THE NAS RECOMMENDATIONS FOR EVALUATION OF THE FORENSIC DISCIPLINES

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JSM 2011

Topics

- The NAS Committee
  - Background and process.
  - The NAS Committee: Major recommendation
  - Report recommendations on research, standards, and education
- Evaluation of accuracy of forensic analyses
  - Concepts for scientific evaluation
  - Errors and error rates
  - Learning from other fields

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CHALLENGES FACING THE FORENSIC SCIENCE COMMUNITY

1. Disparities in the Forensic Science Community
2. Lack of Mandatory Standardization, Certification, and Accreditation
3. Broad Range of Forensic Disciplines
4. Problems Relating to the Interpretation of Forensic Evidence
5. Need for Research to Establish Limits and Measures of Performance
6. Admission of Forensic Science Evidence in Litigation
7. Political Realities

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WHAT IS NEEDED

1. The forensic science enterprise needs strong governance to adopt and promote an aggressive, long-term agenda to help strengthen the forensic science disciplines.
2. Governance must be strong enough—and independent enough—to identify the limitations of forensic science methodologies, and must be well connected with the nation's scientific research base to effect meaningful advances in forensic science practices.
3. The governance structure must be able to create appropriate incentives for jurisdictions to adopt and adhere to best practices and promulgate the necessary sanctions to discourage bad practices.
4. It must be able to identify standards and enforce them.

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WHAT IS NEEDED, cont'd

5. The governance structure must have influence with educators in order to effect improvements to forensic science education.
6. It must be able to identify standards and enforce them.
7. A governance entity must be geared toward (and be credible within) the law enforcement community, but it must have strengths that extend beyond that area.

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A NEW AGENCY FOR FORENSIC SCIENCE

- The problems at issue are too serious and important to be subsumed by an existing federal agency.
- No existing federal agency has the capacity or appropriate mission to take on the roles and responsibilities needed to govern and improve the forensic science enterprise.
- What is needed to support and oversee the forensic sciences community is a new, strong, and independent entity that could take on the tasks that would be assigned to it in a manner that is as objective and free of bias as possible.

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COULD A GOVERNING ENTITY BE ESTABLISHED WITHIN AN EXISTING FEDERAL AGENCY?

- National Science Foundation and National Institute of Standards and Technology considered, but the committee concluded that neither NSF nor NIST has the breadth of experience or institutional capacity to establish an effective governance structure for the forensic science enterprise.
- Department of Justice considered, but DOJ's principal mission is to enforce the law and defend the interests of the United States according to the law and the research funding strategies of DOJ have not adequately served the broad needs of the forensic science community.
- The entity that is established to govern the forensic science community cannot be principally beholden to law enforcement. The potential for conflicts of interest between the needs of law enforcement and the broader needs of forensic science are too great.

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HOW SHOULD THIS ENTITY LOOK?

The new entity must be an independent federal agency established to address the needs of the forensic sciences community, and it must meet the following minimum criteria:

- **Must have a culture strongly rooted in science, with strong ties to the national research and teaching communities, including federal labs.**
- **Must not be part of a law enforcement agency.**
- **Must have funding, independence, and sufficient prominence to raise the profile of the forensic science disciplines and push effectively for improvements.**

No federal agency currently exists that meets all criteria.

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MAJOR RECOMMENDATION

- **Recommendation 1:**

  To promote the development of forensic science into a mature field of multidisciplinary research and practice, founded on the systematic collection and analysis of relevant data, Congress should establish and appropriate funds for an independent federal entity, the National Institute of Forensic Science (NIFS).

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MAJOR RECOMMENDATION, Continued

NIFS should focus on:

- **establishing and enforcing best practices for forensic science professionals and laboratories;**
- **establishing standards for the mandatory accreditation of forensic science laboratories and the mandatory certification of forensic scientists and medical examiners/forensic pathologists—and identifying the entity/entities that will develop and implement accreditation and certification;**
- **promoting scholarly, competitive peer-reviewed research and technical development in the forensic science disciplines and forensic medicine;**
- **developing a strategy to improve forensic science research and educational programs, including forensic pathology;**

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MAJOR RECOMMENDATION, Continued

- **establishing a strategy, based on accurate data on the forensic science community, for the efficient allocation of available funds to give strong support to forensic methodologies and practices in addition to DNA analysis;**
- **funding state and local forensic science agencies, independent research projects, and educational programs as recommended in this report, with conditions that aim to advance the credibility and reliability of the forensic science disciplines;**
- **overseeing education standards and the accreditation of forensic science programs in colleges and universities;**
- **developing programs to improve understanding of the forensic science disciplines and their limitations within legal systems; and**
- **assessing the development and introduction of new technologies in forensic investigations, including a comparison of new technologies with former ones.**

RECOMMENDATIONS 2-13 address:

- Standardized Terminology and Reporting
- More and Better Research
- Best Practices and Standards
- Quality Control, Assurance, and Improvement
- Codes of Ethics
- Insufficient Education and Training
- The Medicolegal Death Investigation System
- AFIS and Database Interoperability
- Forensic Science Disciplines and Homeland Security

MORE AND BETTER RESEARCH

- Recommendation 3:
  - Research is needed to address issues of accuracy, reliability, and validity in the forensic science disciplines. The National Institute of Forensic Science should competitively fund peer-reviewed research in the following areas:
    1. Studies establishing the scientific bases demonstrating the validity of forensic methods.

MORE AND BETTER RESEARCH, cont.

2. The development and establishment of quantifiable measures of reliability and accuracy of forensic analyses. Studies of the reliability and accuracy of forensic techniques should reflect actual practice on realistic case scenarios, averaged across a representative sample of forensic scientists and laboratories. …The research by which measures of reliability and accuracy are determined should be peer reviewed and published in respected scientific journals.
3. The development of quantifiable measures of uncertainty in the conclusions of forensic analyses.
4. Automated techniques capable of enhancing forensic technologies.

RESEARCH ON HUMAN FACTORS

Recommendation 5:

- The National Institute of Forensic Science (NFIS) should encourage research programs on human observer bias and sources of human error in forensic examinations.
- Such programs might include studies to determine the effects of contextual bias in forensic practice.
- Research on sources of human error should be closely linked with research conducted to quantify and characterize the amount of error.

EDUCATION AND TRAINING

Recommendation 10:

- To attract students in the physical and life sciences to pursue graduate studies in multidisciplinary fields critical to forensic science practice, Congress should authorize and appropriate funds to the National Institute of Forensic Science (NIFS) to work with appropriate organizations and educational institutions to improve and develop graduate education programs designed to cut across organizational, programmatic, and disciplinary boundaries.
- Emphasis should be placed on developing and improving research methods and methodologies applicable to forensic science practice and on funding research programs to attract research universities and students in fields relevant to forensic science.
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BEST PRACTICES AND STANDARDS

Recommendation 6:

1. Congress should authorize and appropriate funds to NIFS to work with the National Institute of Standards and Technology (NIST), in conjunction with government laboratories, universities, and private laboratories, and in consultation with Scientific Working Groups, to develop tools for advancing measurement, validation, reliability, information sharing, and proficiency testing in forensic science and to establish protocols for forensic examinations, methods, and practices.
2. Standards should reflect best practices and serve as accreditation tools for laboratories and as guides for the education, training, and certification of professionals.

BEST PRACTICES AND STANDARDS, cont

3. NIFS should develop standard operating procedures (that will lay the foundation for model protocols) to minimize, to the greatest extent reasonably possible, potential bias and sources of human error in forensic practice.
4. These standard operating procedures should apply to all forensic analyses that may be used in litigation.

QUALITY CONTROL, ASSURANCE, AND IMPROVEMENT

Recommendation 7:

1. Laboratory accreditation and individual certification of forensic science professionals should be mandatory, and all forensic science professionals should have access to a certification process.
2. In determining appropriate standards for accreditation and certification, the National Institute of Forensic Science (NIFS) should take into account established and recognized international standards, such as those published by the International Organization for Standardization (ISO).

QUALITY CONTROL, ASSURANCE, AND IMPROVEMENT, cont.

3. No person (public or private) should be allowed to practice in a forensic science discipline or testify as a forensic science professional without certification.
4. Certification requirements should include, at a minimum, written examinations, supervised practice, proficiency testing, continuing education, recertification procedures, adherence to a code of ethics, and effective disciplinary procedures.
5. All laboratories and facilities (public or private) should be accredited, and all forensic science professionals should be certified, when eligible, within a time period established by NIFS.

QUALITY CONTROL, ASSURANCE, AND IMPROVEMENT, cont

Recommendation 8:

- Forensic laboratories should establish routine quality assurance and quality control procedures to ensure the accuracy of forensic analyses and the work of forensic practitioners.
- Quality control procedures should be designed to:
  - identify mistakes, fraud, and bias;
  - confirm the continued validity and reliability of standard operating procedures and protocols;
  - ensure that best practices are being followed;
  - correct procedures and protocols that are found to need improvement.

STANDARDIZED TERMINOLOGY AND REPORTING

Recommendation 2:

- The National Institute of Forensic Science (NIFS), after reviewing established standards such as ISO 17025, and in consultation with its advisory board, should establish standard terminology to be used in reporting on and testifying about the results of forensic science investigations.
- Similarly, it should establish model laboratory reports for different forensic science disciplines and specify the minimum information that should be included.
- As part of the accreditation and certification processes, laboratories and forensic scientists should be required to utilize model laboratory reports when summarizing the results of their analyses.

CODES OF ETHICS

Recommendation 9:

- The National Institute of Forensic Science (NIFS), in consultation with its advisory board, should establish a national code of ethics for all forensic science disciplines and encourage individual societies to incorporate this national code as part of their professional code of ethics.
- Additionally, NIFS should explore mechanisms of enforcement for those forensic scientists who commit serious ethical violations.
- Such a code could be enforced through a certification process for forensic scientists.

ORGANIZATION AND GOVERNANCE

Recommendation 4:

- To improve the scientific bases of forensic science examinations and to maximize independence from or autonomy within the law enforcement community, Congress should authorize and appropriate incentive funds to the National Institute of Forensic Science (NIFS) for allocation to state and local jurisdictions for the purpose of removing all public forensic laboratories and facilities from the administrative control of law enforcement agencies or prosecutors' offices.

THE MEDICOLEGAL DEATH INVESTIGATION SYSTEM

Recommendation 11:

To improve medicolegal death investigation:

- Congress should authorize and appropriate incentive funds to the National Institute of Forensic Science (NIFS) for allocation to states and jurisdictions to establish medical examiner systems, with the goal of replacing and eventually eliminating existing coroner systems
- Congress should appropriate resources to the National Institutes of Health (NIH) and NIFS, jointly, to support research, education, and training in forensic pathology.

AFIS AND DATABASE INTEROPERABILITY

Recommendation 12:

- Congress should authorize and appropriate funds for the National Institute of Forensic Science (NIFS) to launch a new broad-based effort to achieve nationwide fingerprint data interoperability.
- Standards for representing and communicating image and minutiae data among Automated Fingerprint Identification Systems. Common data standards would facilitate the sharing of fingerprint data among law enforcement agencies at the local, state, federal, and even international levels, which could result in more solved crimes, fewer wrongful identifications, and greater efficiency with respect to fingerprint searches; and
- Baseline standards—to be used with computer algorithms—to map, record, and recognize features in fingerprint images, and a research agenda for the continued improvement, refinement, and characterization of the accuracy

FORENSIC SCIENCE DISCIPLINES AND HOMELAND SECURITY

Recommendation 13:

Congress should provide funding to the National Institute of Forensic Science (NIFS) to prepare, in conjunction with the Centers for Disease Control and Prevention and the Federal Bureau of Investigation, forensic scientists and crime scene investigators for their potential roles in managing and analyzing evidence from events that affect homeland security, so that maximum evidentiary value is preserved from these unusual circumstances and the safety of these personnel is guarded.

EVALUATING THE ACCURACY OF FORENSIC ANALYSES

An approach to defining and quantifying (some) types of error

Overview

- Forensic sciences draw from across a very broad spectrum of scientific disciplines.
- Scientific analysis and reporting of results needs to account for ***uncertainty*** about conclusions
- Important theme in forensic analysis: ***Errors and error rates***
- Evaluating the ***accuracy*** of forensic analyses:
  - Borrowing from the paradigm of diagnostic testing

Forensic sciences are interdisciplinary

Examples

Molecular biology
- Nuclear DNA analysis
- Mitochondrial DNA analysis

Pattern recognition
- Fingerprint analysis
- Handwriting

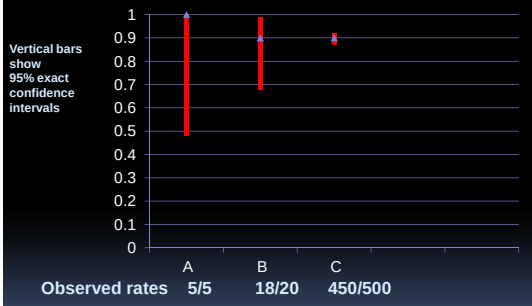
Analytical Chemistry

Hair and fiber analysis

Uncertainty and errors

- **Results of scientific analyses are subject to uncertainty.**
- **Example:** Success of forensic laboratory in a classification task
  - Laboratory A: 5 successes in 5 cases (100%)
  - Hospital B:18 successes in 20 cases (90%)
  - Hospital C: 450 successes in 500 cases (90%)
- **Questions:**
  - Do we have same uncertainty about the true success rate in Labs B and C?
  - Can Lab A claim their true success rate is 100%?

Observed rates of success and estimates of true rates with confidence intervals, showing statistical uncertainty



Questions and answers

- Questions:
  - Do we have same uncertainty about the true success rate in Hospitals B and C?

  No. The uncertainty about the rate in hospital C is considerably smaller.
  - Can Hosp. A claim their true success rate is 100%?

  No. With confidence 95%, the true rate could be as low as 48%.

Errors and error rates

- Fuzzy use of language. Need to state precisely the error under consideration.
- Examples:
  - Laboratory analyses are subject to **measurement error** (i.e. uncertainty about true quantity)
  - Fingerprint analyses can lead to **false identification** of individual prints, e.g. because of observer error, low specimen quality, etc
  - DNA analyses can lead to **false identification** of individuals, e.g. because of contamination of samples, laboratory errors, etc

Step 1 in the evaluation of the accuracy of forensic analyses : Define the task

- Individualization:
  - Can a piece of evidence be associated with a particular source?
- Classification:
  - Can a piece of evidence be associated with a particular class of sources?
- A few modalities have potential for individualization.
- More of them have potential for classification.

Keep evaluation focused on the task

- **Individualization:**
  - **Can a piece of evidence be associated with a particular source?**
- **Classification:**
  - **Can a piece of evidence be associated with a particular class of sources?**
- **Avoid "mission creep"**

Measuring accuracy

- Borrowing from the paradigm of diagnostic testing
- The well known 2x2 table for dichotomous test and truth:

	Forensic analysis results	
Truth	**"yes"**	**"no"**
"yes" (Target condition present)	**True Positives**	**False Negatives**
"no" (Target condition absent)	**False Positives**	**True Negatives**

Objective: Detection

- Sensitivity: Probability that analysis will find target condition, when target condition is present.
- Specificity: Probability that analysis will declare target condition is not there when target condition is absent.

Measures of error: 1-sensitivity, 1- specificity

	Hair analysis results	
Truth	**Class C**	**Not Class C**
Hair comes from individual in class C	**TP**	**FN**
Hair comes from individual not in C	**FP**	**TN**

Errors!

Objective: Detection

- Sensitivity: Probability that analysis will find target condition, when target condition is present.
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	Hair analysis results	
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$$\text{spec} = \frac{TN}{FP + TN}$$

Objective: Prediction

- Positive Predictive Value : Probability target condition is actually present when analysis says it is.
- Negative Predictive Value: Probability target condition is absent when analysis says it is not there.

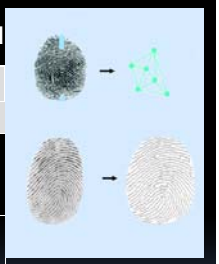
Measures of error: 1-PPV, 1- NPV

	Hair analysis results	
Truth	**Class C**	**Not Class C**
Hair comes from individual in class C	TP	FN
Hair comes from individual not in C	FP	TN

Errors!

Approach also useful for individualization studies

Hypothetical fingerprint study:
A set of pairs of prints is analyzed



	Analysis results	
Truth	**match**	**No match**
Pair of prints comes from same individual	TP	FN
Pair of prints comes from different individuals	FP	TN

Errors!

Designing studies of accuracy

- Measures of accuracy can be estimated via designed studies.
- Accuracy likely to be influenced by several factors that should be part of the experimental design:
  - "Difficulty" of cases ("case mix")
  - Experience and training of analysts
  - Contextually available information
- Ideally, we need to know
  - **average accuracy (across analysts, laboratories etc)**
  - **range (variability) of accuracy (across analysts, laboratories etc)**

Implementing the accuracy paradigm

- **This paradigm of accuracy assessment can be useful in many settings.**
- **It requires substantial research effort.**
- **It does not address important questions in individualization:**
  - **Definition of "match"**
  - **Estimation of random match probabilities**
- **Of key importance in judicial setting:**
  Paradigm addresses performance *over repeated instances* of the analysis. It does *not* necessarily guarantee the correct answer in a *specific case*.

In summary

- Several types of errors and error rates are of interest.
- Studies of accuracy of forensic analyses
  - Define the task!
  - Define measures of accuracy.
  - Conduct experiments.
  - Monitor practice.