This document provides a protocol for evaluating the accuracy of a test to discriminate between two subclasses of subjects when there is some clinically relevant reason to separate them. In addition to the use of receiver operating characteristic curves and the comparison of two curves, the document emphasizes the importance of defining the question, selecting the sample group, and determining the “true” clinical state.

A guideline for global application developed through the Clinical and Laboratory Standards Institute consensus process.
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For additional information on committee participation or to submit comments, contact CLSI.

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Assessment of the Diagnostic Accuracy of Laboratory Tests Using Receiver Operating Characteristic Curves; Approved Guideline—Second Edition

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Abstract

Clinical and Laboratory Standards Institute document EP24-A2—Assessment of the Diagnostic Accuracy of Laboratory Tests Using Receiver Operating Characteristic Curves; Approved Guideline—Second Edition provides guidance for laboratorians and manufacturers who assess clinical test accuracy. It is not a recipe; rather, it is a set of concepts to be used to design an assessment of test performance or to interpret data generated by others. In addition to the use of ROC curves and comparison of two curves, the document emphasizes the importance of defining the question, selecting a sample group, and determining the “true” clinical state. The statistical data generated can be useful whether one is considering replacing an existing test, creating or adding a new test, or eliminating a current test.
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Assessment of the Diagnostic Accuracy of Laboratory Tests Using Receiver Operating Characteristic Curves; Approved Guideline—Second Edition

1 Scope

This guideline outlines the steps and principles of prospectively planned and retrospective studies to evaluate the intrinsic diagnostic accuracy of a clinical laboratory test, defined as its fundamental ability to discriminate correctly among alternative states of health. It is not intended to help determine how best to use a diagnostic test in clinical practice, but instead to determine how accurate a laboratory test is in terms of diagnostic sensitivity and specificity.

Receiver operating characteristic (ROC) curve methodology arose in response to needs in electronic signal detection and problems with radar in the early 1950s. It is derived from conditional probabilities, as originally formulated by Bayes. This guideline aims to define ROC curves and to explain how to design, construct, interpret, and apply the information from ROC studies to evaluate diagnostic tests. For simplicity, only continuous scales, such as those typical for in vitro diagnostic tests, are discussed. The clinical condition that the test is intended to detect must be verifiable through some means other than the test under investigation. In other words, there must be an independent clinical reference standard against which one can compare the test. By selecting cutoffs between positive and negative diagnoses along the continuous scale of the test, the diagnostic outcomes for these decision levels are compared to the true clinical condition, which, in turn, generates the ROC curve.

This guideline will be of value to a wide variety of possible users, including:

- Investigators who are developing new tests for specific applications
- Manufacturers of reagents and devices for performing tests who are interested in assessing or validating test performance in terms of diagnostic accuracy
- Regulatory agencies interested in establishing requirements for claims related to diagnostic accuracy
- Clinical laboratorians who are reviewing data or the literature, and/or generating their own data, to make decisions about which tests to employ in their laboratories
- Health care or scientific workers interested in critical evaluation of data being presented on clinical test performance

2 Introduction

An ROC curve provides the following advantageous properties:

- It visually displays the performance of one or more diagnostic markers or tests across the entire measuring interval.

- By plotting unitless values (sensitivity vs specificity or sensitivity vs 1 – specificity), one can compare the diagnostic performance of two or more diagnostic markers or tests regardless of:
  - Units of expression of different markers or tools (eg, mg/dL, mmol/L, U/L)
  - Type of diagnostic test (eg, a clinical laboratory test, pulmonary function test, radiography)
  - Type of biological sample analyzed (eg, serum vs urine, saliva vs blood)
• It gives a clinician flexibility to select the appropriate medical decision level depending upon the medical situation and the clinical setting. (NOTE: In a pivotal study, selecting the optimal cutoff and evaluating the diagnostic accuracy in the same study leads to the biased estimation [overestimation] of the diagnostic accuracy. These issues are discussed in detail in the literature.4-6)

By evaluating (or examining) ROC based on a marker, the clinician could choose a decision level offering high sensitivity but lower specificity. In another situation using this marker, the clinician could choose a different decision level offering high specificity but lower sensitivity to reduce false positives (FPs).

3 Standard Precautions

Because it is often impossible to know what isolates or specimens might be infectious, all patient and laboratory specimens are treated as infectious and handled according to “standard precautions.” Standard precautions are guidelines that combine the major features of “universal precautions and body substance isolation” practices. Standard precautions cover the transmission of all known infections agents and thus are more comprehensive than universal precautions, which are intended to apply only to transmission of blood-borne pathogens. Standard and universal precaution guidelines are available from the Centers for Disease Control and Prevention.7 For specific precautions for preventing the laboratory transmission of all known infectious agents from laboratory instruments and materials and for recommendations for the management of exposure to all known infectious diseases, refer to CLSI document M29.8

4 Terminology

4.1 A Note on Terminology

CLSI, as a global leader in standardization, is firmly committed to achieving global harmonization wherever possible. Harmonization is a process of recognizing, understanding, and explaining differences while taking steps to achieve worldwide uniformity. CLSI recognizes that medical conventions in the global metrological community have evolved differently in the United States, Europe, and elsewhere; that these differences are reflected in CLSI, International Organization for Standardization (ISO), and European Committee for Standardization (CEN) documents; and that legally required use of terms, regional usage, and different consensus timelines are all important considerations in the harmonization process. In light of this, CLSI’s consensus process for development and revision of standards and guidelines focuses on harmonization of terms to facilitate the global application of standards and guidelines.

Essentially, new documents are obliged to adhere to the most current version of the *International Vocabulary of Metrology – Basic and General Concepts and Associated Terms* (VIM)9 whenever an ambiguity occurs in the interpretation or understanding of terms. In the latest edition, many definitions have become more explicit and understandable, but the language of the VIM is difficult and compact. VIM deals with general metrology and terminology that should be useful for most disciplines that measure quantities.

The understanding of a few terms has changed during the last decade as the concepts have developed. *Precision* (measurement precision) is defined as closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions. The term *measurand* is used when referring to the quantity intended to be measured, instead of *analyte* (component represented in the name of a measurable quantity) when its use relates to a biological fluid/matrix. Additionally, *clinical accuracy* has been changed to *diagnostic accuracy* because the term “clinical” has a regulatory connotation in Europe and elsewhere.
The Quality Management System Approach

Clinical and Laboratory Standards Institute (CLSI) subscribes to a quality management system approach in the development of standards and guidelines, which facilitates project management; defines a document structure via a template; and provides a process to identify needed documents. The quality management system approach applies a core set of “quality system essentials” (QSEs), basic to any organization, to all operations in any health care service’s path of workflow (ie, operational aspects that define how a particular product or service is provided). The QSEs provide the framework for delivery of any type of product or service, serving as a manager's guide. The QSEs are as follows:

- Organization
- Customer Focus
- Facilities and Safety
- Personnel
- Purchasing and Inventory
- Equipment
- Process Management
- Documents and Records
- Information Management
- Nonconforming Event Management
- Assessments
- Continual Improvement

EP24-A2 addresses the QSE indicated by an “X.” For a description of the other documents listed in the grid, please refer to the Related CLSI Reference Materials section on the following page.
Related CLSI Reference Materials∗


EP17-A  Protocols for Determination of Limits of Detection and Limits of Quantitation; Approved Guideline (2004). This document provides guidance for determining the lower limit of detection of clinical laboratory methods, for verifying claimed limits, and for the proper use and interpretation of the limits. An NCCLS-IFCC joint project.

M29-A3  Protection of Laboratory Workers FromOccupationally AcquiredInfections; Approved Guideline—Third Edition (2005). Based on US regulations, this document provides guidance on the risk of transmission of infectious agents by aerosols, droplets, blood, and body substances in a laboratory setting; specific precautions for preventing the laboratory transmission of microbial infection from laboratory instruments and materials; and recommendations for the management of exposure to infectious agents.

∗ CLSI documents are continually reviewed and revised through the CLSI consensus process; therefore, readers should refer to the most current editions.
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