



LIMS for Medical Examiners

What are the key elements of a LIMS for forensics and medical examiners?





Introduction

A [forensics and medical examiners lab](#) may analyze anything from body fluids and bone fragments to metals and fire debris as part of their broad commitment to answering questions of interest to a legal system. These laboratory-based investigations see forensic scientists collect, preserve, and analyze these types of samples (i.e., evidence) using a variety of special laboratory equipment and techniques. Given their role in verifying the status of evidence, the forensics lab will also see its laboratorians take part in legal proceedings, requiring even more strict requirements for data and evidence management. This broad array of analytical techniques and set of legal implications means such labs turning to informatics solutions like the [laboratory information management system](#) (LIMS) will require their information management solutions to meet the specific needs of their lab.

This brief topical article will examine the typical forensics and medical examiners lab's operations and workload, and suggest a base set of LIMS functionality (i.e., system requirements) that is critical to fulfilling the information management and workflow requirements of this lab type.

Note: Any citation leading to a software vendor's site is not to be considered a recommendation for that vendor. The citation should however still stand as a representational example of what vendors are implementing in their systems.

Forensics laboratory workflow, workload, and information management

The U.S. Department of Justice (DOJ) duly notes the practice of forensic science is multi-disciplinary, spanning from forensic chemistry, molecular biology, and toxicology to anthropology and entomology.^[1] This suggests that depending on what a forensics lab or researcher is focusing their efforts on, workflows may differ, sometimes significantly. These workflows may be further complicated by activities outside the laboratory, including collecting evidence, giving testimony, providing forensic psychiatry services, or conducting forensic engineering investigations.^[1] This typically results in diverse types of information and data being collected both physically and digitally inside and outside the forensics lab, at all hours of the day. Additionally, the integrity of that information, data, and evidence is vital to establishing legal provenance and positively developing forensic intelligence.^[2] This is where a well-developed and -maintained LIMS comes into play.

The use of LIMS in crime labs has grown over time, with the DOJ's Bureau of Justice Statistics (BJS) reporting 75% of publicly funded crime labs using a LIMS in 2002 and 84% in 2009.^[3] (A separate survey by Levy in 2011 found 82% of surveyed death investigation offices were using LIMS.^[4]) BJS' 2014 report did not discuss this statistic^[5], but with the U.S. Drug Enforcement Administration's (DEA's) National Forensic Laboratory Information System (NFLIS) program reporting 88% of labs



testing controlled and non-controlled substances secured by law enforcement operations using a LIMS^[6], it appears LIMS adoption by forensics and medical examiners labs is continuing to increase. This is important because the processes within these labs match up well with what a LIMS has to offer, with a LIMS capable of enhancing caseload management, reporting, health data security, evidence control, and more.^{[4][6][7][8]}

It's clear that between any two forensics labs, workflows will likely differ, depending on what functions are performed. The 2014 BJS survey found that among publicly funded crime labs, an average of five different forensic functions were performed in or near the lab. The most common activities included identification of drugs and other controlled substances, analysis of biological specimens, analysis of fingerprints, analysis of firearms and toolmarks, and analysis of crime scenes and trace evidence.^[5] Some functions, such as toxicology analysis and forensic biology casework, also get outsourced to other labs, with 38% of publicly funded crime labs outsourcing at least one function in 2014.^[5] This outsourcing, which may occur as a result of increased forensic testing demand or lack of in-house resources, inevitably puts the forensic workload on other specialty labs that may not necessarily identify purely as forensics labs, muddying the waters further.

Additionally, the workflows of a single lab may change over time as new areas of forensic practice are added to the lab or medical examiners office, requiring additional specialized equipment and LIMS to better manage those new areas of practice.^[8] The NFLIS, for example, notes that controlled substance testing labs "are constantly dealing with the need to identify and test for new or emerging drugs," requiring reference spectra, standards, procedures validation, and staff who are familiar or can be trained on the new procedures.^[6] It may take time to integrate this sort of new testing into existing workflows; however, a well-maintained configurable LIMS can arguably speed that process along by housing the reference spectra, tracking the inventory of standards, managing the workflows, and documenting staff training on the procedures.

Finally, workflows and workload can get modified due to increasing demand for forensic laboratory services, creating backlogs.^{[5][6][8]} These backlogs may occur at no fault of the lab^{[5][8]} and be in part due to a loss of critical staff, an influx of emerging drugs, workload and responsibility increases, lack of funding, and evidence collected for testing that actually doesn't need to be tested.^{[6][8]} Given the state of increasing workloads and backlogs, a LIMS is more important than ever to help improve efficiencies in the laboratory, monitor turnaround times, give insights into backlogs, and better track evidence that doesn't or no longer requires analyses. Of course, as a forensics and medical examiners lab grows and takes on more functions to better meet demand, a highly configurable LIMS also helps integrate those new, related workflows into the dynamics of the lab.

Base LIMS requirements

Given the above, it's clear LIMS adoption and use must continue in crime labs. But a generic LIMS won't do; it's imperative the lab find a solution that meets all or most its workflow requirements. This more often than not requires a configurable solution that enables trained users to quickly make the changes they need, if those changes make sense within the overall data structure of the LIMS.^[7]

What follows is a list of system functionality important to most any forensics and medical examiner laboratory, with a majority of that functionality found in many vendor software solutions.^{[7][8][9][10][11][12][13][14][15][16][17][18][19]} In many cases, those solutions aren't necessarily LIMS but rather "case management systems," "medical examiner systems," "medical case management systems," or "coroner management systems." In the end, however, the features across this spectrum of solution types are relatively similar. In some cases, a LIMS will even incorporate the case management features of these specialty systems.

Test, sample and case management

- Sample, property and evidence log-in and management, with support for unique IDs
- Support for pre-logging of death and evidence data before physical materials arrive
- Body reception, location, and disposition support
- Barcode and RFID support
- End-to-end sample, body, property, and evidence tracking
- Custom and industry-specific test and method management, including for breath alcohol and sexual assault testing
- Test, instrument, subpoena, and other event scheduling
- Test requesting
- Configurable screens and data fields
- Analytical tools, including data visualization, statistical analysis, and data mining tools
- Data import and export
- Robust query tools
- Document and image management
- Workflow management
- Case management, including case assignment, reassignment, and prioritization, with support for unique and third-party IDs:
 - Story-related entry for cases
 - Geolocation capture and support
 - Mass casualty event support
 - Cluster and crime scene mapping tools
 - Mobile and offline data entry support for remote work
 - Dashboard view of all pertinent information for a case, including criminal case status
 - Dashboard or other view showing case and test assignment, status, and backlog

Quality, security and compliance

- Quality assurance / quality control mechanisms
- Standardized terminology via built-in dictionaries and medical classification codes like ICD
- National Association of Medical Examiners (NAME) and International Association of Coroners and Medical Examiners (IAC&ME) accreditation support
- Results review and approval
- User qualification, performance, and training management
- Audit trails and chain of custody support
- Configurable and granular role-based security
- Configurable system access and use (log-in requirements, account usage rules, account locking, etc.)
- Electronic signature support
- Data encryption and secure communication protocols
- Archiving and retention of case and other data and information
- Configurable data backups
- Status updates and alerts

Operations management and reporting

- Customizable rich-text reporting, with multiple supported output formats
- Custom and industry-specific forms, including body release, autopsy authorization, media release, cremation authorization, subpoena, etc.
- Support for state-specific death certificates
- Industry-compliant labeling
- Email integration
- Instrument interfacing and data management
- Instrument calibration and maintenance tracking
- Inventory and reagent management
- Third-party software and database interfacing
- Integrated (or online) system help
- Hour, mileage, and expense tracking
- Turnaround time calculation

Specialty LIMS requirements

As noted previously, the DOJ points out many disciplines and sub-disciplines that are used in and near the forensics laboratory.^[1] It is beyond the scope of this article to address the system functionality for each. However, an attempt has been made to cover the most important sub-disciplines associated with forensics and medical examiners labs in regards to LIMS functionality.



Forensic pathology and histology

The workflows of a forensic pathology and histology (or histopathology) lab tend to be marginally different from their purely clinical counterpart. However, the information management needs of the forensic [pathology](#) lab will be similar to those found in clinical information management solutions like a laboratory information system (LIS), designed to manage clinical pathology and [histology](#) workflows. That said, in addition to the base functionality above, a LIMS that addresses forensic pathology and histology will still need to address (or allow users to)^{[20][21][22][23][24][25]}:

- Configure the system using templates for histology and cytology case types
- Add, view, and link pre-generated organ maps and other diagrams
- Add, view, and link custom annotated pathology imaging
- Support blocks and slides, as well as whole organs, as specimens, with predefined descriptions
- Document grossing examinations
- Print slides and cassettes
- Provide case management, reporting, and test requisition
- Provide specialty workflow for autopsy
- Provide stain panels and histology worksheets
- Support shared management of tissue samples among departments
- Support polymerase chain reaction (PCR) workflow and reporting
- Support pathology-specific reflex testing
- Create a preliminary findings report for the coroner

Forensic neuropathology

Forensic neuropathology takes many of the aspects of forensic pathology and narrows them down to examinations of the brain and its corresponding structures in the medico-legal context. As such, a forensic LIMS will need to allow users to better perform and manage examinations of head injuries, spinal injuries, infections, and neurological conditions.^{[26][27][28]} This means, in addition to base LIMS and pathology LIMS functionality, forensic neuropathologists need a forensics LIMS that:

- Comes with pre-configured tests, templates, and case forms specific to neuropathology
- Fully supports imaging applications and management, typical to forensic neuropathology practice
- Fully supports a variety of standardized image formats with large file sizes

Forensic toxicology

A 2017 report by NFLIS indicated that among medical examiner/coroner offices surveyed, 96% of them outsourced their toxicology work to an off-site or reference [toxicology](#) lab.^[29] As such, the



toxicology functionality of a forensics LIMS may be of more importance to forensic crime labs than medical examiners offices. That said, such a LIMS should assist the lab with a variety of toxicology, chemistry, and pharmacology test methods. In addition to the base features of a forensics LIMS, the forensic toxicology lab will ask their LIMS to^{[25][30][31][32][33][34]}:

- Support industry-specific drug, alcohol, chemical (e.g., ethylene glycol) and gas (e.g., carbon monoxide) testing
- Support customizable drug panels and tests
- Provide management for compounds and compound grouping
- Provide toxicology-specific reporting formats supporting best practices
- Support the management of drug court cases associated with testing
- Provide trend monitoring

Forensic DNA and molecular testing

Like molecular and genetic diagnostics (i.e., its clinical counterpart), forensic molecular biology turns to a number of chemical, immunological, microscopic, and physical methods for extracting and interpreting DNA and other genetic materials. A wide array of methods encompass these activities, demanding a LIMS that is capable of managing the workflows and tools that assist the forensic molecular biologist. Along with the base LIMS functionality described prior, the forensic molecular biology lab will require its LIMS to^{[35][36][37][38][39][40][41]}:

- Support common testing for molecular biology, including methods and protocols for serology, short tandem repeat (STR) analyses, and mitochondrial DNA analyses
- Provide customized workflows for molecular and next-generation sequencing (NGS) testing, including FISH, PCR, gel electrophoresis, cytogenetics, and more
- Manage sample collection kits
- Track sample and aliquot lineage for cell lines, tissues, slides, etc.
- Track nucleic acid quantity and quality of samples or specimens
- Connect with third-party analytical software systems, e.g., probabilistic genotyping software
- Provide cleanly formatted rich-text reports customized for molecular diagnostics

Forensic anthropology and entomology

Given the specialized studies involved in these fields, any forensic LIMS will need to address the additional requirements they demand. In the case of forensic anthropology, in addition to base functionality, the LIMS needs to^{[42][43]}:

- Support high-resolution radiographic imaging
- Support the workflows and methods of analyzing bones and other hard remains
- For the forensic entomology LIMS, it should also^{[44][45][46][47][48][49]}



- Provide consistent terminology for insects and their capture methods
- Offer workflow support in-line with standardized forensic entomology methods
- Provide sample management and tracking functionality that reduces insect evidence collection errors and provides environmental monitoring of corpse temperatures
- Be able to differentiate between research activities and casework while still allowing for mining of both types of data and information

Conclusion

This brief topical article sought to answer "what are the key elements of a LIMS for forensics and medical examiners?" It notes that in particular, the forensics and medical examiners lab can be a diverse place, with a wide variety of disciplines and sub-disciplines being practiced inside and outside the lab, creating a wide variety of information and data and requiring a wide variety of methods and procedures. This is the type of environment where a LIMS can really shine when applied well. The LIMS continues to be adopted in these labs for good reason: they can improve efficiencies, manage workflows, improve information and data security, and better provide integrity to evidence and data provenance. This is especially important as workloads continue to increase for these labs and new drugs and other substances emerge.

A generic LIMS won't do for the forensics and medical examiners lab, however, requiring a software system that takes into account the wide variety of testing and workflow variations within the multi-disciplinary field of forensics. This software system may actually come in the form of a case management system or some variation thereof, but the modern LIMS is gradually starting to include case management functionality, along with sub-disciplinary forensics functionality. When examining the most common sub-disciplines, we find the base forensics LIMS, while useful, may require some additional functionality. The LIMS vendor may bake that into their solution, though they may also leave some aspects of extensibility to the user by making their solution highly configurable. Nevertheless, some functionality can't be added by the lab, leaving attentive LIMS vendors to include specialty functionality such as support for entomological terminology dictionaries and toxicological trend monitoring.

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