

# Quality management systems and the admissibility of scientific evidence: the Costa Rican experience

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## **ABSTRACT**

*Certainty and truth are, by definition, objectives of science. There is a tendency among people to believe that anything produced by a scientist is science and is therefore certain. On the contrary, scientific findings are not free of error. In fact, science evolves, among other things, by questioning and verifying the ideas and theories that are held to be scientifically valid and by continuously searching for new knowledge.*

*As judicial systems in several countries have evolved over time, they have established minimum criteria for the admissibility of scientific evidence in order to ensure accuracy as far as possible. Forensic laboratories in countries with such requirements have established quality systems as a tool for verifying the standards of the scientific information they provide to courts as evidence. The International Standard ISO/IEC 17025 has been chosen in testing laboratories, including forensic laboratories, to provide uniform technical criteria for developing a quality management system.*

*There is agreement between the ISO standard and admissibility requirements for courts. Therefore, the application of international quality standards to forensic laboratories is of interest to, and must be understood by, not only scientists but also judicial authorities. The present article describes the Costa Rican experience.*

**Keywords:** physical evidence; scientific evidence; system of justice; crime scene; forensic scientist; forensic laboratory; quality; quality management system; ISO/IEC 17025; standard operating procedure; inter-laboratory studies; occupational health

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## **Importance of quality for a forensic laboratory**

Requirements for the operation of a forensic laboratory vary in accordance with the level of experience and development of the justice system that the

laboratory serves, the importance that the system attaches to the quality of scientific evidence and the demands imposed by the judicial system in that respect.

That becomes clear when considering the potential consequences of ignorance on the part of the parties involved, including the judiciary, of the strengths and weaknesses of the scientific tools used to evaluate the physical evidence as part of the overall body of evidence and, even more so, when trying to understand the impact of those tools on how a given conclusion is reached. Today, it is generally accepted that physical evidence provides invaluable support in the conduct of criminal investigations, because it yields information that is equal in value to testimonial evidence, and more objective.

The ideal of science is to seek truth or certainty through the use of the scientific method. Experience over the centuries has shown that, generally speaking, scientific theories and ideas must be continually reviewed by the scientific community in order to reconfirm their validity or further develop them, by applying the appropriate scientific methods and principles to substantiate the results obtained.

Between the time it is collected at the crime scene and the moment when it is submitted to a court, physical evidence is given to a forensic scientist, who must examine and analyse it in order to obtain scientific results that provide useful information on the case under investigation, thus supporting or rejecting any theory formulated by the police or the investigating group. Those scientific results are communicated in writing (as an expert report) and orally (during an appearance in court). It is the forensic scientist's interpretation of the physical evidence that transforms it into scientific evidence.

Understanding the impact of scientific evidence on legal proceedings can significantly enhance a justice system, depending on that system's evidentiary requirements. It should be kept in mind, however, that, given its experimental nature, scientific evidence is not immune to error and must therefore meet minimum requirements before it can be deemed admissible. Lack of awareness of its limitations can give rise to complacent systems that consider anything labelled "scientific" to be true without first subjecting such evidence to a critical assessment.

Thus, there are general standards governing the methods used, the results obtained and the interpretation of those results by the forensic scientist that serve as guidelines for determining the admissibility of evidence. The courts of the United States of America widely use the following criteria, which have been adopted by other countries, as a guide for admitting scientific evidence:

- (a) The scientific technique or theory can be or has been tested;
- (b) The technique or theory has been submitted to prior review and publication;
- (c) The potential margin of error of the technique is known;
- (d) Standards for monitoring the application of the technique exist and are maintained;

- (e) The scientific theory has gained wide acceptance among the relevant sections of the scientific community;
- (f) The courts and the legal community accept the scientific findings concerned and use them as relevant evidence.

It is clear that the foregoing criteria broadly relate to the universal concept of quality. Today, no forensic laboratory concerned with quality could fail to incorporate a quality management system into its expert procedures because such systems are closely related to the basic, routine laboratory procedures that are so crucial to the justice system.

In Costa Rica, the Department of Forensic Science of the Judicial Investigation Bureau of the Judicial Power has adopted a strategic development plan to promote productivity and efficiency policies and improve the value of available expertise as scientific evidence, with the aim of obtaining conclusions of greater certainty, using due procedures with the help of a quality management system. The aims are spelled out in the vision and mission statement of the Department:

“Mission: to serve the administration of justice efficiently and effectively by integrating technical and scientific knowledge into analysis procedures, thus ensuring that evidence is collected in a lawful, useful and truthful manner.

“Vision: by constantly keeping up to date with the most recent advances in technical and scientific knowledge, to establish an organizational model for forensic science that serves as an example across the continent and, at the same time, to optimize analysis quality levels and production in order to respond to the needs and requirements of society.”

In short, the primary focus is on providing a better service to users without departing from the rules and standards for the admissibility and attainment of scientific results, which should be an integral part of both the concept of quality that experts are trained to respect and the development of an organizational culture.

The task of establishing and developing quality management systems in forensic institutions and laboratories, as an aspect of scientific and administrative development, has been undertaken not only in Costa Rica, by the Department of Forensic Science; it is a global trend that has been growing in recent years. As is happening in most countries, in developing a quality management system, the Department of Forensic Science has adopted ISO/IEC 17025 of the International Organization for Standardization (ISO), which provides the general requirements for the competence of testing and calibration laboratories, divided into two categories: management requirements and technical requirements. Given that the standard is of a generic nature, various institutions and groups have produced manuals and guides for applying the standard to forensics. Those have been used by the Department of Forensic Science for guidance on the implementation and application of ISO/IEC 17025.

ISO/IEC 17025 provides tools for ensuring compliance with the above-mentioned criteria determining the admissibility of scientific evidence, such as documentation control, development of standard operating procedures, validation of analytical methods and introduction of measures to ensure that the quality of analytical results is regulated and consistent. That helps to ensure that physical evidence can be used to provide scientific evidence by applying forensic scientific knowledge and skill in the analysis of evidence.

The Department of Forensic Science started to use ISO/IEC 17025 in implementing its quality management system during the first quarter of 2000. The strategic approach adopted was to provide training so that each of the Department's eight sections could achieve a basic level of quality assurance. During the initial phase, all staff members received training in the requirements of ISO/IEC 17025 and the applicable procedures. Department staff compiled lists of all the activities and expert tasks carried out in the various sections in order to learn the details of the individual procedures being used. As part of that process, a distinguished professional in the area of natural sciences with extensive experience in metrology was brought in to coordinate and promote quality assurance measures. At the same time, an induction process on the forensic science work carried out in the Department, lasting more than a year, was introduced.

The Department of Forensic Science also introduced training courses and lectures, given by both in-house staff and outside experts, on the subject of quality and forensics so that uniform standards could be achieved throughout the Department in matters relating to quality assurance and scientific development, with a view to fostering a culture of excellence in tandem with the move to improve quality, develop new scientific methods and modernize the administration of the Department. In other words, the strategic objectives proposed for the period 2000-2005 encompassed scientific and administrative development as well as the implementation of a quality management system.

In the context of that vision of development, one aspect of which is the establishment of a quality management system, there have been several major achievements.

### **Quality management system**

As part of the Department's quality management system, a quality manual to be used in every area covered by the system will be drafted. The manual will contain cross references to manuals on general and specific standard operating procedures, always taking into account the admissibility and the chain of custody of evidence. The general standard operating procedures include administrative processes such as procurement and documentation control, with the aim of achieving standardization in the various sections of the Department.

### ***Documentation control***

The control of documentation generated both outside and within the laboratory is an essential part of the quality management system because it ensures that

documentation is safe and accessible at all times, as required by chain-of-custody principles and regulations of Costa Rica.

The Department of Forensic Science now has lists of standard operating procedures, worksheets for experts, equipment operation manuals and bibliographic material. In addition, a single uniform system of physical and electronic archiving has been introduced to facilitate the storage and retrieval of the information generated.

Within the framework of a major project initiated by the judicial authorities in Costa Rica, the Department of Forensic Science is in the process of computerizing all its offices to provide an essential means of communication in areas such as the dispatch of advisory opinions and reports to various judicial offices. That computerized infrastructure is being developed on the basis of experience acquired during visits to forensic laboratories in Europe and will be used for information management within the quality management system, especially with regard to standard operating procedures. One of the recommendations made by laboratories consulted by the Department was that controls to ensure information security should be implemented as part of the computerization process, in order to show that information is safe from unauthorized modifications. One option is to install specialized software already available on the market. Alternatively, software could be built to suit the specific needs of the system.

### *Purchasing services and supplies*

The purchasing of services and supplies was considered a critical factor at meetings held under the auspices of the United Nations to promote regional integration in forensics, attended by the directors of eight forensic laboratories in the region.

One practical recommendation made in the course of the meetings was to draw up lists of possible suppliers of goods and services and establish systems for the technical assessment of those suppliers, in cooperation with the personnel in each country's procurement departments responsible for implementing and ensuring compliance with the administrative procedures involved in contracting.

Further, a computer system has been installed in the Department of Forensic Science to monitor, line by line, contracted materials, delivery dates and inventory flows, including the registration of data from the relevant suppliers.

The above-mentioned measures have enabled the Department of Forensic Science to maintain a uniform methodological standard in assessing the availability, accessibility and cost of materials for any contingency. Action has also been taken to establish control over possible sources of error caused by changes in reagent lots, for example. All this has had an impact on the proper functioning of the Department and on the efficiency and quality of its service.

### *Corrective actions*

A range of possible corrective actions has been incorporated into all standard operating procedures developed by the Department of Forensic Science, to deal with situations in which the criteria for the validity of results are not fulfilled.

### *Control of records*

One crucial aspect of a quality management system for forensic work is documenting the results of the work carried out. Thus, the Department of Forensic Science has set itself the task of rationalizing the recording of general information from expert worksheets and standardizing their formats. The Department now has lists and a general format for the preparation of expert worksheets, each of which has a code and a unique number to prevent mistaken identification.

Record control is considered to be vital to meeting the criteria for the admissibility of scientific evidence. In meeting those criteria, it becomes possible to maintain a manual or electronic record of the results of the various activities and tasks required by the standard operating procedures. Thus, results can be assessed and monitored by the person who generated them and by external experts wishing to check the reliability and the quality of the data underlying the conclusions of a given report.

### *Human resources*

The Department of Forensic Science has set up a prototype database to register all required staff information, such as academic training, courses and participation in inter-laboratory tests, on which each employee's initial assessment can be based.

It should be noted that in order to maintain the high level of competence that is established by the standards and the criteria for the admissibility of scientific evidence, forensic scientific knowledge must be constantly updated. That is a major obstacle for Cost Rica, because the country lacks formal or vocational university courses in forensics, which would enable the Department of Forensic Science to offer training and refresher courses to staff and thus avoid hiring external experts, which is a much more expensive and limited option.

The assistance provided through the United Nations has been important for the Department of Forensic Science, which has benefited from study tours, meetings of the directors of forensic laboratories in the region, regional internships and other activities generating feedback valuable for guiding the development of the Department in the area of forensic science.

The staff of the Department of Forensic Science have been an invaluable resource in the development activities carried out to date, because the limited nature of their international contacts and of their access to first-hand sources of information and to courses in specialized fields has been compensated by their determination in their constant search for information and in their experimental work.

### *Environmental conditions and security of custody*

One of the achievements of the Department of Forensic Science is the establishment of temperature- and humidity-controlled areas to carry out various expert tasks. They include special drying rooms for items of evidence that need to be dried, such as bloodstained clothes, and separate areas for processing those items of evidence that come from victims and those from the accused. Most storage areas have video cameras and digital access systems. Those are among the most crucial aspects of ensuring the authenticity and the integrity of the physical evidence required by the chain of custody, regardless of the system used.

### *Test and calibration methods and method validation*

Given the need for clearly described written procedures, the Department of Forensic Science has developed a master guide for the development of further standard operating procedures. It requires specific factors to be detailed, such as objective, scope, theoretical basis, symbols, equipment, reagents and reference materials, management of primary and secondary evidence, validation parameters, criteria for the acceptance or rejection of results, corrective action, uncertainty calculation and assessment, analysis and result reports and bibliography. Those procedures are based on methods and techniques accepted by the international scientific community—a crucial factor for the admissibility of scientific evidence—or on internally developed methods and techniques combined with appropriate checks and adjustments to ensure their correct use.

A basic requirement in this area is the validation of analytical methods and uncertainty calculations. To that end, procedures can draw on international publications such as *The Fitness for Purpose of Analytical Methods: Laboratory Guide to Method Validation and Related Topics from Eurachem* and the *Guide to the Expression of Uncertainty in Measurement* by ISO and the Bureau international des poids et mesures. One of the six criteria for the admissibility of scientific evidence is knowing the potential margin of error of a technique. The process of validation and uncertainty calculations are two tools that can be of assistance in that connection; they also provide an opportunity for verification by any of the parties involved in legal proceedings.

### *Equipment*

The maintenance and the calibration and/or verification of equipment are of crucial importance for the values or results obtained, which have a significant impact on the final outcome of an analysis.

Since the end of 2002, having succeeded in making its administrative bodies aware of the importance of maintaining and calibrating the instruments used to obtain analytical data, the Department of Forensic Science was able gradually to implement, as part of its management plan, a preliminary programme involving contracting out the relevant services. In addition, drafts of the

standard operating procedures for various items of equipment were drawn up, establishing the basic steps to be taken for the daily or periodic verification of the condition of that equipment.

Unfortunately, over the past year, the costs of maintenance, calibration and/or verification services have unexpectedly increased by up to 70 per cent. As a result, it has become necessary to consider options such as transferring responsibility for some services, especially verification and/or calibration, to Department staff. If that course of action is followed, the Department will require service manuals, which are not traditionally included in procurement contracts, for each item of equipment. In addition, staff would need to be trained to carry out the work.

### *Measurement traceability*

Of particular importance is the use of reference materials, which are indispensable both for validating analytical methods and for checking day-to-day measurements and how the technical procedures are carried out. Those actions are essential to determining the admissibility of scientific evidence. In that regard, control charts play a crucial role in monitoring the variability of processes over time.

In recent years, the Department of Forensic Science has made efforts to obtain reference materials, including certified reference materials, both through the United Nations International Collaborative Exercises programme and by purchasing them from private companies. Laboratories should invest in the acquisition of such materials, since they are indispensable for those carrying out specific analyses and tests.

Sometimes, however, it is extremely difficult to find certain materials, owing to the nature of the samples analysed by forensic laboratories. Further, the situation can be particularly serious in the case of certified reference materials, which are prohibitively expensive.

### *Handling of test and calibration items*

With regard to the handling of test and calibration items, since 2000, the Department of Forensic Science has been promoting a project on the use of bar codes and a digital system to register and generate labels for identifying and locating items of evidence, request forms and samples. The project is already at the implementation stage, especially in the area of DNA, thanks to the support of the Computer Science Department of the Judicial Power. It is hoped that the project will be fully implemented throughout the Department of Forensic Science within the next two years. Such controls are commonly used in many forensic laboratories around the world, enabling evidence and documentation to be handled more expeditiously and objectively.

### *Assuring the quality of test and calibration results*

Forensic institutions have widely adopted inter-laboratory study programmes and proficiency tests as a means of assuring the quality of results, because those

two verification procedures are considered to be among the most objective mechanisms for monitoring the proper operation of the techniques used, which is a requirement for determining the admissibility of scientific evidence.

Accordingly, over the past two years, the Department of Forensic Science has participated in 12 different types of inter-laboratory studies—on DNA, paints, fibres, accelerants, tool marks, ballistics, seized drugs, drugs in biological specimens, alcohol in blood, and clinical chemical analyses such as pregnancy tests and urinalyses—and obtained satisfactory results. The Department has, however, encountered difficulties in arranging inter-laboratory studies relating to all disciplines or types of analysis, perhaps owing to its geographical location and the lack of a regional forensic organization to promote such studies. In a recent report to the United Nations, Costa Rica proposed that support be provided for a body similar to the European Network of Forensic Science Institutes (ENFSI) and the American Society of Crime Laboratory Directors (ASCLD). With significant support from the Guardia Civil of Spain, the Latin American Academy of Criminalistics and Forensic Studies (AICEF) was established last year, in Bogotá, Colombia. The Academy's membership includes almost all official forensic laboratory directors from Latin America, Spain and Portugal. Like ENFSI, it works to develop forensic science and the standardization of procedures and quality assurance in all member countries; those standards include a code of conduct and collaboration agreements. The organization is expected to conduct inter-laboratory tests in the near future.

It should be mentioned that the United Nations International Collaborative Exercises, which cover seized drugs and drugs in biological specimens, have given Costa Rica invaluable experience in monitoring the technical competence of the laboratory of the Department of Forensic Science in those areas and in finding more selective and accurate analytical methods.

### *Scientific development*

Scientific development is an extremely important aspect of an integrated quality management system. For that reason, modernizing the skills and improving the service quality and the response times of the various sections have been central issues for the Department of Forensic Science.

In that connection, several initiatives have been adopted in the laboratory during the transition phase under way:

(a) The Department of Forensic Science is promoting the automation of the drug analysis equipment used in analytical chemistry and toxicology and the use of analytical techniques such as solid-phase extraction and microextraction;

(b) The Department now uses instrumental techniques such as gas chromatography, gas chromatography/mass spectrometry, liquid chromatography, liquid chromatography/mass spectrometry, Fourier transform infrared spectroscopy and plasma emission spectroscopy to confirm analytical results for various kinds of matrix;

(c) The Gunpowder and Explosives Unit now issues reports on specialized subjects such as firing distances and gunpowder residues on hands, compiled using instrumental methods for corroboration. Also, the Central Evidence Inspection Unit has been established in response to the need for a central area in the Department of Forensic Science where packages of trace evidence can be opened, the trace evidence described and preserved and, as part of the same process, samples can be taken using, among other things, CrimeScope alternative light sources, for dispatch to the various sections;

(d) One major advance in recent years has been the automation of DNA analysis, using ABI PRISM 310 and 3100-Avant sequencers;

(e) The analysis of mitochondrial DNA has been introduced, resulting in far fewer tentative results than did the morphological tests formerly carried out on hair samples, and use of the technique has been extended to other kinds of samples, such as body fluids, blood, fingernails and bone;

(f) A more efficient method of extracting DNA from bone remains has been introduced. Faced with the impossibility of obtaining amplifiable DNA from some bone remains that had been exhumed or which had been discovered after lengthy exposure to the elements, the DNA Unit of the Department of Forensic Science decided that it needed an alternative method specifically for such cases. The method adopted was that used by the DNA Analysis Unit of the Federal Bureau of Investigation. That has made it possible to obtain DNA profiles in some cases where the previously used routine method failed. The new method has become the method of choice, with the additional advantages of taking less time and costing less;

(g) Progress has been made in the conduct of analyses using forensic digital photography and in the use of three-dimensional computer animation for accident reconstruction and crime scenes, among other things;

(h) In the field of toxicology, work has continued on implementing new methods of instrumental analysis. That has enabled the Department of Forensic Science to corroborate many results that, in the past, had to be reported in a tentative fashion owing to the lack of a method with the specificity needed to meet international standards. Foremost among those new methods is blood-alcohol analysis.

It is important to note that a quality management system may be established in any laboratory, regardless of the analytical instruments at its disposal. The most important factors in establishing such a system are the commitment of staff, their knowledge of the scope and the implications of the work involved, their mastery of the methods used and their strengths and weaknesses in terms of providing satisfactory advice to the courts about the significance of the results and conclusions. The laboratory of the Department of Forensic Science is a good example of that because it has evolved in a sustained manner over recent years, though many problems have yet to be overcome, such as that of tentative analyses that need to be replaced or supplemented by corroborative analyses. Many laboratories worldwide have already transcended those limitations. This

situation has not, in any case, proved to be an obstacle in implementing a quality management system while gradually improving the level of performance.

## Occupational health

In addition to the above-mentioned achievements, there has been an improvement in the measures for ensuring the safety and occupational health of staff of the Department of Forensic Science. One objective in that regard has been to improve the management of solid waste, especially biological waste. To that end, the Department has purchased materials and equipment such as containers designated for specific types of waste, masks, safety goggles, needle disposal units, sterilization bags and protective clothing for the management of dangerous substances. In addition, all staff have been trained in areas such as the management and disposal of infectious waste.

The level of development achieved by the Department of Forensic Science has been surpassed by many forensic laboratories in the world; however, since the establishment of the Department in 1974 and, above all, in the past five years, efforts have been directed towards constant further development, in a quest to achieve a level considered average by international standards. In addition to strengthening the justice system in Costa Rica, that would allow expert results produced by the Department to be accepted by courts elsewhere, in the context of the globalization of crime. Another aim of these efforts is to create greater opportunities for cooperating and sharing information and experience with forensic laboratories worldwide.

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