

Turnaround Time

Definition.—This indicator refers to the percentage of specific laboratory tests that do not meet a reporting deadline.101 There are no widely accepted turnaround time (TAT) goals for specific laboratory tests. Laboratories most commonly (41%) defined TAT as time of specimen receipt in the laboratory to time of results reporting.102 However, order-to-reporting TAT is the most common clinician definition for TAT.102-111

Rationale.—Timely reporting of laboratory tests may improve patient care efficiency, effectiveness, and satisfaction.111 In particular, the speed of diagnosis of acute myocardial infarction using cardiac troponin tests in the ED may determine the type of therapy and patient outcomes.112

Quality Gap.—Of about 500 hospital laboratories returning data on more than 2.2 million stat (results expected to be reported within 1 hour from the time ordered per CAP definitions used in past Q-Probes studies [1991-2008], http://www.cap.org/apps/docs/q_probes/q-probes_definitions.pdf. Updated December 8, 2008. Accessed January 24, 2009) tests, TATs in excess of 70 minutes were observed for 11% of such tests.110 In another study using a different definition of unacceptable TAT, of approximately 300 hospitals monitoring the TAT for 225,000 stat ED potassium levels, 15% fell short of the expectations of the ordering clinicians.113

Evidence Base.—Many stat tests are not used for urgent clinical decisions; therefore, faster results may not impact outcomes.106 Some studies have shown shorter TATs can shorten LOS in certain ED situations.108,114-118 but the impact on other outcomes is unclear. Except for implementation of point-of-care testing,115,119-121 no published studies were identified on any intervention that was consistently effective in improving laboratory TAT.

Clinician Satisfaction With Laboratory Services

Definition.—This indicator is the percentage of clinicians satisfied with various aspects of laboratory services such as TAT, accessibility, and communication.115,122-127 There are no standardized measures.

Rationale.—Customer satisfaction is generally considered a quality measure, with clinicians being the immediate customer for most laboratory services.

Quality Gap.—The lowest satisfaction scores have been related to poor communication, including timely reporting, communication of relevant information, and notification of significant abnormal results.127 The following dissatisfaction rates have been reported for clinicians: 5% for overall surgical consultation process,123 10% to 47% for various aspects of reference laboratory telephone services,124 9% to 47% for various aspects of anatomic pathology services,127 22% for a hospital transfusion service,125 and 10% to 21% for chemical pathology services (communication with laboratory, TAT, and reporting format).122

Evidence Base.—Specific aspects of clinician dissatisfaction may be related to diagnostic or treatment errors or delays and inappropriate utilization of laboratory services and their associated costs; however, no evidence was found related to any outcomes. Except for indirect evidence that implementation of point-of-care testing reduces TAT,115,119-121 there is no direct evidence for any interventions that would improve clinician satisfaction with laboratory services.
Follow-up of Abnormal Cervical Cytologic Results

**Definition.**—This indicator is the percentage of abnormal cervical cytologic (Pap smear) results that were not followed up within 6 months. 128 Follow-up procedures, however, have not been uniformly defined.

**Rationale.**—For Pap smear screening to be effective in preventing cervical cancer, appropriate and timely clinical follow-up for patients with abnormal findings is needed. 128

**Quality Gap.**—A survey of more than 300 hospital laboratories reported follow-up information for approximately 16,000 patients with cervical cytologic diagnoses of carcinoma, high-grade squamous intraepithelial lesion (SIL), low-grade SIL, or glandular intraepithelial lesion. 128 Within 6 months, the following percentages of patients with the following diagnoses had not received any follow-up procedures: 18% with carcinoma, 18% with high-grade SIL, 28% with low-grade SIL, and 26% with glandular intraepithelial lesions. More than 12% of patients with cytologic findings of high-grade SIL or carcinoma had no documentation of follow-up within 1 year. 129 Similarly, an earlier study found 12% of abnormal cervical cytologic results lacked follow-up. 129 Of 60 adolescent patients referred to a colposcopy clinic, 38% did not keep their colposcopy appointment despite outreach, and 13% to 17% of patients had no documented procedural follow-up 1 year later. 130

**Evidence Base.**—There is no published, direct evidence that follow-up of women with abnormal cervical cytologic results is related to any clinical, health, or cost outcomes. However, considering the strong evidence supporting Pap smear screening, 30 follow-up of abnormal cytologic results can be linked by inference to health outcomes. Involvement of the family physician, 129 outreach interventions, 131,132 enhancement of teamwork and functional coordination, 133 direct-mail communications with and without phone intervention, 134 intensive follow-up protocol, 135 and provision of risk communication packages 136 and economic vouchers 135 have been shown to increase the rate of cervical cytology follow-up.

**Discussion**

This review summarizes published information on certain laboratory testing–related quality indicators and is, therefore, subject to publication bias. A more detailed evaluation of the indicators reviewed was not completed owing to the paucity of published information; considerable variation and inconsistency in key terms, definitions, implementation, and measurement and reporting practices; and a lack of basic supporting evidence. These problems resulted in a general lack of evidence supporting the importance, scientific soundness, and usefulness of most of these indicators, particularly those typically used for internal QI because laboratories do not generally publish their internal monitoring data.

For the laboratory indicators reviewed, standardized terminology, measurement specifications, data collection methods and evidence establishing quality gaps, and relationships to process, clinical, health, and economic outcomes are needed. The relevance of the identified quality indicators to various health system stakeholders and their use to positively impact the health care system were typically not addressed in the information that was available, indicating their selection was not made on the basis of evidence-based evaluation but instead relied on opinion within the laboratory community. Although most of the quality indicators identified may be useful for internal QI, for the many reasons identified, they are not meaningful for external comparisons or public reporting.

One of the limitations of the reviewed indicators is that they do not apply as well to commercial laboratories despite the considerable proportion of testing conducted by these entities. A reason that these quality indicators do not apply as well in such settings is that there has been a lack of effort by commercial laboratories and the broader field of laboratory medicine to develop such indicators and to make them publicly accessible despite their disproportionately large share of laboratory testing volume.

Many of these indicators are based primarily on self-reported surveys rather than on scientific study designs and/or adequately specified, standardized, and consistently implemented data collection methods. The general lack of evidence supporting many laboratory medicine indicators results in part from the difficulty inherent in such studies because it is not easy to attribute effects on outcomes to specific laboratory processes considering many other confounding variables.

There seems to be a dearth of data even from any retrospective, observational studies scientifically validating many of these indicators. Laboratory testing and related process improvements certainly have the potential to improve outcomes of interest and consequences that are also relevant to the IOM domains; however, this has not been demonstrated for the quality indicators identified in this review with the exception of blood culture contamination and population-based testing measures consistent with guidelines that have originated in the broader health care community (Table 2).

This review highlights the fact that the reviewed laboratory medicine quality indicators do not adequately address the stages of the total laboratory testing process or the IOM domains of health care, most notably equity and patient-centeredness. The most germane elements of patient-centeredness (eg, participatory and shared decision making 137) are not usually evaluated in the area of laboratory testing.

These include involving patients in the decision to order a test consistent with their values and preferences and understanding
of laboratory results and possible future clinical or preventive actions. 138

Other areas that have not been adequately monitored are metrics related to laboratory-driven clinical and preventive actions in which effective use of health information technology and medical decision-support systems have been shown to improve the provision of service.139,140 Notwithstanding the lack of published evidence-based indicators for laboratory performance, a great deal of collective and individual expert review and effort went into developing laboratory indicators by organizations such as the CAP and the Joint Commission based on consensus around accreditation standards, best practices, and measures of performance. Until the advent of new evidence-based laboratory medicine guidelines and quality indicators, however, it seems prudent to continue relying on accepted industry and clinical time-tested standards to guide laboratory practice in lieu of other available and reasonable alternatives.

Because there are so many processes involved in laboratory testing, there is considerable challenge in identifying, defining, and, ultimately, implementing indicators that cover the various stages of the total laboratory testing process, in general and specific to different diseases and conditions, that address the IOM domains, various testing environments, and multiple relevant stakeholders. We did not present any review of quality indicators for some steps in the laboratory testing process such as specimen receipt, log in, and processing, even though they are frequent sources of errors, because metrics for assessing these steps have not been well defined and standardized, and published laboratory literature has not evaluated these steps in multi-institutional settings. Progress requires developing common priorities, standards, and definitions to facilitate meaningful measurement development initiatives and data collection for external comparisons. This requires substantial effort because these basic, necessary requirements have not yet been met for laboratory testing–related indicators. Ultimately, future efforts should be directed to developing a set of laboratory medicine quality indicators that have significant health importance and are scientifically sound, implementable with standardized and available data elements, and useful to multiple stakeholders.23 This set of indicators should make it possible to develop meaningful public reporting on the status of laboratory-based health care with the ultimate goal of improving the provision and utilization of laboratory services consistent with contributing to improved health care quality and population health.

References


From the Laboratory Practice Evaluation and Genomics Branch, Division of Laboratory Systems, National Center for Preparedness, Detection and Control of Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA.

Address reprint requests to Dr Shahangan: CDC, 1600 Clifton Rd, NE, Mailstop G-23, Atlanta, GA 30329; sshahangan@cdc.gov.


Overview on patient safety in healthcare and laboratory diagnostics

Giuseppe Lippi1*, Ana-Maria Simundic2, Camilla Mattiuzzi3

1Laboratory of Clinical Chemistry and Hematology, Department of Pathology and Laboratory Medicine, University Hospital, Parma, Italy
2University Department of Chemistry, Sestre Milosrdnic University Hospital, Zagreb, Croatia
3Medical Direction, University Hospital, Verona, Italy

*Corresponding author: glippi@ao.pr.it, ulippi@tin.it

Abstract

The healthcare context is characterized by a high degree of complexity. Despite eager efforts of the healthcare personnel, sometimes things go wrong and produce unintentional harm to the patients. As such, patient safety must be considered as one of leading healthcare challenges. Some foremost studies have highlighted that serious medical errors might occur rather frequently, jeopardizing patient’s health and costing a huge amount of money to the healthcare system. A medical error is traditionally defined as an unintended act, the failure of a planned action to be completed as intended, the use of a wrong plan to achieve an aim when the failure can not be attributed to chance. Medical errors can be classified according to several models, such as the clinical pathway (i.e., diagnostic, treatment, prevention and others), or the resulting harm to the patient (i.e., near misses, no harm or harmful incident). Medical errors can also be classified in skill-based slips and lapses (i.e., errors of action), or rule and knowledge-based mistakes (i.e., errors of intention). According to the source, most errors result from the combination of active failures and latent conditions. It is noteworthy, however, that diagnostic errors have been frequently underestimated in the clinical practice. A laboratory error is any defect occurring at any part of the laboratory cycle, from ordering tests to reporting, interpreting, and reacting to results. Although they have been traditionally identified with analytical problems and uncertainty of measurements, an extensive scientific literature now attests that the vast majority of these arise from the extra-analytical activities of the total testing process. Data from representative studies also show that preanalytical errors are the first cause of variability in laboratory testing. The aim of this article is to provide an overview on the current knowledge about patient safety in healthcare and laboratory diagnostics.

Key words: errors; quality; patient safety; outcome; prevention

Introduction

The healthcare context is characterized by a high degree of complexity, involving a broad number and variety of medical disciplines networked for prevention, diagnosis, therapy and follow-up of human pathologies. Despite the eager efforts of the healthcare personnel, sometimes things might (and actually do) go wrong, thus producing unintentional harm (eventually serious) to the patients. As such, patient safety must be considered one of leading healthcare challenges.

Some foremost studies in the field of patients safety, reviewed in the eminent Editorial “Reducing errors in medicine” published by Donald M. Berwick and Lucian L. Leape in the British Medical Journal in 1999 (1), highlighted that serious or potentially serious medical errors can occur in the care of 6.7 out of every 100 patients, in 3.7% of hospital admissions, over half of which would have been preventable and 13.6% of which might lead to death. It was also estimated that medical errors cost the U.S. $17–29 billion a year. Remarkably, approximately 2.2 million US hospital patients experience adverse drug reactions (ADRs) to prescribed medications each year (2). These concerning esteems are strongly supported by various data collected over the past 20 years. In 1995, the U.S. federal Centers
for Disease Control and Prevention (CDC) assessed the number of unnecessary antibiotics prescribed annually for viral infections to be 20 million. Moreover, approximately 7.5 million unnecessary medical and surgical procedures were performed annually in the US, while approximately 8.9 million Americans were hospitalized unnecessarily (3). According to various sources, the overall estimated annual mortality and economic cost of improper medical intervention is predictably much higher, approaching 783,936 and $282 billion respectively (106,000 deaths and $12 billion for ADRs, 98,000 and $2 billion for generic medical errors, 115,000 deaths and $55 billion for bedsores, 88,000 deaths and $5 billion for hospital-acquired infections, 37,136 deaths and $122 billion for unnecessary procedures, 32,000 deaths and $9 billion for surgery-related complications) (3). It is therefore noticeable that the American healthcare system might be itself the leading cause of death and injury, and the estimated 10-year total of 7.8 million iatrogenic deaths are predictably higher than all the casualties from all the wars fought by the US throughout its entire history.

The notorious document “To Err is Human”, published by the US Institute of Medicine (IOM) in 1999, reported that as many as 98,000 people die each year needlessly due to preventable medical harm, the equivalent of a national disaster every week of every year (4), three jumbo-jet crashes every 2 days, and largely overcoming the death rate due from motor vehicle accidents, breast cancer, or AIDS, which are the three causes that receive far more public attention (5). Shortly afterward, these data began to marshal considerable public and professional sentiment. President Clinton suddenly embraced them and promoted an effort to address the problem with the Quality Interagency Coordination Task Force. The IOM also recognized the urgent need to establish firm actions to intervene, in the attempt to reduce this sorrowful number of preventable harms, whereas the U.S. Congress allocated $50 million to the Agency for Healthcare Research and Quality (AHRQ) of the U.S. Department of Health & Human Services for patient safety research grants in the budget of the year 2001. Despite this initial flurry of activity, progress slowed once the media moved on to the next crisis and, as such, a further document was released by the IOM in late 2001, entitled “Crossing the Quality Chasm: A New Health Care System for the 21st Century”(6). This report renewed the urgent call for fundamental change to close the quality gap in healthcare, also recommending a sweeping redesign of the U.S. healthcare system and providing overarching principles for specific direction for policymakers, healthcare leaders, clinicians, regulators, purchasers, and others. In this volume, the steering committee presented a set of performance expectations for the 21st century health care system, a set of 10 new rules to guide patient-clinician relationships, a suggested organizing framework to better align the incentives inherent in payment and accountability with improvements in quality, as well as the key steps to promote evidence-based practice and strengthen clinical information systems. In May 2004, the World Health Organization (WHO) also recognized the magnitude of the problem and supported the creation of an international alliance named “World Alliance for Patient Safety”, to facilitate the development of patient safety policy and practice in all Member States, to act as a major force for international improvement. The WHO’s World Alliance for Patient Safety work was supported by a growing number of partnerships with safety agencies, technical experts, patient groups and many other stakeholders from around the world who should help to drive the patient safety agenda forward. One of the leading issues was the development of an International Classification for Patient Safety (ICPS), which is intended to harmonize the description of patient safety incidents into a common (standardized) language, allow systematic collection of information about patient safety incidents (both adverse events and near misses) from a variety of sources and allow statistical analysis, learning and resource prioritization aimed to harmonize the description of patient safety incidents (7).

Despite the notable focus placed on the issue of patient safety the Consumers Union has recently released a report, which was symbolically entitled “To Err is Human – To Delay is Deadly”. The heading is somehow frustrating, asserting that “Ten years
This expert, independent, nonprofit U.S. organization whose mission is to work for a fair, just, and safe marketplace for all consumers and to empower consumers to protect themselves, highlighted that it is still unclear whether any real progress has been made in this field, and efforts to reduce the harm caused by the medical care system were few and fragmented. With little transparency and no public reporting (except where hard fought state laws required public reporting of hospital infections), scarce data are not in support of any real progress. It was in fact reported that preventable medical harm still accounts for more than 100,000 deaths each year—a million lives over the past decade—and medication errors in hospitals alone still cost $3.5 billion a year. Moreover, based on paper chart reviews and billing records, it is also estimated that patient safety declined by 1 percent in each of the six years following the IOM report so that, according to these concerning data, the U.S. healthcare context is supposed to be less safe than in 1999. Some key issues were brought to attest the failure of the safety policy of the healthcare system, including evidence that:

1. few hospitals have adopted well-known systems to prevent medication errors and the U.S. Food & Drug Administration (FDA) rarely intervenes;

2. a national system of accountability through transparency as recommended by the IOM has not been created;

3. no national entity has been empowered to coordinate and track patient safety improvements; and

4. doctors and other health professionals are not expected to demonstrate competency.

It was thereby concluded that this unjustified medical harm is as yet unacceptable, demanding urgent and determined actions from the healthcare system that might include further prevention of medication errors, creation of accountability through transparency (i.e., identification and learning from preventable medical harm through both mandatory and voluntary reporting systems), establishment of a national focus to track progress, increase of the standards for improvements and establishment of major competency in patient safety for doctors, nurses and healthcare organizations.

To further boost the establishment of a culture of safety in healthcare, in 2006 the former U.S. President George Bush signed the Deficit Reduction Act (DRA), requiring the Secretary to identify conditions that are:

a) high cost or high volume or both;

b) result in the assignment of a case to a Diagnosis Related Group (DRG) that has a higher payment when present as a secondary diagnosis; and

c) could reasonably have been prevented through the application of evidence-based guidelines.

For discharges occurred after October 1, 2008, hospitals have no longer received additional payment for cases which had been identified by the National Quality Forum in which one of the selected conditions was not present on admission (object inadvertently left in after surgery, air embolism, blood incompatibility, catheter associated urinary tract infection, pressure ulcer (decubitus ulcer), vascular catheter associated infection, surgical site infection—mediastinitis (infection in the chest) after coronary artery bypass graft surgery and certain types of falls and traumas). In 2009 additional conditions were included (i.e., surgical site infections following certain elective procedures, including certain orthopedic surgeries, and bariatric surgery for obesity, certain manifestations of poor control of blood sugar levels, deep vein thrombosis or pulmonary embolism following total knee replacement and hip replacement procedures). By adopting this restrictive policy, the Centers for Medicare and Medicaid Services estimate the federal government will realize savings of $60 million per year, beginning in 2012. The UK government is now starting a similar embargo inasmuch as the UK National Health Care System (NHS) operating framework for 2010-11 has set important changes, with payment increases to hospitals only available by improving quality. Beginning from April 2010, primary care trusts will not pay if treatment results in one of the seven listed “never events” (i.e., wrong site surgery, retained instrument after an operation, wrong route of administration of chemotherapy, misplaced nasogastric or orogastric tube not detected before
use, inpatient suicide by use of non-collapsible rails, in-hospital maternal death from postpartum haemorrhage after elective caesarean section, and intravenous administration of miss-selected concentrated potassium chloride) (11). The clinical conditions for which both the U.S. Medicare and the UK NHS will cease to pay are obviously preventable, as are the vast majority of laboratory errors. In the predictable scenario that national healthcare systems may generalize the principle of refusal to pay for poor-quality care beyond these initial and predictably symbolic national initiatives, laboratory professionals will be encouraged to place more focus on the best possible quality and clinical value of laboratory diagnostics (12).

**Taxonomy of patient safety**

Quality is the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge. Patient safety is commonly considered as the reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum, which encompasses the collective notions of given current knowledge, resources available and the context in which care is delivered weighed against the risk of non-treatment or other treatment. A patient safety practice is therefore a type of process or structure whose application reduces the probability of adverse events resulting from exposure to the healthcare system across a range of diseases and procedures. Healthcare-associated harm is any harm arising from or associated with plans or actions taken during the provision of healthcare, rather than an underlying disease or injury. A patient safety incident is an event or circumstance that could have resulted, or did result, in unnecessary harm to a patient, thus meaning impairment of structure or function of the body and/or any deleterious effect arising there from (i.e., disease, injury, suffering, disability and death) (13).

The definitions of medical error are still subjected to debate, as there are many types (from minor to major), and the causality is often undetermined while being usually attributed to a variety of factors such as human vulnerability, medical complexity and system failures. Although a medical error is technically portrayed as an adverse event or near miss that is preventable with the current state of medical knowledge (14), more conventionally medical errors are referred to as an incorrect clinical diagnosis, a mishandled therapeutic procedure or, globally, as the result of a flawed clinical decision making. On the other hand, a medical mistake has also been defined as a commission or an omission with potentially negative consequences for the patient that would have been judged wrong by skilled and knowledgeable peers at the time it occurred, independent of whether there were any negative consequences (15). The IOM also defined an error as the failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (4). Luciana L. Leape defines an error as an “unintended act (either omission or commission) or an act that does not achieve its intended outcome” (5), while James Reason defines it as a “failure of a planned sequence of mental or physical activities to achieve its intended outcome when these failures cannot be attributed to chance” (16). There is however a major area of agreement in all these definitions that is the obvious exclusion of the natural history of disease that does not respond to treatment as well as the foreseeable complications of a correctly performed medical procedure from the adverse outcome occurred. According to the IOM, medical errors can be classified according to four major categories according to the clinical path, that are “diagnostic”, “treatment”, “prevention” and “others” (Table 1). Incidents are traditionally classified in near miss (an incident which did not reach the patient), no harm incident (an incident which reached a patient but no discernable harm resulted) and harmful incident or adverse event (an incident which resulted in harm to a patient). The degree of patient safety incident can be further streamlined in the broad conceptual framework of patient outcome, ranging from no harm (patient is not symptomatic or no symptoms detected and no treatment is required), mild harm (patient is symptomatic, symptoms are mild, loss of function or harm is minimal or intermediate but short term, and no or
minimal intervention is required), moderate harm (patient is symptomatic, requiring intervention, an increased length of stay, or causing permanent or long term harm or loss of function), severe harm (patient is symptomatic, requiring life-saving intervention or major surgical/medical intervention, shortening life expectancy or causing major perma-

nent or long term harm or loss of function), and death (which was caused or brought forward in the short term by the safety incident) (13). Most errors results from active failures, that are unsafe acts committed by people who are in direct contact with the system and have a direct and usually short-lived effect on the integrity of the defenses, or latent conditions, that are fundamental vulnerabilities in one or more layers of the system such as system faults, system and process misfit, alarm overload, inadequate maintenance. As such, latent conditions may lie dormant within the system for many years before they combine with active failures and local triggers to create an accident opportunity. Errors can also be classified in skill-based slips and lapses (i.e., errors of action), or rule and knowledge-based mistakes (i.e., errors of intention). In the former case the operators actually knew what to do but did the wrong action/s (e.g., administering the wrong drug, processing an unsuitable specimen), whereas in the latter case they failed to chose the right rule (e.g., requesting an inappropriate diagnostic test), violated rules (e.g., administering the right drug at the wrong time, release laboratory test results while violating quality controls), or did not know what they were doing (e.g., failing to understand the distinction between references and values in a spreadsheet) (Figure 1).
Basically, slips and lapses are the easiest to identify and recover from as users can always recognize that they have made an error. Conversely, recovering from rule-based errors is more challenging since this means that the whole system has to understand the process and rules associated with some specific intention. Finally, recovering from knowledge-based errors is very difficult because the system has to know the intentions of the user.

As other medical areas, laboratory diagnostics is frequently delivered in a pressurized and fast-moving environment, involving a vast array of innovative and complex technologies, so that it can not be considered completely safe. A reliable definition of laboratory errors is that originally provided by Bonini et al. as “a diagnosis that is missed, wrong, or delayed, as detected by some subsequent definitive test or finding”, which has been further acknowledged and adopted by the ISO Technical Report 22367, as “a defect occurring at any part of the laboratory cycle, from ordering tests to reporting, interpreting, and reacting to results” (17).

**Diagnostic errors**

Although it is difficult to esteem accurately the rate of diagnostic errors in general, it has been reported that the prevalence of laboratory errors can be as high as one every 330–1000 events, 900–2074 patients, and 214–8316 laboratory test results (18). It is therefore surprising to notice that diagnostic errors have been frequently underestimated in the clinical practice over the past decades. This has been attributed to two main reasons. First, it is commonly perceived that diagnostics has pursued a virtuous path, culminating in a substantial reduction of vulnerable steps. Then, diagnostic errors in general might go frequently undetected since they not always translate into a real harm for the patient, or the eventual harm can not be truthfully related to a diagnostic error. While laboratory errors are traditionally identified with analytical problems and uncertainty of measurements, an extensive scientific literature now attests that most errors (up to 80–90%) seem to occur from the extra-analytical phase of the total testing process (19–24). Even more interestingly, patient care involving non-laboratory personnel seems to account for the majority of errors, representing 95.2% of these mistakes. Data from the most representative studies on this topic, show that preanalytical errors (e.g., insufficient samples, poor sample conditions, inappropriate sample handling and transport, incorrect identification, incorrect sample) are the first cause of variability in laboratory testing, accounting for more than half (46–68%) of all laboratory errors, whereas analytical (e.g., equipment malfunction, release of results despite poor quality controls, analytical interferences) and postanalytical errors (e.g., inappropriate reporting or analysis, improper data entry, high turn around times, failure to notify critical values) represent respectively 7–13% and 18–47% of all mistakes in the total testing process. Although it is rarely clear whether a diagnostic error might still impact negatively on patient outcome inasmuch as spurious or absurd results are usually ignored because easily recognized, under critical conditions there is indeed a high chance that near-misses might translate into serious incidents (5 to 20% of the cases) such as the use of redundant procedures (e.g., blood grouping, blood safety testing, constitutional tests in general), repeat testing, misdiagnosis and thereby wrong clinical decision making.

In spite of this apparent underestimation of diagnostic errors, laboratory medicine has been foremost in pursuing the issue of patient safety. More than 80 years ago, the American Society of Clinical Pathologists (ASCP), the herald of the current College of American Pathologist (CAP), settled a voluntary proficiency testing program focused on analytical quality (25). In the early 1990s, the CAP initiated several Q-Probes studies and Q-Tracks investigations to collect and analyze results on a variety of performance measures, including magnitude and significance of errors, strategies for error reduction, and willingness to implement each of these performance measures (26). As such, laboratory professionals, regulation bodies together with the diagnostics industry have been focusing for decades for improving the analytical quality, by establishment of Internal Quality Controls (IQC) and External Quality Assessment (EQA) schemes (19, 27–28).
Several national and international bodies and organizations, not necessarily linked to the field of laboratory medicine, still include diagnostic errors among the most preventable causes of harm for the patients. The Patient Fact Sheet issued by the AHRQ lists “Five steps to safer health care” that are:

1. ask questions if you have doubts or concerns;
2. keep and bring a list of all the medicines you take;
3. get the results of any test or procedure;
4. talk to your doctor about which hospital is best for your health needs; and
5. make sure you understand what will happen if you need surgery.

As regards the third item, which actually refers to diagnostic errors, it is clearly specified to “ask when and how you will get the results of tests or procedures. Don’t assume the results are fine if you do not get them when expected, be it in person, by phone, or by mail. Call your doctor and ask for your results. Ask what the results mean for your care” (29). The 2010 National Patient Safety Goals (NPSGs) issued by the Joint Commission still include several items targeting laboratory diagnostics, which are:

1. Goal 1 – Improve the accuracy of patient identification (Use of two patient identifiers),
2. Goal 2 – Improve the effectiveness of communication among caregivers (Timely Reporting of Critical Tests and Critical Results) (30).

In the Forward Programme 2008–2009 issued by the WHO’s World Alliance for Patient Safety, misdiagnosis is also included within the priority areas of research for developed countries (7). Alongside this aim, the National Quality Forum (NQF, supported by the Centers for Disease Control), has recently issued a document entitled “Preferred Practices for Measuring and Reporting Patient Safety and Communication in Laboratory Medicine: A Consensus Report”, where six preferred practices have been endorsed as national voluntary consensus standards to drive quality improvement within the pre- and postanalytical phases of the total testing process (laboratory leadership, patient/specimen identification, sample acceptability, test order accuracy, verbal communication, critical value/result reporting) (31). Interestingly, compliance with these recommendations is not mandatory, since they are mainly aimed at improving both patient safety and communication of laboratory information with stakeholders (Table 2).

### Incident reporting in medicine and laboratory diagnostics

The one thing we have learned well is that it almost impossible to have safety where transparency is not assured. In 1994, Lucian L. Leape affirmed that medical errors were not being reported, an asser-

<table>
<thead>
<tr>
<th>Agency of the Healthcare Research and Quality - Five steps to safer health care</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ask when and how you will get the results of tests or procedures.</td>
</tr>
<tr>
<td>• Don’t assume the results are fine if you do not get them when expected, be it in person, by phone, or by mail.</td>
</tr>
<tr>
<td>• Call your doctor and ask for your results.</td>
</tr>
<tr>
<td>• Ask what the results mean for your care</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Join Commission - 2010 National Patient Safety Goals (NPSGs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Goal 1 – Improve the accuracy of patient identification (Use of two patient identifiers)</td>
</tr>
<tr>
<td>• Goal 2 – Improve the effectiveness of communication among caregivers (Timely Reporting of Critical Tests and Critical Results).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• International Classification for Patient Safety (ICPS)</td>
</tr>
<tr>
<td>- Patient Identification</td>
</tr>
<tr>
<td>- Referral/Consultation</td>
</tr>
<tr>
<td>- Response to Emergency</td>
</tr>
<tr>
<td>• Prevent misdiagnosis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>National Quality Forum - Preferred Practices for Measuring and Reporting Patient Safety and Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Laboratory leadership</td>
</tr>
<tr>
<td>• Patient/specimen identification</td>
</tr>
<tr>
<td>• Sample acceptability</td>
</tr>
<tr>
<td>• Test order accuracy</td>
</tr>
<tr>
<td>• Verbal communication</td>
</tr>
<tr>
<td>• Critical value/result reporting</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>International Federation of Clinical Chemistry (IFCC) - Working Group on laboratory errors and patient safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Development of a Model of Quality Indicators (MQI)</td>
</tr>
</tbody>
</table>
tion that is actually supported by reliable esteems attesting that as few as 5% and no more than 20% of iatrogenic events are ever reported (5). Errors in healthcare can be identified by several mechanisms. Historically, medical errors were revealed retrospectively through morbidity and mortality committees, malpractice claims data and retrospective chart review to quantify adverse event rates. Basically, the concept of incident recovery, which is derived from industrial science and error theory, is of particular importance for learning from patient safety since it successfully allows developing reporting systems for serious accidents and important “near misses” (32). It is inherently a meaningful process by which a contributing factor and/or hazard is identified, acknowledged and addressed, thereby preventing a hazard to develop into an incident. Event reporting is also defined as the primary means through which ADRs and other risks can be identified. The leading purposes of event reporting are to improve the management of an individual patient, identify and correct systems failures, prevent recurrent events, aid in creating a database for risk management and quality improvement purposes, assist in providing a safe environment for patient care, provide a record of the event, and obtain immediate medical advice and legal counsel. As yet, the IOM has recommended two types of reports, that are mandatory reports for the small fraction of events resulting in death or serious harm to patients, and voluntary reports focusing on errors that result in minor or temporary harm or near-misses.

In the U.K., the National Patient Safety Agency encourages voluntary reporting of healthcare errors, and considers several specific instances known as “Confidential Enquiries” for which investigation is routinely initiated (i.e., maternal or infant deaths, childhood deaths to age 16, deaths in persons with mental illness, and perioperative and unexpected medical deaths) (33). Medical records and questionnaires are requested from the involved clinician, and participation has been predictably high, since individual details are confidential. In 1995, hospital-based surveillance was mandated by the U.S. Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) because of a perception that incidents resulting in harm were occurring frequently. As one component of its Sentinel Event Policy, the JCAHO created a Sentinel Event Database which accepts voluntary reports of sentinel events from member institutions, patients, families, and the press. In 2005, the U.S. Congress passed the long-debated Patient Safety and Quality Improvement Act, establishing a federal reporting database. Hospitals reports of serious patient harm are thus voluntary, collected by patient safety organizations under contract to analyze errors and recommend improvements. Reports remain however confidential, and they cannot be used in liability cases (34). An additional example of national incident reporting system is the Australian Incident Monitoring Study (AIMS), which works under the auspices of the Australian Patient Safety Foundation (35). Investigators have created an anonymous and voluntary near miss and adverse event reporting system for anesthetists based on a form that has been distributed to participants, and which contains instructions, definitions, space for narrative of the event, and structured sections to record the anesthesia and procedure, demographics about the patient and anesthetist, and what, when, why, where, and how the event occurred. Several other examples of incident reporting are running throughout Europe, though mostly heterogeneous in their path, since the local national system typology may include sentinel event reporting (which is often mandatory by law), specific clinical domain reports (which are often voluntary) and system-wide, all-inclusive reports (which can be either mandatory or voluntary). It is inherently clear however that unless a European body will be established to put forward some sort of standardization or harmonization, most national efforts will remain isolate, not allowing transferability of results and practices, as well as making benchmark analysis almost impossible.

Whilst major focus has been placed on incident reporting for several medical conditions, lesser efforts have been devoted on translating this noteworthy practice into laboratory diagnostics. The laboratory professionals are however patient fiduciaries and thereby responsible for every type of problem involving a serious harm for the patient.
Whereas major efforts have been placed to monitor the state of the art in the preanalytical phase and provide reliable solutions in some countries such as Croatia (36) and Italy (37,38), it is surprising that formal programs of incident reporting have not been so pervasive in laboratory diagnostics as in other healthcare settings. This calls for the urgent need to establish a reliable policy of errors recording, possibly through informatics aids (39), and settle universally agreed “laboratory sentinel events” throughout the total testing process, which would allow gaining important information about serious incidents and holding both providers and stakeholders accountable for patient safety. Some of these sentinel events have already been identified, including inappropriate test requests for critical pathologies and patient misidentification (preanalytical phase), use of wrong assays, severe analytical errors, critical tests performed on unsuitable samples and release of laboratory results in spite of poor quality controls (analytical phase), failure to alert critical values and wrong report destination (postanalytical phase) (40,41). The Drafting Group of WHO’s International Classification for Patient Safety (ICPS) has also developed a conceptual framework which might also be suitable for diagnostics errors, and consists of 10 high levels that include incident type, patient outcomes, patient characteristics, incident characteristics, contributing factors/hazards, organizational outcomes, detection, mitigating factors, ameliorating actions, actions taken to reduce risk. Among these, some items can be used for identifying and reporting problems in laboratory diagnostics, as listed in Table 3.

**Solutions**

In agreement with the foremost model of James Reason, the most reliable approach to enhance patient safety in laboratory diagnostics, and more generally in healthcare, encompasses a multifaceted approach based on predicting eventual accidents, reducing the number of latent conditions in the different layers of the system (plug the holes), increasing and diversifying the strength of the defenses, so that probability of accident trajectories

### Table 3. Examples of incident reporting in laboratory diagnostics: potential indicators from WHO’s International Classification for Patient Safety (ICPS).

<table>
<thead>
<tr>
<th>Process involved</th>
<th>Potential problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident related to a clinical process/procedure</td>
<td></td>
</tr>
<tr>
<td>- Screening/prevention/routine checkup</td>
<td>- Not performed when indicated</td>
</tr>
<tr>
<td>- Diagnosis/assessment</td>
<td>- Incomplete/inadequate</td>
</tr>
<tr>
<td>- Tests/investigations</td>
<td>- Unavailable</td>
</tr>
<tr>
<td>- Specimens/results</td>
<td>- Wrong patient</td>
</tr>
<tr>
<td>- Verification</td>
<td>- Wrong process</td>
</tr>
<tr>
<td>- Verifications</td>
<td>- Wrong body part/site</td>
</tr>
<tr>
<td>- Reports/results</td>
<td>- Detention/restraint</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blood/blood products</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Pre-Transfusion Testing</td>
<td>- Wrong patient</td>
</tr>
<tr>
<td>- Blood/blood products</td>
<td>- Wrong blood</td>
</tr>
<tr>
<td>- Any medical device/equipment</td>
<td>- Wrong dispensing label</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resources/organizational management</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Matching of workload management</td>
<td></td>
</tr>
<tr>
<td>- Service Availability/adequacy</td>
<td>- Lack of availability</td>
</tr>
<tr>
<td>- Staff availability/adequacy</td>
<td>- Inappropriate for task</td>
</tr>
<tr>
<td>- Organization of teams/people</td>
<td>- Failure/malfunction</td>
</tr>
<tr>
<td>- Protocols/policy/procedure/guideline</td>
<td>- Dislodgement/miscarriage</td>
</tr>
<tr>
<td>- Proven policies</td>
<td>- Removal</td>
</tr>
<tr>
<td>- User error</td>
<td></td>
</tr>
</tbody>
</table>

Biochemia Medica 2010;20(2):131–43

139
and active faults is minimized (42,43). The final results is a kind of “vicious circle”, where harm is being measured, causes understood, solutions identified, impact and translation of evidence into safer care finally evaluated to get back to the starting point of the loop (Figure 2). In this context, risk management, clinical governance and root cause analysis (RCA) all play a prominent role. The Failure Mode and Effect Analysis (FMEA) has been broadly cited as a reliable approach to risk management. It is a systematic process for identifying potential process failures earlier before they occur, with the aim to eliminate them or minimize the relative risk. This model of risk management was originally developed in the 1940s by the U.S. Army, and further developed by the aerospace and automobile industries. The US department of Veteran Affairs (VA) National Center for Patient Safety developed a simplified version of FMEA for being applied to healthcare, called Healthcare FMEA (HFMEA) (44). Considering that all human errors, including medical errors, always have a preceding cause, RCA is an additional valuable aid, since it is based on a retrospective analytical approach, which has found broad applications to investigate major industrial accidents (16). Basically, a root cause is the most basic casual factor which, when corrected or removed, might prevent recurrence of an adverse and unwelcome event (e.g., a medical error). As such, RCA focuses on identifying the latent conditions that underlie variation in medical performance and, if applicable, developing recommendations for improvements to decrease the likelihood of a similar incident in the future.

As for any other type of medical error, development and widespread implementation of a total quality management system is the most effective strategy to minimize uncertainty in laboratory diagnostics. Pragmatically, this can be achieved using three complementary actions, that are preventing adverse events (error prevention), making them visible (error detection), and mitigating their adverse consequences when they occur (error management). Owing to the volume and complexity of testing, a large number of errors still occur in laboratory diagnostics, especially in the extra-analytical phases of testing. In particular, the high frequency of errors still attributable to processes external to the laboratory requires additional efforts for the governance of this neglected phase of the total testing process (23,42-43). A primary solution is the adoption of uniform reporting schemes for error events based on reliable quality indicators covering both the analytical and extra-analytical phases of testing (45). As such, the division of Education and Management (EMD) of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) has established a Working Group named “Laboratory Errors and Patient Safety (WG-LEPS)”, with the specific mission to promote and encourage investigations into errors in laboratory medicine, gather available data on this issue, and establish strategies and paths for improving patient safety (46). The anticipated outcome is the creation of reliable Model of Quality Indicators (MQI), which would grant major improvements of laboratory performance as well as identify suitable actions to undertake when dealing with critical events throughout the total testing process. In strict analogy with the analytical phase, the next step to improve the quality of the total testing process therefore foresees development and introduction of ICQ.
and EQA programs embracing the total testing process, downstream and upstream the analytical phase. There are already some noteworthy examples on how this can be translated into practice, such as the forthcoming introduction of a national EQA scheme in Croatia for the preanalytical phase (24), or the development of a reliable program of quality control of the hemolysis index among different laboratories (47,48).

Conclusions

Patient safety is the healthcare discipline that emphasizes the reporting, analysis, and prevention of medical error that often lead to adverse healthcare events. Besides carrying serious harms to the patient health, medical errors translate into a huge amount of money wiped out of the national and international economy. Significant progress has been made since the release of “To Err is Human”. Basically, what has changed is the willingness to recognize the challenge and not argue about the numbers, but appreciate that care must be safe always and everywhere for each patient. This has led to remarkable changes in the culture of healthcare organizations, so that medical errors can no longer be seen as inevitable, but as something that can be actively streamlined and prevented. At this point in time, reliable patient-centered initiatives should be prompted or reinforced to make the healthcare arena a safety place for everybody. Attention to organizational issues of structure, strategy and education – that is establishing and disseminating a “real” culture of safety – are foremost standpoints. Over the past century laboratory medicine has been forerunner in pursuing the issue of patient safety, and several recent endeavors confirm that we are probably on the right way to succeed for delivering safe, high-quality care. Thousands of analysts and advocates worldwide are looking for ways to make the health care system work more efficiently. The solution is apparently simple: healthcare should be delivered in a more efficient and affordable manner, with better quality and clinical outcomes. Significant improvements thereby require an overhaul of the delivery system which can’t be done without sizable investments from Governments and national healthcare systems. Almost everything in laboratory diagnostics and more generally in healthcare is being developed in response to market demand, but a lot more might be done for patient safety with more financial incentives. We all know that the money devoted for quality are those best spent, and always associated with a paradoxical but tangible reduction of costs.

References

9. Larkin H. 10 years, 5 voices, 1 challenge. To Err Is Human jump-started a movement to improve patient safety. How far have we come? Where do we go from here? Hosp Health Netw 2009;83:24-8


Lippi G, Mattiuzzi C, Plebani M. Event reporting in laboratory medicine. Is there something we are missing? MLO Med Lab Obs 2009;41:23.


Osvrt na sigurnost bolesnika unutar sustava zdravstvene skrbi i laboratorijske dijagnostike

Sažetak
Sustav zdravstvene skrbi obilježava visok stupanj kompleksnosti. Usprkos velikim naporima medicinskog osoblja, ponekad stvari podu krivo te se bolesniku nanese neželjena šteta. Bolesnikova se sigurnost mora shvatiti kao jedan od vodećih izazova na području zdravstvene skrbi. Nedavna su istraživanja naglasila da se prilično često događaju ozbiljne medicinske pogreške koje ugrožavaju zdravlje bolesnika te skupo stoje sustav zdravstvene skrbi. Pogreška u medicini se tradicionalno definira kao nenamjerni čin, neuspjeh da se planirana radnja izvrši kako se namjeravalo, primjena krivog plana kako bi se postigao cilj u slučajevima kada se neuspjeh ne može pripisati slučaju. Medicinske se pogreške mogu klasificirati prema nekoliko modela, kao što su klinički put (primjerice dijagnostika, liječenje, prevencija i ostalo) ili rezultirajuća šteta nanesena bolesniku (primjerice promašaji, ne nanesena šteta ili štetni događaj). Pogreške u medicini se također mogu podijeliti na omaške i pogreške zbog nedostatka iskustva (primjerice pogreške djelovanja), ili pogreške zbog nedostatka znanja ili nepoznavanja pravila (primjerice pogreške namjere). Prema izvoru, većina pogrešaka nastaje kombinacijom aktivnih propusta i propuštenih prilikama. Međutim, vrijedno je spomena da se u kliničkoj praksi dijagnostičke pogreške često podcjenjuju. Laboratorijska pogreška je bilo koja nepravilnost koja se dogodi u bilo kojoj fazi laboratorijskog ciklusa, od narudžbe pretrage do izvještavanja, tumačenja nalaza te reagiranja na isti. Iako se tradicionalno dijagnostičke pogreške poistovjećuju s analitičkim problemima i nesigurnostima u mjerenju, opsežna znanstvena literatura upućuje da velika većina pogrešaka potiče iz izvananalitičkih postupaka cjelokupnog laboratorijskog ispitivanja. Podaci reprezentativnih istraživanja također ukazuju na činjenicu da su pogreške u prijeanalitičkoj fazi prvi uzrok varijabilnosti u laboratorijskom ispitivanju. Cilj ovog članka jest osvrnuti se na nova saznanja o područja sigurnosti bolesnika u sustavu zdravstvene skrbi i laboratorijske dijagnostike.

Ključne riječi: pogreške; kvaliteta; sigurnost bolesnika; prevencija
Accreditation in clinical laboratories

Tomáš Zima

Institute of Clinical Chemistry and Laboratory Diagnostics, First Faculty of Medicine, Charles University, Prague, Czech Republic

Corresponding author: zimatom@cesnet.cz

Abstract

At the beginning of the 21st century there are defined priorities in laboratory medicine such as laboratory automation, laboratory consolidation, molecular diagnostics, imaging analysis, POCT, economics and accreditation of laboratories aiming to improve the quality of patient care. Laboratory medicine is backbone in the medical treatment, diagnosis and prevention. Laboratory diagnostics influences 70–80% of hospital health care decisions and costs between 3–5% of total health care costs. Laboratory attempts to improve quality aim to reduce diagnostic errors and decrease turn around time with traceability of all laboratory procedures. Concerning quality, the strategic plans of IFCC and EFCC include focusing of accreditation of labs based on ISO standards and cooperation with European Accreditation and national accreditation bodies. IFCC recognises that ISO 15189:2007 – Medical laboratories – Particular requirements for quality and competence, encompasses all the assessment criteria specified in the policy statement and as such should form the basis for the accreditation of laboratories. There are also different systems in EU countries based on national quality systems which are based on ISO 15189. Accreditation is not about who the best is, but who has a system of standard procedures. Quality system is about people, with people and for people.

Key words: accreditation; ISO 15189 standard; quality system

Introduction

At the beginning of the 21st century there are defined priorities in laboratory medicine such as laboratory automation, laboratory consolidation, molecular diagnostics, imaging analysis, POCT, economics and accreditation of laboratories aiming to improve the quality of patient care. Quality in the health care is the level of excellence of the health care provided in relation to the current level of knowledge and technical development with customer orientation.

The main indicators of health care quality are the health of the population, equal opportunities in access to health care, effective provision of services, the efficiency and accessibility of the system and also the results of the health care provided. Lifestyle, genetic and environmental factors have a much higher influence on the health of the population than health care itself.

Regulation through quality in the health care sector is based on accreditation, certification, quality monitoring, patients’ rights, standard operation processes and standards of health care quality.

Laboratory medicine is backbone in the medical treatment, diagnosis and prevention. Laboratory diagnostics influence 70–80% of hospital health care decisions and costs between 3–5% of total health care costs.

Laboratory attempts to improve quality aim to reduce diagnostic errors and decrease turn around time with traceability of all laboratory procedures and to assure the safety of patients and staff alike; they concentrate on “tailor-made” or personalised medicine, striving for the highest possible quality service. Basic requirements and criteria for laboratories from client’s perspective are availability, comprehensiveness, fast response, reliability and accuracy, information and consultation as well as analysis of complaints and claims.

First systems or level of quality management systems in labs are internal and external quality control and educational activities which are the core points in all accreditations systems in labs.
The concept of laboratory accreditation is defined by ISO/IEC as formal recognition that the testing laboratory is competent to carry out specific tests or specific types of tests. Test is defined as a technical operation that consists of determination of one or more characteristics of a given product, process, or service according to a specified procedure. This is not quite appropriate for clinical laboratory. An importance set of criteria was done in EN 45 001 (European Standard), specifying general criteria for the operation of a testing laboratory. The accreditation body must be legally identifiable, impartial, and independent of external influences (1).

Next standard for accreditation was documented in ISO 17025 (General Requirements for the Competence of Testing and Calibration Laboratories) (2). This standard is widely used for testing laboratories in whole world in industry and also in medicine. The ISO 17025:2005 is the basis for the accreditation. This standard not only requires a management system and manual in the laboratory but also requires that the laboratory be found competent to perform specific tests/calibrations or types of tests/calibration.

Concerning quality, the strategic plans of IFCC and EFCC include focusing of accreditation of labs based on ISO standards and cooperation with European Accreditation and national accreditation bodies. IFCC recognises that ISO 15189:2007 – Medical laboratories – Particular requirements for quality and competence (3), encompasses all the assessment criteria specified in the policy statement and as such should form the basis for the accreditation of laboratories.

Accreditation in the world

Accreditation is done in several countries by independent National Accreditation Bodies. The situation of Europe was presented at the First European symposium on Quality Management in Laboratory Medicine, held in Paris in February 2009.

United Kingdom: CPA/UKAS partnership developed in 1996 and CPA standards were incorporating ISO 15189 requirements and the future development of accreditation consider the use of ISO 15189.

USA: The main program is CLIA (Clinical Laboratory Improvement Amendment) certification, but this program is far for the rules of accreditation based on ISO 15189.

Netherlands: The first Guidance document about quality was published in 1991 and the experts set the specific Accreditation Body for Medical Laboratories – CCKL in 1994. This body became as a division (of health) of national accreditation body in the Netherlands in 2008. The process of accreditation is voluntary, but more then 90% of clinical chemistry labs are accredited.

Germany: Quality assessment of quantitative measurements in medical laboratories has been regulated by the directive of German Federal Medical Board since 1971. In the most recent edition of RiLiBAK a new chapter has been added that prescribes quality requirements on the basis ISO 15189. Three accreditation bodies will be joint together based on EU rules that one country has only one national accreditation body. Accreditation is still performed voluntarily and around 20% of labs are accredited (4).

Sweden: Quality system management was implemented from 1989 (ISO Guide 25, EN 45001, ISO 17025 and 15189). Accreditation is on voluntary basis but it is the key part for health care insurance companies for the contract and reimbursement of expenses for health care.

Belgium: Clinical laboratories must be licensed by Ministry of Health and quality manual was adopted in the royal decree in 1999. There is close cooperation between professional society and BELAC (National Accreditation Body). A mandatory quality system based on the requirements of ISO 15189 but no formal accreditation is required. Formal accreditation becomes more and more conditional for reimbursement of laboratory tests.

France: According the decision of Ministry of Health all clinical labs must be accredited (ISO 15189) by COFRAC (National Accreditation Body) to the end of 2010.

Finland: In early 1990s, a working group in lab quality published guidelines on how to create a duality manual for clinical laboratories. Clinical labs have been mainly accredited by national Accre-
ditation Body (FINAS) under ISO 17025, but ISO 15189 is also used (5).

Italy: In fact, Italy is divided into 20 regions, each of them having a different quality requirements, even when they are within the frame of a national health service and a set so-called „minimal requirements”. The requirements are based on criteria inspired by the ISO 9001 standard and some laboratories are certified according to this standard. A small number of laboratories applied for a CPA UK accreditation. Now, the ISO 15189 is considered to be the reference standard for accreditation, but the accreditation body dedicated to clinical laboratories does not exit (6).

Korea: The Korean Laboratory Accreditation Program (KLAP) was started in 1999 and this program based on national algorithm using guidelines, checklist, inspections etc. (7).

Canada: Accreditation of medical laboratories in Canada is regulated by provincial health authorities, five of them having accreditation bodies. Each of the bodies has developed its own standards implementing ISO documents. Canadian Coalition for Quality in Laboratory Medicine (CCQLM) has recently been incorporated to provide a national structure for harmonisation across Canada (8).

Croatia: The process of improvement quality is organised by national society (Croatian Society of Medical Biochemists) and professional chamber (Croatian Chamber of Medical Biochemists) and also cooperation with national accreditation body. Currently, three labs are accredited according to ISO 15189 standard (9).

Czech Republic: The first meeting focusing only on the system of clinical labs accreditation was in 2000. There was discussion which way of implementation of QMS would be effective – ISO or national standards. Now, the accreditation of clinical labs is provided by Czech Institute of Accreditation (ISO 15189 preferable), and Czech Medical Association established NASKL (National Authorization Centre for Clinical Labs) with the aim to prepare the labs for accreditation according to ISO 15189. During this educational process the NASKL issues the certificate – Audit I and Audit II. There is a voluntary system but accreditation becomes more and more conditional for reimbursement of laboratory tests for health care insurance companies.

Accreditation according ISO 15189:2007 – Medical laboratories – Particular requirements for quality and competence

Accreditation is a procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks, it is an independent process (10,11).

The inspiration for national standards are ISO documents (ISO 9001, ISO 17025, ISO 15189) all around the world. The gold standard is ISO 15189 for clinical laboratories accreditation in Europe.

Main parts of ISO 15189:2007 and short comments

The main parts of ISO 15189:2007 and short comments are presented in table 1.

Accreditation process

To accredit or not to accredit, that is the question! The reason to start the process of accreditation would be interest in improvement of quality of lab services with better documentation of processes and responsibilities or interest of management (institute, hospital, owner, government, etc.), sometimes somebody should start after long time discussion about the quality.

The first step before accreditation is building enthusiastic team with education on quality management system. Other steps include selection of methods, describing the processes in the lab, developing or improving the metrology system, definition and structure of documents, preparation of a quality manual, SOPs, etc. (Figure 1).

Somebody described the accreditation process: “Do the right things right, describe how you do it, do the things as you describe and evaluate everything.”
**Table 1.** Main parts of ISO 15189:2007 and short comments.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scope</td>
<td>Developing quality of management system, assessing competence</td>
</tr>
<tr>
<td>3</td>
<td>Terms and definitions</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Management requirements</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Organization and management</td>
<td>• identification, responsibilities and qualification of personnel, implementation and improvement of QMS, conflict of interest, responsibilities, protection of confidential information, quality manager, qualified deputies</td>
</tr>
<tr>
<td>4.2</td>
<td>Quality management system (QMS)</td>
<td>• policies, processes, programmes, procedures, instructions, documentation</td>
</tr>
<tr>
<td>4.3</td>
<td>Document control</td>
<td>• definition of documents (regulations, by-laws, ethical codex, SOPs, standard working processes, forms, operating regulations, instructions, directives of head, etc.), structure (traceability, regulation of internal and external documents), process of approval, periodical reviewing, changes of documents, information of all staff and training</td>
</tr>
<tr>
<td>4.4</td>
<td>Review of contracts</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>Examination by referral laboratories</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>External services and supplies</td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>Advisory services</td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>Resolution of complaints</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>Identification and control of nonconformities</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>Corrective action</td>
<td>• procedure, relevance, types of nonconformities</td>
</tr>
<tr>
<td>4.11</td>
<td>Preventive action</td>
<td>• identification of possible points for nonconformities</td>
</tr>
<tr>
<td>4.12</td>
<td>Continual improvement</td>
<td>• systematic processes, education and training</td>
</tr>
<tr>
<td>4.13</td>
<td>Quality and technical records</td>
<td>• collection, access, storage, archive system (e.g. length of storage), national, regional, local regulations</td>
</tr>
<tr>
<td>4.14</td>
<td>Internal audits</td>
<td>• plan, programme, protocol, recommendation, conformity</td>
</tr>
<tr>
<td>4.15</td>
<td>Management review</td>
<td>• regular annual report</td>
</tr>
<tr>
<td>5</td>
<td>Technical requirements</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Personnel</td>
<td>• qualification, education and training, job description, management, GLP, research, education, responsibilities, competences, continual education incl. QMS, confidentiality of information, periodical reassessment</td>
</tr>
<tr>
<td>5.2</td>
<td>Accommodation and environmental conditions</td>
<td>• safety and adequate place, suitable environment, control access to the lab, relevant storage, monitor and record environmental conditions</td>
</tr>
<tr>
<td>5.3</td>
<td>Laboratory equipment</td>
<td>• capable to comply, programme for proper calibration and function of instruments, reagents and analytical system, service, records for each item, identity, maintenance, plan, preventive action, authorised and responsible personnel, processes, for implementation of new equipment to the lab</td>
</tr>
<tr>
<td>5.4</td>
<td>Pre-examination procedures</td>
<td>• the request form, identification of patient and examination request, instruction for proper collection and handling of primary samples (e.g. primary sample collection manual – web page, leaflets, brochure, etc.), criteria for acceptance or rejection of samples, monitoring of transport (temperature)</td>
</tr>
<tr>
<td>5.5</td>
<td>Examination procedures</td>
<td>• appropriate examination procedures, validated procedures, documentation, calibration, reference materials, SOPs, analytical characteristics, annual revalidation, biological reference intervals</td>
</tr>
</tbody>
</table>
We should summarize that accreditation process has some benefits for labs as standardization of all processes, responsibility of each member of team, personal policy, demonstrability of results, systematic evaluation of suppliers, prestigious, better communication with partners (12). Never the process has only positive features, and also the negatives of accreditation exist, such as investments to education, to equipment and facilities, expenses on accreditation and consultation bodies and spent time of each member of staff. The accreditation improves the processes in the laboratories, increasing the quality in all areas in labs – reduction of errors in the pre-analytical processes, facilitation of accurate and rapid diagnosis, participation in acceleration and efficiency of treatment, facilita-

<table>
<thead>
<tr>
<th>5.6</th>
<th>Assuring quality of examination procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• internal quality control system – uncertainty of results, sources of uncertainty, acceptable ranges, corrective actions</td>
</tr>
<tr>
<td></td>
<td>• programme/plan of calibration of measuring systems, calibration of methods, calibrators</td>
</tr>
<tr>
<td></td>
<td>• periodical verification</td>
</tr>
<tr>
<td></td>
<td>• analytical parameters e.g. reproducibility, trueness,</td>
</tr>
<tr>
<td></td>
<td>• system for measurement of uncertainties</td>
</tr>
<tr>
<td></td>
<td>• participation in EQA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.7</th>
<th>Post-examination procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• review the results, conformity with clinical information</td>
</tr>
<tr>
<td></td>
<td>• authorized personnel for releasing the result</td>
</tr>
<tr>
<td></td>
<td>• list of critical value – system of announcing the results out of the critical range</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.8</th>
<th>Reporting of results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• reporting results – format of report (electronic or paper), turn around time</td>
</tr>
</tbody>
</table>

Annex A  Correlation with ISO 9001 and ISO 17 025

Annex B  Recommendations for protection of LIS environment, system of security data reports, HW, SW

Annex C  Ethics in laboratory medicine – Ethical codex for patients and personnel

**FIGURE 1.** Map of accreditation process.
tion of personalised medicine development, continuous improvement.

We need standardization of process of improving quality systems. The national systems should be suitable and tailored-made for national specifics and modalities (types of labs, etc.) but in global world we need one accreditation systems which now presents by ISO 15189 and all experts around the world know the expectations of system inside of laboratory.

Laboratory services will be the centre of attention regarding quality due to their wide ranging impa-

ct on patient care. Accreditation is not about who the best is, but who has a system of standard procedures. Accreditation is an instrument rather than aim, which increases the quality with high standard of services for clients – patients, physicians. Quality system is about people, with people and for people.

Acknowledgements

The study was supported by research project VZ MZO 000 64165 (MZ0VFN 2005).

References

Patient Safety and Clinical Effectiveness as Imperatives for Achieving Harmonization inside and outside the Clinical Laboratory

Ronald W. McLawhon1*

For clinical laboratorians, the case for standardization and harmonization has been evident for more than 4 decades, since Radin first proposed using traceable reference standards for calibration as a means to harmonize laboratory results produced with different in vitro diagnostic methods (1). Over the intervening period, the subject has been reviewed (2) and debated extensively—both inside and outside the laboratory community—yet a striking majority of our physician and surgeon colleagues still fail to grasp or understand the limitations of current laboratory measurements, the lack of interchangeability of results obtained by different analytical methods, and the resulting effects on interpretation, clinical decision-making, and patient management.

Some incremental progress has been made in addressing these issues through professional organizations, multidisciplinary practice guidelines developed by national and international committees, peer-review publications, and the global in vitro diagnostic manufacturing industry. Notable successes include the National Glycohemoglobin Standardization Program (including the recommendations of the Diabetes Control and Complications Trial), the National Cholesterol Education Program, and the National Kidney Disease Education Program, which have helped drive improvements in laboratory methods for hemoglobin A1c, total cholesterol, and creatinine, respectively, and helped establish clinical practice guidelines based on laboratory measurements that meet defined performance criteria. As recently as October 2010, the AACC hosted an international conference for a diverse group of stakeholders to improve harmonization of laboratory results and to make recommendations for the future.

Regrettably, personnel in the clinical laboratory must continue to cope on a day-to-day basis with the blissful ignorance or blatant denial of these multifactorial methodologic differences by many practicing clinicians and, sadly, a few fellow laboratory colleagues. Harmonization of results remains the “holy grail.” How often have we been asked, “Isn’t one test result the same as another from a different laboratory?” Even after careful explanation and intensive efforts to educate, many practitioners choose to interpret and act on test results with little consideration of the potential implications and outcome to the patient. We are all familiar with the laboratory tests whose differences and limitations frequently present a challenge to explain to clinicians—troponin I, natriuretic peptides, thyroid-stimulating hormone, fertility hormones, tumor markers, and, more recently, vitamin D metabolites and many molecular-diagnostic assays (e.g., bcr-abl, BK virus). The lack of understanding of these limitations and differences by clinicians becomes a greater threat to patient safety and quality of care in the information technology age (3, 4), in which the focus tends to be on looking at cumulative merged results, reacting to flagged abnormal findings, and plotting graphical trends in electronic health records, while at the same time disregarding actual quantitative values and critical details in appended comments (e.g., failure to recognize different sources of testing and/or the specific methods used).

In parallel with ongoing efforts to educate clinicians and laboratorians alike about the risks of misinterpretation, misdiagnosis, and improper monitoring of patient results obtained with different laboratory methods (either within or between facilities), the desire to find a solution to minimize or mitigate the lack of harmonization is increasing, both inside and outside the clinical laboratory. Historically, one of the earliest and greatest educational efforts in this area, which concerned the use of tumor markers in the diagnosis and monitoring of neoplastic diseases, is exemplified by the 2008 publication of the National Academy of Clinical Biochemistry (NACB)2 guidelines for tumor markers (5, 6). These guidelines highlighted the challenges with the lack of standardization and harmonization of cur-

---

1 University of California, San Diego, School of Medicine, La Jolla, CA.
* Address correspondence to the author at: University of California, San Diego, School of Medicine, 200 West Arbor Dr. #8320, MFF/402 Dickinson Suite 4-420, San Diego, CA 92103-8320. Fax 619-543-3730; e-mail rmclawhon@ucsd.edu.

Received May 12, 2011; accepted May 13, 2011.
Previously published online at DOI: 10.1373/clinchem.2011.166041

2 Nonstandard abbreviations: NACB, National Academy of Clinical Biochemistry; PSA, prostate-specific antigen; PCa, prostate cancer.
rent tumor marker assays, the different molecular variants and isoforms detected by these assays, the lack of interchangeability of results obtained with the different methods used to monitor patients with known disease, and the need to reestablish new baselines when making conversions. These and other identified limitations confound test interpretation and impede the ability to create specific, defined, and uniformly accepted cutoff values for clinical decision-making.

In this issue of Clinical Chemistry, Stephan et al. present findings (7) from a study of a large cohort of patients that compared the effects of different prostate-specific antigen (PSA) methods (for total PSA and the percentage of free PSA), as well as calibration changes, on the results of logistic regression–based nomograms for predicting the risk of prostate cancer (PCa). Multivariate models, including artificial neural networks and logistic regression–based nomograms, have been proposed since the late 1990s (8, 9) as an adjunct for PCa risk prediction, for monitoring disease progression, and for guiding therapeutic intervention, to help address the low specificity of measurements of total and the percentage of free PSA alone for diagnostic and prognostic assessments. Recently, such combined approaches, which can account for other factors such as age, digital rectal examination findings, and prostate volume, have been advocated widely (10) and embraced by the medical community; however, an important assumption of these approaches has been that variation in the PSA measurement methodology used does not affect assessment outcomes. The NACB guidelines, in discussing the promise of nomograms for predicting PCa risk, suggested that these tools may be “the most accurate means of individualizing therapy and predicting outcome, and reflect the most recent advances in patient management” (6). The expert panel cautioned, however, that it might be difficult to select the best nomogram when several competing versions apply to the same clinical decision.

A critical and comprehensive comparison of the effects of assay-dependent variation in measurements of total PSA and the percentage of free PSA on commonly used PCa risk-prediction nomograms has not previously been well documented. To clinical chemists and pathologists familiar with the issue of the lack of PSA assay harmonization, it may seem intuitively obvious that some differences in the performance and outcomes of these nomograms could be observed with different assays and calibration methods. Despite the advances in the availability of WHO reference materials and assay improvements from all manufacturers, we are still far from achieving the desired harmonization and interchangeability of PSA results across all available methods (11, 12). Stephan and his colleagues, who were early proponents of the value of PCa nomograms, have documented the obvious (and not so obvious) limitations of these nomograms, the use of which may alter clinical decisions, depending on the PSA methods used. In this large retrospective study of nearly 800 patients (which included some assays that are no longer commercially available), Stephan et al. have documented very important PSA test method–dependent differences between 5 commonly used assays when results are applied to 5 of the most widely used and readily available (“plug and play”) regression-based predictive nomogram models. Not only did results of the 5 assays lead to different PCa probabilities with the same nomogram, but the various nomograms (which differ in their inclusion of other factors, such as the percentage of free PSA, sampling density, and prostate volume) also produced different PCa probabilities when the same PSA assay was used. Although the authors’ ROC curve analyses yielded comparable areas under the curves, there were significant differences between the 5 assays in the diagnostic sensitivities and specificities at various PCa probability cutoff values for the majority of the evaluated nomograms.

Although this study may not have examined the effects on all currently used nomograms, such as those described by Finne et al. (13), and did not take into account other PSA assays, its findings raise some well-founded concerns that merit the attention of both clinicians and the laboratory community. Yes, the conclusions of Stephan et al. may state the obvious—namely, the accuracy of predicted PCa probabilities produced with different nomograms is affected and can be compromised by the lack of harmonization of PSA assays. Moreover, the variations in PCa risk prediction and discrimination can be substantial and unacceptable, depending on the model used and differences in calibration, even with the same assay. Nonetheless, this study reinforces the point that until harmonization of results is truly achieved in the laboratory, caution is still warranted. Few tools outside the laboratory can substitute for harmonization for accurately informing and appropriately guiding clinical decision-making and ensuring safe and effective patient care.

In the US, PCa remains the most common cancer in men and the second-leading cause of cancer deaths. Although the incidence of PCa and PCa deaths has declined steadily over the last 2 decades because of early detection and treatment (6), we must remain vigilant in raising awareness that current laboratory results are neither standardized nor harmonized and may lead to erroneous decisions with serious consequences (i.e., just plugging the numbers into a risk-calculation nomogram can give misleading results). The decade-old Institute of Medicine report (14) on building a safer health system states that “to err is human,” but no-
where in the report does it say that “to forgive is divine,” especially now that we have knowledge of factors that can lead to the wrong call and potential harm.

Author Contributions: All authors confirmed they have contributed to the intellectual content of this paper and have met the following 3 requirements: (a) significant contributions to the conception and design, acquisition of data, or analysis and interpretation of data; (b) drafting or revising the article for intellectual content; and (c) final approval of the published article.

Authors’ Disclosures or Potential Conflicts of Interest: No authors declared any potential conflicts of interest.

References