CLINICAL AND LABORATORY STANDARDS INSTITUTE®

1st Edition

# AUTO15

## Autoverification of Medical Laboratory Results for Specific Disciplines



This guideline includes detailed information for design, testing, validation, implementation, and ongoing support of an autoverification algorithm system for use in the medical laboratory.

A guideline for global application developed through the Clinical and Laboratory Standards Institute consensus process.

AUTO15, 1st ed.
September 2019

# Autoverification of Medical Laboratory Results for Specific Disciplines

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## Abstract

Clinical and Laboratory Standards Institute guideline AUTO15—*Autoverification of Medical Laboratory Results for Specific Disciplines* provides general guidance, as well as discipline-specific direction, on design and validation of an autoverification system. Autoverification is the process by which laboratory analyte results are accepted or rejected for automatic delivery to a patient data repository. This process uses a predetermined set of criteria applied at one or more points during the electronic flow of information. This guideline is provided for use by laboratorians, personnel responsible for information systems, and vendors for medical informatics and *in vitro* diagnostics.

Clinical and Laboratory Standards Institute (CLSI). *Autoverification of Medical Laboratory Results for Specific Disciplines*. 1st ed. CLSI guideline AUTO15 (ISBN 978-1-68440-056-0 [Print]; ISBN 978-1-68440-057-7 [Electronic]). Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087 USA, 2019.





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**Suggested Citation**

CLSI. *Autoverification of Medical Laboratory Results for Specific Disciplines*. 1st ed. CLSI guideline AUTO15. Wayne, PA: Clinical and Laboratory Standards Institute; 2019.



ISBN 978-1-68440-056-0 (Print)
ISBN 978-1-68440-057-7 (Electronic)
ISSN 1558-6502 (Print)
ISSN 2162-2914 (Electronic) Volume 39, Number 11

## Contents

## Foreword

This guideline is an extension of CLSI document AUTO10,[1] published in 2006. CLSI document AUTO10[1] discusses general Boolean logic principles and autoverification algorithm design and briefly covers preexamination, examination, and postexamination elements that might be included at decision points in an autoverification system. It explains the definition and principle behind delta checks and compares the use of various numerical limits, such as reference intervals, critical-risk results, and medical decision values. CLSI document AUTO10[1] also provides details on repeat analysis, follow-up, and the possibility of using health care provider profiles in algorithm design. Additionally, general information on regulatory and accreditation compliance and validation of algorithms is included.

Logistics and technical ability (through LIS), instrument software, or middleware (MW) to autoverify medical laboratory results have been available for some time. However, many North American laboratories are not using autoverification for some (or all) of the laboratory's key areas where it is a plausible option.[2] The need for autoverification in medical laboratories stems from many contributing factors. Currently, there are three major concerns in the medical laboratory: laboratorian shortages,[3] quality requirements, and a demand for shorter turnaround times.[4,5] Autoverification covers all these issues. However, implementing an autoverification system in the average laboratory is challenging because of the same issues it manages. When an autoverification system is designed from current manual review processes, multiple rules and interactions occur. At each stage, information that would otherwise come from laboratorian intervention should be captured. This information includes:

- What detail is being reviewed or sought out?
- What is the follow-up to that detail and is it a manual process (eg, repeat, reflex another test, make a dilution, investigate for X)?
- Is it possible that one (or more) software programs that interact with this information can detect that detail and possibly start, complete, or provide an alert to the desired follow-up? If not, is there a hybrid automated/manual solution that could provide the same function?

For AUTO15, consideration has been taken to make the autoverification approach scalable and actionable and thus suitable across laboratories, patient types, and acuity. Different approaches to implementing autoverification range from using basic minimum ranges to complex cascading Boolean rule sets; AUTO15 provides direction along this continuum.

Some vendors offer predefined rule sets that can be purchased for autoverification. However, laboratory staff should understand the variables that exist from both a laboratory (instrument, MW, LIS) and clinical perspective and that these variables can make those rule sets ineffective and potentially dangerous. There are currently no autoverification standards for many departments in the medical laboratory. AUTO15 helps laboratories develop their own standards based on their needs and pathologist (or director) requirements.

This guideline contains discipline-specific algorithmic design concepts; assay-specific preexamination, examination, and postexamination concerns; and result-specific suggestions for definable numerical limits that can be considered when local algorithms are developed. Defined numbers (eg, 28 to 38 seconds) do not apply to all instrument-reagent-population combinations for a given assay. However, terms such as "reference interval" and "critical-risk results," which are applicable in most assays, are used. Where possible, guidance for specific intervention from a laboratorian, because of the algorithm, is included in this guideline.

In addition to the information provided in this guideline, other permutations may be added to these guidelines based on local patient populations, health care provider, instrumentation, reagents, conditions, etc. Local statistics and/or studies may be used to define criteria. For example, if clotted samples are found to be a high percentage of samples with a result below reference interval for a given test, values below reference interval may be held back from autoverification to verify sample integrity. Each chapter contains discipline- or test-specific validation guidelines to aid the user in confirming that the algorithms or rules perform as expected. Additional validation may be needed, depending on the exact steps used in the autoverification system's design.

The laboratory should follow regulatory and accreditation requirements for autoverification (including validation and postvalidation follow-up) where applicable. Awareness of regulatory and accreditation requirements is the laboratory's or user's responsibility. Current existing regulatory and accreditation requirement details are included where relevant. Because AUTO15 is intended for global use, including a comprehensive list of regulatory and accreditation requirements is not feasible.

Various subchapters contain some material that appears more than once. Basic information for all users is found in Subchapter 2.3, whereas specific information relating to the same concepts are found in subchapters pertaining to certain laboratory areas. This redundancy provides more specific information, examples, or levels of detail that could not be cohesively included in the basic subchapter.

**NOTE:** The content of this guideline is supported by the CLSI consensus process and does not necessarily reflect the views of any single individual or organization.

**Key Words**

Algorithm design, autoverification, Boolean logic, implementation, laboratory information system, middleware, rules, validation

# Autoverification of Medical Laboratory Results for Specific Disciplines

## Chapter 1: Introduction

This chapter includes:

- Guideline's scope and applicable exclusions
- Background information pertinent to the guideline's content
- "Note on Terminology" that highlights particular use and/or variation in use of terms and/or definitions
- Terms and definitions used in the guideline
- Abbreviations and acronyms used in the guideline

### 1.1 Scope

This guideline provides recommendations for designing autoverification algorithms for specific disciplines and types of testing in the medical laboratory (eg, chemistry, coagulation, hematology, immunochemistry, infectious diseases, toxicology, and urinalysis), as well as guidance for human intervention, whether results are generated from an automated system or manual result entry. Additionally, it provides recommendations for the creation of scalable algorithms that provide levels of adaptation from simple to more complex criteria and the actionable implementation of autoverification in the medical laboratory.

The intended users of this guideline are clinical pathologists, medical directors, and medical technology staff responsible for the timely delivery of actionable health care information provided by medical laboratories. Additionally, laboratory personnel responsible for the information systems, medical informatics vendors, and *in vitro* diagnostics vendors should ensure their products and services comply with the recommendations provided in this guideline.

This guideline is not intended to provide a specific programming language, vendor-specific implementations for autoverification for a discipline, or analyte-specific autoverification algorithms. This guideline is not applicable to all possible medical permutations that are present in the medical laboratory respective to a specific discipline. These recommendations are not applicable to transfusion medicine, microbiology, molecular medicine, anatomic pathology, or point-of-care testing.

### 1.2 Background

From large laboratories where tracks carry specimens onto centrifuges and to analyzers, to small laboratories where one analyzer is used to measure over 100 different analytes, automation is widely used. Even small point-of-care instruments are becoming more complex and automated. However, review and release of results continues to be a primarily manual process that can take up a great deal of a laboratorian's time. With increasing labor shortages and demand for quality improvement and shorter turnaround time (TAT) requirements, implementing an autoverification system is a recommended solution.

Autoverification, or automated result verification, consists of the automated actions performed by a computer system related to the release of test results to the medical record using criteria and logic established, documented, and tested by the laboratory's medical staff. Autoverification implementation is usually measured by percent of analytes autoverified. For example, 50% autoverification means that 50% of the total number of results generated are autoverified.

Different laboratory disciplines, as well as various assays within that discipline, achieve different autoverification rates. These autoverification rates depend on the acuity of the algorithm and patient population served for that specific assay or laboratory specialty. Implementation of autoverification dramatically alleviates labor pressures, decreases TAT, and improves quality. With the proper tools, algorithms, and implementation, it may be possible to achieve autoverification rates over 95%. Fifty percent autoverification rates are acceptable and achievable relatively quickly, but the laboratory should continue to implement new autoverification systems, provided that the quality is not compromised by subpar software or procedures. CLSI document AUTO10[1] is a primer to understanding the concepts behind autoverification. It is recommended that readers become familiar with CLSI document AUTO10[1] before reading AUTO15.

## 1.3 Terminology

### 1.3.1 A Note on Terminology

CLSI, as a global leader in standardization, is firmly committed to achieving global harmonization whenever 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 different countries and regions and that legally required use of terms, regional usage, and different consensus timelines are all important considerations in the harmonization process. CLSI recognizes its important role in these efforts, and its consensus process focuses on harmonization of terms to facilitate the global application of standards and guidelines. Table 1 is provided to clarify the intended interpretations of the following terms.

**Table 1. Common Terms or Phrases With Intended Interpretations**

| Term or Phrase | Intended Interpretation |
|---|---|
| **"Needs to" or "must"** | Explains an action directly related to fulfilling a regulatory and/or accreditation requirement or is indicative of a necessary step to ensure patient safety or proper fulfillment of a procedure |
| **"Require"** | Represents a statement that directly reflects a regulatory, accreditation, performance, product, or organizational requirement or a requirement or specification identified in an approved documentary standard |
| **"Should"** | Describes a recommendation provided in laboratory literature, a statement of good laboratory practice, or a suggestion for how to meet a requirement |

No international consensus has yet been achieved on the terminology for laboratory results that imply immediate and severe or significant risk of harm to patients. Common terms include "critical-risk results," "critical values," "panic values," "critical alarms," or "alarm values." This guideline uses the term "critical-risk result" rather than "critical value," because the concept encompasses qualitative results as well as quantitative or semiquantitative values, and emphasis is placed on the risk of patient harm rather than on the actual value of the result. The terms "alarm" and "panic" are discouraged, because laboratories and health care organizations are expected to have carefully planned and well-designed systems to manage results that pose critical and significant patient risk in an organized manner.

### 2.3.9 Order of Rules

The order of the autoverification rules should be consistent. The rule that is most likely to fail should be triggered first. Rules should be written in order based on the plausibility of the result being accurate. For example, the laboratory should first look at the result format itself to determine whether it is acceptable (eg, if a numerical result is expected and a "?" is received, the autoverification algorithm cascade can be stopped immediately). Whether rules are written directly in the LIS or in the MW, their order is extremely important. Typically, rules are triggered from the top downwards and from left to right. Because rules are based on pure logic, the improper placement of parentheses can cause rules to function improperly. Rules should be labeled and/or numbered in order, from top to bottom, because they can be unintentionally moved.

### 2.3.10 Instrument Messages, Flags, Error Codes, and Warnings

Instrument flags and warnings presented in the instrument message stream may be used in autoverification rule building. In designing an algorithm, the laboratorian and instrument manufacturer need to have knowledge of all the instrument flags that could occur and what actions, if any, to perform when they occur. Results from a specific instrument should have specific autoverification rules, because instrument messaging may differ between different vendor instruments or even within the same vendor but between various models. Standardization of similar instruments across a laboratory enterprise offers advantages to autoverification design and table maintenance.

Not all error flags are failures of the system (eg, "H" for above the reference interval). But there must be a rule to stop autoverification for any error flag related to instrument malfunction. Writing the rule requires an understanding of all the error flags that can be generated and transmitted by the analyzer. Analyzer manufacturers have documentation of the host interface specifications that list all the codes the instrument will transmit. As expertise in developing autoverification algorithms in the laboratory improves, specific algorithms should use the different error flags and instrument codes to direct the laboratorian to potential problems or perform more complex autoverification cascading rules.

Codes that are displayed on analyzer screens and printouts may be different than the actual codes sent through the interface. The display for the user should be easily recognizable and include the tests affected by the error code, as well as the action to take (eg, ignore, hold for review, repeat). These error codes may be handled differently based on the LIS being used. For rules to be written using the error codes listed in Table 3, the LIS must be able to capture them.

**Table 3. Examples of Instrument Error Code Follow-up**

| Instrument Error Code | LIS Code | Display Name | Tests Affected | Default Action |
|---|---|---|---|---|
| **>** | ? | Result is above the linearity range | Any | Hold all tests for verification; proceed with dilution |
| **A** | ? | Result is abnormal | Any | See suspect flag |
| **H** | ? | Result is higher than the reference interval | Any | No action |
| **L** | ? | Result is lower than the reference interval | Any | No action |
| **N** | ? | Result is normal | Any | No action |
| **W** | ? | Result is flagged with low reliability | Any | See suspect flag |

Abbreviation: LIS, laboratory information system.

# Chapter 3: Discipline Specification Autoverification Design

This chapter includes:

- Discipline-specific autoverification items for consideration
- Discipline-specific examples of algorithms
- Discipline-specific examples of information tables

## 3.1 Chemistry

### 3.1.1 General Considerations

Chemistry covers assays performed by an automated chemistry platform. These tests are often the most difficult to autoverify, primarily because chemistry tests are often interrelated. The following subchapters cover various topics that should be reviewed and discussed with the implementation team when preparing to determine the limits for what is to be autoverified.

#### 3.1.1.1 Interfering Substances

Depending on the model and manufacturer, automated chemistry analyzer results can be affected by a variety of interfering substances. Many of these interferences are cellular (eg, hemolysis) or colorimetric (eg, high bilirubin [icterus] or lipemia) or due to osmotic imbalance (eg, hypo- and hypernatremia). The laboratory should review all potential interferences and at what level their interference becomes significant for all analytes, as well as understand which parameter(s) may be affected, and include them in the algorithm. Different instruments measure these interferences differently, and the algorithm must consider how the instrument transmits this information (eg, a flag or an actual result for each component).

For example, hemolysis typically interferes with the potassium result. To attain the highest rate of autoverification, the algorithm would be defined to automatically comment on the potassium result, indicating that hemolysis is present and to what level (eg, slight, moderate, gross). If gross hemolysis is present, the laboratory may opt to remove the result and substitute a "TNP" ("test not performed") with a comment that gross hemolysis was present. In this specific example, the anion gap is also affected. For particulate interferences, the laboratory's procedure should cover each of these, defining at what level autoverification failure needs to be set to detect potential interference. The autoverification algorithm would then be designed to mirror the procedure.

#### 3.1.1.2 Chartable and Unchartable Comments

Chartable comments should be standardized as much as possible to ensure consistency across patients, and LIS systems should be able to accept chartable comments from any MW software. Unchartable comments should be used to denote any corrective actions taken, reruns, critical-risk result reporting (to the health care provider), and potential instructions to the laboratorian for corrective action. An example of an unchartable comment to a laboratorian is, "Please check for clots in the probe and rerun. The albumin was higher than the total protein in this patient."

#### 3.1.1.3 Preexamination Considerations

Typically, automated chemistry analyzers need minimal sample volumes, depending on the number of tests ordered. Fibrin clots should not be present in serum before analysis. Many laboratories have switched to plasma to alleviate some of these concerns. Because specimen integrity checking is usually automated, manually checking the specimen integrity is typically not needed, but the algorithms must consider these


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PRINT ISBN 978-1-68440-056-0

ELECTRONIC ISBN 978-1-68440-057-7