



Professional Review and Commentary^a

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Forensic Science Review's Professional Review and Commentary (R&C) section highlights contemporary issues and events in the profession of forensic science. To contribute updates or commentary or to recommend books for review, please contact Mike Baylor (mbaylor@nc.rr.com), Jeff Teitelbaum (Jeff.Teitelbaum@wsp.wa.gov), or Ray Liu (rayliu@uab.edu).

^aThe views expressed are those of the authors and do not necessarily reflect the view, the position, or the policy of *Forensic Science Review* or members of its editorial board.

FORENSIC SCIENCE AROUND THE WORLD

This article provides a brief history and a description of the laboratory systems adopted by the different states, federal laboratories, and an overview of the private forensic laboratories. It is the first in a three-part series on the origins and current status of forensic science in the United States. Part II will focus on forensic pathology and the coroner/medical examiner system along with the challenges faced by forensic pathologists. Finally, Part III will address the key strengths and challenges for forensic science in the United States as well as look at future directions for the field.

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Forensic Science in the United States. I: Historical Development and the Forensic Science Laboratory System

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Historical Development

The 1800s

Forensic science in the US has developed primarily through the efforts of law enforcement and academic researchers. Well before it became a recognized field, forensic evidence was accepted and presented in court. As shown in **Table 1** [1], bullet and hair comparisons, gunshot residue, and fingerprints as well as expert testimony had all been accepted as evidence. The Federal Bureau of Alcohol, Tobacco, and Firearms (ATF) established its first laboratory to test alcohol products in 1886.

Microscopes and cameras were the dominant tools used by the experts of this period. Documents, fingerprints, drugs, fibers and fabrics, hair, and even blood underwent microscopic examination. However, there were no standards for maintaining a chain of custody, preserving the evidence in its original condition, or informing the defense of its existence. Experts were also publishing their work, much of it in microscopy journals. This was the period of the generalist, often self-taught.

1900–1950: Forensic Science Laboratories

Forensic science did not significantly progress in the early 1900s, possibly due to a transition of microscopy research to industrial applications, not being valued by police agencies, and the coroner versus medical examiner system in the US. The only recognized publications in the field were the *Journal of Criminal Law and Criminology* and the *Fingerprint Magazine*, established in 1910 and 1919, respectively. The former is still in print and *Fingerprint Magazine* continued as *Fingerprint and Identification Magazine* until 1972. Two developments in the early 1900s did result in the formation of forensic laboratories in many cities and states. One was the adoption of fingerprints for identification in court and the establishment of bureaus of identification. Many of the bureaus began adding evidence processing to their analyses. The second was the growth of firearms examination, through the works of Charles E. Waite and Calvin Goddard, who together established the Bureau of Forensic Ballistics of New York City [1].

The first standard for the acceptance of expert witness testimony was established in 1923 by the US Supreme Court's ruling in *Frye v. the United States* [2]. Testimony relating to a lie detector test based on systolic blood pressure was rejected because the method was novel, setting the standard of general acceptance by the relevant scientific community for the admissibility of expert testimony.

The first publicly funded crime laboratory was established by August Vollmer, chief of the Los Angeles (LA) Police Department, in 1923 and many cities and states established crime laboratories between 1925 and 1950.

Table 1. Early appearances of forensic evidence in US courts [1]

Year	Area	Forensic evidence
1840–1857	Questioned documents	Primarily civil cases
1868	Crime scene	Found marking on wrapping paper made by a clerk
1876	Soil comparison	Inconclusive
1876	Blood stains	No further information
1876	Firearms	How recently a firearm was discharged
1896	Firearms	Gunshot residue, results of test fires
1879	Firearms	Bullet comparison eliminated one firearm, consistent with a second
1884	Hair comparison	Not hair, but a cotton fiber
1892	Hair comparison	Not the suspect's hair, but from the suspect's dog
1893	Blood patterns	Bloodstains on a weapon
1894	Fingerprints	Express agent convicted of robbing a safe
1902	Firearms	Effect of rifling and markings on gun barrel on a bullet

The first state forensic laboratory, the California State Division of Criminal Identification and Investigation, was established in 1931. Most local and state laboratories were imbedded within a police agency, though a few were associated through the coroner's or district attorney's office. As the early years of this time period coincided with the Great Depression, the laboratories were often severely underfunded and employees were pulled from the ranks of police officers.

The founding date for early state and municipal laboratories are listed in **Table 2**. Two state laboratories were established independently of law enforcement, the Alabama Department of Forensic Sciences in 1935 and the Wisconsin State Crime Laboratories in 1937. Both were established by mandate of the state legislatures.

Federal forensic laboratories were also established during this time. The Federal Bureau of Investigation (FBI) Technical Laboratory opened in 1932 and included support of law enforcement, intelligence, and the military as part of its mission [3]. The US Postal Service (1940) [4], the US Army (1943) [5], the Treasury Department (1921), the Veterans Administration (1939), and Customs and Border Patrol (1936) [6] also established forensic laboratories during this time. The first US Army Criminal Investigation Laboratory (USACIL) was established in Algiers, French North Africa, during World War II, focusing on internal and battlefield investigations.

The earliest organization of forensic scientists was the International Association for Criminal Identification (now the International Association of Identification, IAI) started in 1915 by Inspector Harry H. Caldwell of the Oakland (CA) Police Department's Bureau of Identification and a group of 22 "criminal identification" operators [7]. The interest in forensic science was evident through the symbol adopted to represent the new organization: a set of Bertillon head calipers clasp a fingerprint (**Figure 1**). The objectives of the IAI include education, research, and advancement in the forensic sciences [8]. The organization recognizes 11 areas of forensic science, including biometrics information services, bloodstain pattern identification, crime scene investigation, digital & multimedia evidence, facial identification, footwear and tire track examination, forensic art, forensic photography and electronic digital imaging, general forensic disciplines, latent prints/latent print development, tenprint fingerprint. The *Journal of Forensic Identification* is published by the IAI.

The American Academy of Forensic Sciences (AAFS) [9] was an outcome of the First American Medicolegal Congress held in December of 1948 and the first organizational meeting was held in October of the same year. In both cases, 'American' includes the 23 countries in North America [10]. Currently, AAFS has 6,600 members from

Table 2. Early forensic crime laboratories

City laboratory	Year established	State laboratory	Year established
Philadelphia, PA	1926	California	1931
Detroit, MI	1927	Michigan	1932
Oklahoma City, OK	1930	West Virginia	1932
St. Louis, MO	1935	Alabama	1935
Toledo, OH	1937	New York	1936
Honolulu, HI	1938	New Jersey	1936
Newark, NJ	1939	Indiana	1936
Kansas City, MO	1939	Wisconsin	1937



Figure 1. The original emblem, adopted by the International Association for Criminal Identification (now International Association of Identification) at its first convention in 1915, composed of a pair of Bertillon head calipers, showing Sir Francis Galton's right fore fingerprint (appeared in the front of Galton's book, *Finger Print*, published in 1892) between the branches (https://theiai.org/history_emblem.php).

71 countries. The goal of the AAFS is to promote justice and integrity in forensic science. The AAFS membership is organized into sections by discipline with criminalistics being the largest as it includes the natural and physical sciences: biology, chemistry, DNA, mathematics, physics, firearms/tool marks, and trace evidence. With the newly approved nursing discipline [11], there are now 12 sections: Anthropology, Criminalistics, Digital & Multimedia Sciences, Engineering & Applied Sciences, General, Jurisprudence, Forensic Nursing Science, Odontology, Pathology/Biology, Psychiatry & Behavioral Science, Questioned Documents, and Toxicology. The *Journal of Forensic Sciences* is the official journal for the Academy.

Courses in forensic science, then called criminology, were offered as early as 1916 at the University of California at Berkeley (Berkeley, CA), and a bachelor's degree in criminology was offered in 1931. The Bachelor of Science in criminalistics was first offered by Michigan State University (East Lansing, MI), in 1949.

1950–2000: Scientific Growth and Expert Witness Testimony

The latter half of the 20th century saw rapid growth in the number of publicly funded forensic crime laboratories, several US Supreme Court decisions on the admissibility of evidence and expert witness, and the introduction of modern analytical instrumentation and DNA typing. In the

late 1960s, there were state-level crime labs in 33 states, 40 municipal crime labs, and 32 such labs in local police departments that handled 312,459 cases. Civilian forensic scientists were more likely to hold a college degree than police personnel, and all laboratories were involved in expert witness testimony. More laboratories were equipped with a comparison microscope than a gas chromatograph and none had a mass spectrometer [12].

Increase in the Number of Crime Laboratories. An 83% increase in crime and drug abuse during the late '60s and '70s led to several federal initiatives for increasing the availability of forensic science services to law enforcement. In 1968, the Omnibus Crime Control and Safe Streets Act [13] created the Law Enforcement Assistance Administration (LEAA), which provided funding for state and local laboratories. LEAA also provided a small level of funding for forensic science research. In 15 years, the number of publicly funded laboratories grew to more than 300. Contrary to established opinion that forensic laboratories should be independent of law enforcement were the findings that police departments were more likely to utilize the services of the forensic scientists if the lab was in close proximity [14].

Along with accessing the needs of forensic laboratories, there was also a focus on quality assurance. The LEAA funded certification boards in criminalistics, questioned documents, toxicology, and proficiency testing. While drug testing and blood typing fared well in proficiency testing, issues in the comparative sciences were identified. A national proficiency test involving 204 laboratories highlighted the range of proficiencies across the publicly funded forensic laboratories [15]. Collaborative Testing Services, Inc. (CTS) began a fee-based proficiency testing program in 1978 [16]. A Crime Laboratory Accreditation Program was established by the American Society of Crime Laboratory Directors (ASCLD) and the Illinois State Police Division of Forensic Services was the first laboratory to be accredited in 1982 [17].

Multiple US Supreme Court rulings also led to promoting reliance on physical evidence in police investigations. The first was the 1966 Supreme Court ruling in *Miranda v. Arizona*, which established that suspects must be informed that they are not required to answer questions and that they have a right to legal representation. Greater reliance on physical evidence reduced the abuse of suspects during interrogation [18] and tripled the clearance rate for cases [19]. In 1975, the Federal Rules, including Rule 702, Testimony by Expert Witnesses, were adopted by the Supreme Court. Rule 702 established that an expert witness was qualified by knowledge, skill, experience, training, or education [20]. The 1993 Daubert [21] decision set

the precedent for the Federal Rule 702 superseding *Frye* and established that the judge would evaluate whether the testimony was relevant and reliable. Two subsequent rulings established that appellate courts should accept the decision of lower courts on the acceptability of a witness [22] and Rule 702 applied to all expert testimony, including nonscientific [23].

Advances in Instrumentation and Methodology. As the number of laboratories grew there was a concurrent growth in scientific instrumentation, although many laboratories had difficulty obtaining funding for the new equipment [12]. Now essential to forensic chemistry, the first high-pressure liquid chromatography (HPLC) and the first commercial gas chromatography (GC) instruments did not appear until 1955 [24] and 1954 [25], respectively. The first mass spectrometer for GC (GC-MS) was released in 1963 [26], but the greatest scientific breakthrough was DNA typing.

The first case where DNA evidence was admitted in a trial was in 1986 [27] and the first case that resulted in a conviction in 1987 [28]. The first National Institute of Justice working group, the Scientific Working Group on DNA Analysis Methods, was formed to establish standards for DNA analysis. It proved fortuitous as very quickly, DNA evidence was challenged. In 1988, a *Frye* trial determined that in *People v. Castro*, the DNA evidence was generally accepted, but could not be admitted because proper procedures had not been followed.

The initial establishment of standards for DNA typing expanded to many forensic disciplines. The formation of TWGDAM — later changed to the Scientific Working Group on DNA Analysis Methods (SWGDM) — was followed by SWGs in fingerprints, drugs, document examination, and firearms and toolmarks. Through the 1990s and early 2000s, SWGs were established to develop quality control guidelines for more than 20 areas of forensic science [29].

The first integrated computer databases were established in the 1990s. The Combined DNA Index System, a searchable DNA database, became available to all states in 1998. The FBI released the Integrated Automated Fingerprint Identification System (IAFIS), with automated fingerprint searching available to all states in 1999 [30].

2000–Present: National Scrutiny

According to the latest published survey of forensic laboratories (2014)^a, there were 409 publicly funded laboratories in the United States that employed 14,300 full-time

^aA more recent study was initiated in 2019, but the results are not yet publicly available.

personnel. The combined operating budget was \$1.7 billion and 3.8 million evidence submissions were received [31]. Drug chemistry received the most submissions, followed by convicted/arrestee samples for DNA databases. The state labs received the greatest number of requests and federal labs received the fewest. About 38% of labs outsourced requests to private or other public labs, with municipal labs being the most likely to outsource analyses.

The greatest influences on forensic science in the US in the new century have been the CSI Effect and the National Academy of Science Report *Strengthening forensic science in the United States: A path forward* (NAS Report) [32,33]. The television series, *CSI: Crime Scene Investigation*, aired its first episode in October 2000, spawning not only multiple versions of itself, but similar forensic dramas, including *Criminal Minds*, *Cold Case Files*, *Numbers*, and *NCIS*. Television crime shows highlighted the capabilities of forensic laboratories to such an extent that juries began to believe forensic science was immediate and infallible; to expect forensic evidence in all criminal cases, even when it was not relevant.

The NAS Report, on the other hand, reported that except for DNA, “no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source.” Subsequently, there were many references to a “crisis in forensic science” although the laboratories have continued to receive and analyze evidence and forensic scientists have continued to be accepted as expert witnesses, with only a few significant challenges.

In response, the US Department of Justice (DOJ) and the US Department of Commerce’s National Institute of Standards and Technology (NIST) established the National Commission on Forensic Science (NCFS) [34] to provide guidance for the practice and reliability of forensic science. The NCFS Charter expired in 2017 and currently, NIST has been designated as the federal agency that can provide national standards for scientifically valid methods for analyzing evidence. NIST identified seven scientific areas in forensic science (SACS) which are further divided into 22 sub areas and established the Organization of Scientific Area Committees (OSACs) with a committee for each area (see **Table 3**) [35]. Many of the SWGs and SWGs guidelines were incorporated into the NIST OSACs [36]. The OSACs draft standards, which are reviewed by the relevant organizations, such as ASTM International and AAFS’s Academy Standards Board (ASB) — the latter was accredited by the American National Standards Institute (ANSI).

Table 3. Scientific areas and disciplines in forensic science [35]

Scientific area	Discipline
Biology	Human Forensic Biology Wildlife Forensic Biology
Chemistry: Seized Drugs & Toxicology	Seized Drugs Forensic Toxicology
Chemistry: Trace Evidence	Ignitable Liquids, Explosives, & Gintshot Residue Trace Materials
Digital/Multimedia	Digital Evidence Facial Identification Speaker Recognition Video/Imaging Technology & Analysis
Medicine	Forensic Anthropology Forensic Odontology Forensic Nursing Medicolegal Death Investigation
Physics/Pattern Interpretation	Bloodstain Pattern Analysis Firearms & Toolmarks Footwear & Tire Forensic Document Examination Friction Ridge
Scene Examination	Crime Scene Investigation & Reconstruction Dogs & Sensors Fire & Explosion Investigation

The Public-Funded Laboratory in the United States

Configurations of Public Forensic Science Laboratories

Forensic laboratories and laboratory systems in the US are organized in many configurations. A state’s unique way of representing the value and weight of forensic science may inform the decisions on how best to create the undergirding. It is also likely that forensic laboratories have sprouted up organically in tandem with population growth and crime rates, resulting in a somewhat ad hoc system. There are several ways to organize the overall infrastructure of a forensic laboratory system. Three main configurations observed in the country will be discussed, but do not represent the entirety of modalities found in states throughout the nation.

- **Central System.** A system adopted in states like Tennessee, in which oversight for all forensic labs located in the counties or small cities lie with the overarching state lab system;
- **Independent System.** In Maryland, for example, while there is a state laboratory, the local and municipal laboratories are independent from it and not organized under a statewide system of connected labs;
- **Unaffiliated System.** There are laboratories usually associated with federal agencies such as the FBI and the ATF or privately owned laboratories that may exist within a state but are not associated with any of the local, regional, municipal, or state laboratories.

There are two additional models that can exist within the Central and Independent configurations:

- **Rural Model.** In less populated states such as South Dakota, the only option for local or municipal officers of small police or sheriff's departments may be to submit evidence to a single state agency for processing;
- **Urban Model.** In areas with high crime rates and population density, there may be a large municipal lab covering the city and a state lab covering all else located in the same geographical area, as in Denver or Los Angeles.

Areas serviced by Rural and Urban laboratory modalities can coexist within both the Independent and Central state systems. There are examples of an Urban laboratory and a Rural Service system coexisting in one county, within an Independent system at the state level.

Example of Central System. Where a state laboratory is present, other forensic science laboratories can exist in relation to it as subordinate or disconnected. When a laboratory is subordinate to an overarching state system, the entire agency is usually independent and not attached to or affiliated with any single police department in that state. An example of this is the Virginia Department of Forensic Science (DFS) [37]. The agency is autonomous in its stance as a standalone agency with independence from other law enforcement entities. The Virginia DFS is responsible for assistance in criminal matters in the Commonwealth of Virginia with four regional labs under its umbrella. The Central, Eastern, Northern, and Western Regional laboratories each offer all major forensic science services employing from 35 to 100 scientists at each location. The organizational structure in this configuration, which is found in other states such as Georgia and Montana, is such that each regional laboratory has its own director or manager who is subordinate and reports to a superior lone agency director. All public forensic laboratory services provided to the state flow out through this single agency.

Within a laboratory system with a "Central" stance, services such as human resources, technical services, and finance are housed completely under the agency's authority. The regional laboratories each receive funding and administrative support via their agency, which has ultimate oversight regarding the levels of this support. Additionally, the powerful state laboratory system may exist via state statute as standalone entities and as such have specially designated appointments for their agency heads such as is the case in the Virginia DFS.

Example of the Independent System. The alternative to the central system model is one where a state-funded laboratory exists but other local or municipal laboratories are disconnected and independent from it. In this model, each independent laboratory is typically associated with a single police agency with jurisdiction over a certain geographical area within the state. The forensic lab as-

sociated with the police agency then provides services to the citizens within that geographical area. An example of this can be found in Maryland.

In Maryland, there are six main full-service and several smaller partial-service forensic science laboratories, each independent of each other. There are also a few smaller, non-accredited or not full-service laboratories within the state operating under a law enforcement agency. Included in this six-strong full-service laboratory group is a state-run forensic service. This state lab is affiliated with its own law enforcement agency and does not have authority over any of the other public forensic laboratories in operation in the state. In this arrangement, each of the forensic science laboratories are responsible for offering forensic science services to their home jurisdictions alone, with some, Arizona for example, also providing support to small law enforcement departments within their boundaries including school police, transportation or housing authorities, and sheriff's departments. All forensic science services flow out of these independent forensic science laboratories under the authority of the laboratory director or chief who is working subordinate to a larger police agency.

In laboratories configured with an independent stance, support services such as human resources, technical services, and finance may not fall under the authority of the laboratory itself, though the lab can exert influence and may have a strong presence in these areas. Under this arrangement, administrative services are supplied to the agency as a whole from their jurisdiction with the laboratory receiving funding as an arm of the overall law enforcement service. Oftentimes, these arrangements are not codified as part of the state statute and have arisen as population and crime density increased.

Examples of Rural/Urban Models. In the model in which a single state forensic science agency or laboratory supports the entire population, smaller law enforcement agencies within the state submit work through a single channel. Laboratories configured in the "Rural" arrangement can be standalone or connected to a major law enforcement agency within a state. An example of this stance can be found in the South Dakota Forensic Laboratory (SDFL). This laboratory provides forensic services in all major disciplines to all law enforcement officers in the state, including federal and tribal agencies. Uniquely, this lab is housed under the umbrella of the Office of the Attorney General rather than with a police or sheriff's department.

In this arrangement, the SDFL receives support for all administrative functions via the AG's office and does not operate in the same manner as a "central" stance laboratory. Similar to the "independent" labs, the laboratory would be able to influence decision-making regarding purchasing

or human resources but may not be able to make the final decision in these areas. Though the laboratory should have independence in scientific decision-making, the day-to-day operational work may be outside of their control.

In contrast to the “rural” modality, is the “urban” stance. In areas with high levels of crime or population density, a city or municipal laboratory may handle the crimes within the city proper or certain types of crimes within it. This will be complemented with a larger state lab handling the majority of the work from the metropolitan areas surrounding this city laboratory and even some work from within the boundaries of the city itself. Though each of these laboratories may be separate from the other, they overlap in the service population.

Various configurations of this theme exist with divisions created by crime type, geography or even submitting officer. In the LA area, there is the LA County Sheriff’s LA Regional Crime Laboratory, the LA County Coroner Forensic Science Laboratory, and the LA Police Department Scientific Investigation Division, all of whom service populations that may overlap and abut one another. In this configuration, each laboratory is independent of one another with resources dedicated to them individually while being somewhat connected to one another based on where a crime happened, what type of crime it was, or who collects the evidence. This complicated arrangement of intertwined forensic science services may seem to be unwieldy but due to the sheer volume of crime and size of the population in this city/county area, is very necessary.

Forensic Science Services Offered by Public Laboratories

The major services offered by forensic labs in the US include *crime scene investigation*, *evidence collection services*, and four main analytical or comparative sciences: *latent print development and comparison*, *firearms and tool marks examination*, *forensic biology* (which can include both serological screening and DNA analysis), and *drug chemistry* (or illicit substances analysis). Most full-service laboratories will offer services in these four main disciplines.

There are also several “micro” disciplines that may be offered depending on the volume of work requests in each. These can include *trace analysis*, a catchall that encompasses any analysis or comparison that does not fall under the main four — *questioned documents*, *tire and foot impression analysis*, *photography*, and *toxicology*. As computer science, social media, and reliance on smartphones grow in popularity, so too does an additional discipline, *digital forensics*. As time progresses, digital forensics is becoming less and less in the category of optional and moving rapidly into one of the major, critical services offered by many crime labs across the US.

Crime Scene Investigation Services. The most critical and important step in any crime lab’s work is the identification, collection, and documentation of physical evidence from crime scenes. A crime scene investigator’s work is the most important step. Not only are these scientists responsible for identifying potential evidence but they are tasked with beginning the item’s life history within the overall forensic service; a step critical to any other future use. Without excellent work on scene, latent prints, DNA, firearms and other types of evidence will never make it to the benches of the second team, the analytical and comparative scientists.

The crime scene investigator’s job is the lynchpin of all other work performed in the crime lab. As more and more universities begin to offer crime scene sciences as a major, the discipline is becoming more professionalized and as a consequence more civilian scientists enter the field. In these degrees, scientists will receive training in crime types from the most basic larceny to the most complex murder. As the complexity of the types of evidence collected grows, the importance of college-educated forensic scientists becomes more critical.

The trend nationally is to civilianize the crime scene investigator job classification as the individuals applying for these spots are earning bachelor’s and master’s degrees in the field. Additionally, the movement of sworn employees back to patrol and detective status is a smart move for a jurisdiction looking for force-multiplying solutions in a time when hiring is historically difficult. In areas with greater population density, the sheer volume of scenes needing the expert attention of trained crime scene investigators continues to grow.

The Latent Print Development and Collection Unit.

The services offered by the latent print development and collection unit is typically the development, identification, evaluation, and comparison of latent prints from items of evidence found on crime scenes. The first part of the full process is development and, as always, the manner in which the process is run can be very individual. Crime scene investigators bring in the lion’s share of the developed latent prints, with black powder processing as the predominant method. Items that cannot be processed on scene are collected and brought back to the laboratory for additional work where techniques unavailable on-scene are utilized. Some laboratories have specialized units for latent print development while others train their forensic analysts or crime scene scientists to perform this work.

Following latent print development and recovery, the lifted prints must be evaluated and compared. The evaluation can be conducted by examiners and/or technicians, sometimes referred to as AFIS techs. This step determines

whether the lifted prints are suitable for comparison, are of database quality, or are of no value. The assessment can be reported independently or as part of a larger comprehensive report depending on the volume and the procedures of the individual laboratory system.

Lastly, the prints, where possible, are compared to a known or entered into the AFIS database for searching. At this stage where matching or exclusions are determined, highly trained latent print examiners are required. These scientists are often trained in house to perform the work through a pseudo-apprenticeship arrangement. This way of training is beginning to slowly evolve toward a more formalized model with schools like Loyola University Maryland (Baltimore, MD) offering bachelor's and master's degrees in the comparative disciplines. As graduate degrees become more available in the comparative sciences, the need for in-house apprenticeship-like training modules begins to be replaced with a more efficient onboarding, and scientists begin casework sooner.

Forensic Biology: Screening and DNA. In the Forensic Biology unit, there can be vastly different capabilities, services, instrumentation, and methodologies in place, depending on the laboratory's mandate, funding, or needs. These units are typically tasked with screening evidence for biological material and generating a final DNA profile. Sounds simple; however, there are innumerable routes to that goal that can be customized to the specific needs of a lab.

The first step for an item of evidence needing biological analysis will be screening, which can go by many names such as serology, triage, or processing. This step allows a lab to quickly identify biological stains or substances suitable for further analysis by evaluating these items for the presence of blood, semen, saliva, or bodily tissues. Occasionally, labs may also identify other bodily fluids and materials such as urine and feces at this step.

Once a stain has been identified as biological in nature, it will likely be confirmed as human via various analytical tests. Following this confirmation step, the stain will move forward into DNA analysis to develop a genetic profile. Moving through the stages of extraction, quantitation, amplification, and genetic analysis will hopefully result in a DNA profile that can be used to exclude or include a reference sample. When a reference is included in an evidence profile, then the data is further interpreted, with validated software providing the statistical strength of the match.

Some laboratories offer probabilistic genotyping services that can assist in the interpretation of the most complex evidence profiles. This service is gaining popularity around the country due to its ability to provide conclusions where human capabilities reach their limits. This can be especially helpful for defendants as the results can definitively exclude where once no answer could be provided.

Another niche service gaining popularity is forensic genetic genealogy. The news is filled with long cold cases being solved by this innovative and powerful new use of DNA profile information. Most publicly funded laboratories are not currently offering this method, relying instead on the capabilities of their nimble partners in the private sector. However, a movement toward providing these services is underway and is generating much discussion around legislation, policy, and appropriate use.

Firearms and Tool Marks Analysis. This comparative science discipline handles all comparisons of unknown tools and firearms markings to knowns through lab-generated exemplars, recovered items, or database matches. The methodology is somewhat standardized among different laboratories, though innovation and creative process-flow design have increased in recent years.

The first step in this analysis is typically to create an inventory of the submission and document any initial gross-level findings. When working on firearms such as handguns and rifles, the lab will conduct an operability test and enter the casings into comparison databases, most likely through the NIBIN (National Integrated Ballistic Information Network) database [38]. Cartridge cases recovered from scenes are evaluated and the most suitable of the groupings will be similarly entered into these databases. The aim is to create matches between the recovered firearms and evidence from fired cartridges to quickly aid investigations. Recent guidelines have been published by the ATF, called the Minimum Required Operating Standards (MROS), which mandate the entries, or acquisitions, happen within 24–48 h of the crime occurrence. This is a monumental task and many labs across the country are working hard to find ways to meet this high bar.

Tool mark evidence is less often submitted to a lab for analysis. When pry marks, etchings, and snipped or pressed items are submitted for work, they are typically compared to exemplars such as screwdrivers and cutting devices to determine if there are similarities. There are no databases for tool marks that can create associations like those for firearms evidence although some regional or local examples may exist.

Illicit Drug/Substances Analysis. This analytical service is responsible for analyzing items submitted that are suspected to be controlled dangerous substances. The scope of methods and instrumentation may vary from one lab to another and be tailored to the legislative agenda of the area serviced. For example, some states may have legalized substances like marijuana while others have not, creating a patchwork of analytical methodologies nationwide.

Though the work does seem straightforward, it can be quite multifaceted. Some jurisdictions are interested in the identification of the substance, some are focused

on quantitation values and purities, some have rules for testing workflows set by their state, and some do not. Each Drug/Illicit Substances analysis unit will create a uniquely tailored workflow to address the needs and conditions of their particular area. This ability to custom configure a process creates environments where laboratories can be innovative and create highly efficient processes.

The custom-fit approach does make the evaluation of competencies between agencies complex and can lead to dramatically different stakeholder experiences when interacting with forensic science laboratories. However, this customized mindset may benefit a discipline that has a continuously moving target. As new analogs and substances are created and sold in illegal marketplaces, the lab must be able to continuously adapt their work to detect them — a sophisticated game of cat and mouse.

The Private Laboratory in the United States

While forensic science in the US is driven by over 400 public crime labs, private laboratories provide valuable forensic services to the criminal justice system both in support of the public laboratories and to provide independent forensic services for the criminal justice system. There are many reputable private laboratories, many which have been in business for decades and offer advantages and disadvantages to public laboratories. As a general rule, private labs are held to the same quality standards as public laboratories, with ISO 17025 as the gold standard. Additionally, many hold state specific certifications and licenses to comply with local requirements.

To explore further, it is best to examine by service offerings, specifically toxicology, DNA, fingerprints, and forensic trace evidence.

Toxicology

Forensic toxicology serves law enforcement and the legal system by analyzing alcohol, drugs, and other toxic substances from biological samples typically associated with crime scenes, deceased individuals, or DUI incidents. The private laboratory market for forensic toxicology is dominated by NMS Labs (Horsham, PA), which provides critical toxicology and drug identification services to medical examiners, coroners, government, and law enforcement. In many instances, the services provided simulate those of the public laboratory — controlled dangerous substances (CDS) analysis on submitted evidence and toxicology analysis of blood. Public laboratories contract with private laboratories to reduce backlogs or provide independent analysis. Additionally, private laboratories provide specialized tests not typically provided by public labs, such as testing for modified abused drugs, therapeutic drugs,

or intermediary metabolites. Private labs offer between 500 to >2,500 tests which are greater in variety than most public laboratories. Private laboratories can supplement the basic drugs of abuse and alcohol tests with expanded testing for abused drugs, therapeutic drugs, or metabolites.

In recent years as marijuana laws across the country changed, many court systems now require a quantitative test for THC rather than just qualitative as well as detection of THC metabolites such as THC-COOH. Another example is the increased recreational but dangerous use of bath salt derivatives. The cathinone derivatives are thermally unstable; therefore, they may be altered during GC/MS analysis. Private laboratories have the analytical equipment (LC/MS, LC/MS/MS, or LC-Q/TOF) and validated protocols to detect these synthetic cathinone analogs [39]. This has led to a surge in utilization of private labs as public laboratories procure new equipment and validate new procedures to adapt to the new laws.

Two certifications are typically required for private forensic toxicology laboratories to serve the forensic community: ISO 17025:2017 and ABFT (American Board of Forensic Toxicology). Based on publicly available information, there are four private toxicology laboratories accredited to comply with the ISO17025:2017 standards for competence of testing and calibration laboratories [40]. In addition to ISO17025:2017 certification, most directors and toxicologists employed by the private forensic toxicology laboratories are board certified through the ABFT or are certified through CLIA (Clinical Laboratory Improvement Amendments) for toxicology. The objective of the ABFT is to establish, enhance, and revise the standards of qualification for forensic toxicologists. Currently, there are a total of 473 toxicologists certified by the ABFT that practice in private or public toxicology laboratories [41].

Deoxyribonucleic Acid (DNA)

Services offered by private forensic DNA typing laboratories include autosomal STRs, Y-STRs, mitochondrial DNA (mtDNA), SNPs, and forensic biology. The types of cases worked by private labs include homicides, sexual assaults, property crimes, burglaries, and missing persons. The stakeholders who send cases to private labs comprise the entire criminal justice system, including prosecuting attorneys, defense attorneys, innocence networks, public crime laboratories, medical examiner's offices, and law enforcement agencies. As of May 5, 2022, eight private labs are accredited to ISO17025:2017 and FBI Quality Assurance Standards (QAS) for Forensic DNA Testing Laboratories [42].

Due to the success of DNA in assisting with the resolution of criminal cases, demand from all stakeholders exceeds the capacity of public laboratories, leading to a

role for private labs. This is best exemplified by the backlog of untested sexual assault kits, which has been estimated to be as many as 400,000. Because public laboratories were already at capacity doing current casework, private labs have been essential in eliminating backlogs across the country. Notable examples where private labs helped to eliminate backlogs include New York City (16,000 kits), Detroit (>10,000), Houston, and LA (>10,000), and efforts continue in states such as North Carolina, Missouri, and Maryland.

The role of CODIS and the FBI's QAS are the primary influencers on private laboratories. As of October 2021, CODIS included over 15 million DNA profiles of offenders, forensic unknowns, and unidentified missing persons [43]. The majority of cases requiring DNA do not have a suspect and rely on CODIS to obtain an investigative lead (i.e., a "hit" to a known individual or to another case). The value of the database cannot be overstated—in many states, there is a greater than 50% hit rate. It is for this reason that DNA is commonly referred to as the most effective law enforcement tool of the 21st century. Critically, only public labs have access to both upload and search CODIS. Private labs do not have access. Therefore, private labs must work closely with public laboratories to ensure any resulting DNA profiles will be uploaded by the public laboratory. This requirement is cemented by the QAS, which requires accredited private labs to obtain agreements for CODIS upload in advance of testing, thereby ensuring that private labs will not bypass CODIS.

There is a private laboratory market for niche services as well. While all public labs offer autosomal STR analysis, due to lower volumes, many do not offer specialized services such as mtDNA testing, Y-STRs, SNPs, specialized collection techniques, specialized extraction techniques for challenging evidence such as human remains, or complex criminal paternity cases. Additionally, private labs typically offer rush services, at premium prices, in situations where a law enforcement agency or attorney requires court-ready DNA results in 24–48 h.

Most recently, private labs have been involved in *rapid DNA* and *forensic genealogy*. While rapid DNA is targeted at booking stations to be run by law enforcement officials, as technology has evolved and crime scene evidence is run on rapid DNA instruments, private labs offer remote DNA services. This consists primarily of troubleshooting or reviewing complex DNA mixtures that are generated by the non-DNA trained rapid DNA operator. Rapid DNA has not been deployed extensively in private labs, primarily because of the logistics. While running a sample in 90 min is critical for certain applications, samples sent to private labs typically require overnight shipping services, thereby negating the "rapid" aspect of testing.

Forensic genealogy, on the other hand, is primarily driven by private labs that provide either SNP or sequencing services. Currently this service is largely unregulated, and labs do not need to be accredited to provide the service and there are no requirements for genealogists who analyze the resulting data. This is expected to change in the near future and states such as Maryland and New York have taken steps to add certification requirements like all other forensic disciplines. Furthermore, the databases utilized for forensic genealogy are privately owned and operated.

Latent Prints

Certification by the IAI's fingerprint certification programs (Latent Print Certification and Tenprint Fingerprint Certification) is typically required to provide services to public laboratories, law enforcement, or the US legal system. A certified examiner will demonstrate expertise in friction skin physiology and morphology, detection, recovery, photography, preservation, enhancement, analysis, comparison, documentation, and reporting of latent print evidence. The examiner will always serve the best interests of the science and will report their findings in a neutral, non-biased manner. There are more than 1,000 IAI-certified latent print examiners in the local, state, federal, and private forensic community [44].

Most business providing latent print examiners are IAI certified for latent print examination or 10-print fingerprint certification; however, only one laboratory was accredited to comply with ISO17025:2017 standards for laboratory processing, and compliant with ISO17043 for providing proficiency testing services, and was staffed with IAI-certified latent print examiners. Similar to businesses providing DNA testing or forensic toxicology services, businesses providing latent print examination services are committed to analyzing the evidence and reporting the data in a non-biased way. They recognize that reporting the scientific results will provide the trier of fact with information to assist in their decision to exclude, convict, or exonerate an individual.

Over 200 private latent print examiner consultants offer latent print examiner services to law enforcement and the legal community [45]. One business, Ron Smith and Associates (Collinsville, MS), offers four services: latent print examination, training, development/processing of latent prints, and proficiency testing. These businesses provide services to decrease the latent print backlog, provide independent analysis, perform fingerprint processing services the public lab is not validated to perform, and provide IAI-certified examiners to maintain consistent contracted service when the local laboratory is temporarily closed. Latent print businesses also serve the community by providing training to meet IAI Latent Print or

Tenprint Fingerprint certification. Their training services are utilized by public laboratories due to the time investment required to effectively train examiners to meet the IAI certification. The private latent print businesses train recruits from law enforcement and crime labs to varying levels of expertise [45].

Forensic Trace Evidence [46]

A few private laboratories offer microscopical examinations and micro chemical analytical capabilities to analyze trace amounts of unknown chemicals, dirt and soil, textile fibers, hair, glass, and biological or chemical particulates that are associated with materials from a crime scene. These labs provide scientific expertise to criminal investigations that are outside of the capabilities of local, state, and federal laboratories. The microanalytical companies provide analytical services, training, and proficiency testing.

The private laboratories often have a variety of carefully chosen analytical chemical instruments that many public crime laboratories do not own. These labs are also staffed by career experts who are specialists in the physical, chemical, and biological sciences and have specifically trained to detect and compare unknown items to suspected reference exhibits. They are also experienced in making critical observations and from these to intuit hypotheses as creative strategies to test them. This approach to forensic trace evidence is especially useful in helping detectives to develop investigative leads that can help officials focus their inquiries. They offer their scientific services to both the prosecution and defense for both criminal and civil litigation. Like the other forensic disciplines, the microchemical analysts will always report the scientific observations in an unbiased manner. The private analytical laboratories can approach the analysis of evidence with greater flexibility than most state or federal laboratories since they must frequently apply the scientific method combined with creative scientific logic to develop and validate micro-analytical methods to identify and compare the frequently atypical traces associated with real-life crime scenes.

Because of the nature of the analytical work they perform, many private laboratories are also contracted by companies that manufacture potential evidence such as textiles, building materials, ceramics, glass, food, building materials, paints, and dyes. Therefore, they have acquired additional specialized knowledge of materials and have developed industrial contacts that can fill in manufacturing details that are almost impossible to attain in any other way. Some of these laboratories curate and maintain comprehensive reference collections of materials that can be applied to analyzing evidence from crime scenes. Again, these are key to developing early investigative leads when no physical clues are available

for comparison. Finally, the analytical companies follow a logical progression of scientific problem-solving that is based on the material of interest as opposed to following a predefined workflow or direct comparison of a known to a reference item. This progression of analysis based on observation of facts followed by informed interpretation is the practical embodiment of the scientific method opposed to investigations driven by a prescribed workflow.

The microanalytical labs are accredited to comply with the ISO/IEC 17025:2017 standards for laboratory processing; additionally, scientists working for these companies are also certified to comply with specific ASTM certifications associated with their chemical or physical science discipline.

Conclusions

In the US, development of forensic laboratories has been initiated by the needs of local and state law enforcement. As the laws and policies of each state differ, policies and procedures were not established at a national level. This began to change with the FBI QAS required for a forensic laboratory submitting DNA to CODIS database searches and the NAS report.

Since inception, forensic laboratories have suffered from lack of funding, personnel, support for research, and a fragmented laboratory system. The current status includes these issues, in addition to casework backlog, access for defense counsel, and standards for admissibility of evidence, accreditation, and certification.

References

1. Dillon DJ: A History of Criminalistics in the United States, 1850–1950 (dissertation); University of California: Berkeley, CA; p 80; 1977; <https://www.libraryofbook.com/books/a-history-of-criminalistics-in-the-united-states-1850-1950> (Accessed May 26, 2022).
2. *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).
3. [US] Federal Bureau of Investigation; <https://www.fbi.gov/services/laboratory/>; (Accessed April 2, 2022).
4. Bell S: *Crime and Circumstance: Investigating the History of Forensic Science*; Praeger: Westport, CT; p 107; 2008.
5. United States Army Criminal Investigation Division: The History of the U.S. Army Criminal Investigation Laboratory; https://www.cid.army.mil/assets/img/dfsc/USACIL_History.pdf#:~:text=To%20assist%20in%20accomplishing%20this%20mission%2C%20the%20Army%E2%80%99s,Lieutenant%20George%20R.%20%E2%80%9CPappy%E2%80%9D%20Bird%20and%20a%20photographer (Accessed April 2, 2022).
6. McAllenan KK: Scientific Method: CBP's Laboratories and Scientific Services; 2017; <https://www.cbp.gov/newsroom/blogs/scientific-method-cbp-s-laboratories-and-scientific-services> (Accessed May 26, 2022).
7. International Association for Identification: IAI History; https://www.theiai.org/iai_history.php. (Accessed May 26, 2022).

8. IAI: Constitution of the International Association for Identification: The International Association for Identification; 2016; https://theiai.org/docs/constitution_20160812.pdf (Accessed June 7, 2022).
9. All AAFS Sections; 2022; <https://www.aafs.org/> (Accessed June 7, 2022).
10. Field KS: *History of the American Academy of Forensic Sciences, 1948–1998*; ASTM International: West Conshohocken, PA; 1998.
11. Williams J: The Practice of forensic nursing science in the United States; *Forensic Sci Rev* 34:90; 2022.
12. Joseph A: Crime Laboratories — Three Study Reports: John Jay College National Survey; Massachusetts Governor’s Committee State Study; Public Administration Service Consolidation Study Excerpt; US Department of Justice (Office of Law Enforcement Assistance): Washington, DC; 1968; <https://www.ojp.gov/ncjrs/virtual-library/abstracts/crime-laboratories-three-study-reports> (Accessed May 26, 2022).
13. Pub. L. No. 90-351, 82 Stat. 197 (1968).
14. Rehling CJ, Rabren CL: Alabama’s Master Plan for a Crime Laboratory Delivery System; US Department of Justice (Law Enforcement Assistance Administration): Washington, DC; 1974; <https://www.ojp.gov/ncjrs/virtual-library/abstracts/alabamas-master-plan-crime-laboratory-delivery-system-0> (Accessed May 26, 2022).
15. Peterson JL, Fabricant EL, Field KS, Thornton JI: Crime Laboratory Proficiency Testing Research Program; US Department of Justice (Law Enforcement Assistance Administration): Washington, DC; 1978; https://books.google.com/books/about/Crime_Laboratory_Proficiency_Testing_Res.html?id=Va80uilHFhIC (Accessed May 26, 2022).
16. Lucas DM, Leete CG, Field KS: An American proficiency testing program; *Forensic Sci Int* 27:71; 1985.
17. Ill. St. Police, ISP Forensic Labs Re-Accredited, <http://www.isp.state.il.us/media/pressdetails.cfm?ID=117> (Accessed Aug. 15, 2007).
18. *Miranda v. Ariz.*, 384 U.S. 436 (1966).
19. Peterson JL: Forensic Evidence and the Police: The Effects of Scientific Evidence on Criminal Investigations; US Department of Justice (National Institute of Justice): Washington, DC; 1984; <https://www.ojp.gov/ncjrs/virtual-library/abstracts/forensic-evidence-and-police-effects-scientific-evidence-criminal-0> (Accessed May 26, 2022).
20. Zlotnick J, Lin JR: Handwriting evidence in Federal courts — From Frye to Kumho; *Forensic Sci Rev* 13:87; 2001.
21. *Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993).
22. *General Electric Co. v. Joiner*, 522 U.S. 136 (1997).
23. *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999).
24. Arnaud CH: 50 years of HPLC; *C&E News* 94(24); 2016; <https://cen.acs.org/articles/94/i24/50-years-HPLC.html> (Accessed April 7, 2022).
25. Kusch P: Introductory Chapter: Gas chromatography — The most versatile analytical technique; In Kusch P (Ed): *Gas Chromatography — Derivatization, Sample Preparation, Application*; IntechOpen: London, UK; 2018; <https://www.intechopen.com/chapters/64120> (Accessed May 26, 2022).
26. Sparkman DO, Penton Z, Kitson: *Gas Chromatography and Mass Spectrometry: A Practical Guide*. Academic Press: Cambridge, UK; 2011.
27. *Com. v. Pestinikas*, 421 Pa. Superior Ct. 371 (1992).
28. *Andrews v. State*, 533 So.2d 841 (1988).
29. NIST: Legacy Scientific Working Groups: National Institute of Standards and Technology; 2013; <https://www.nist.gov/forensic-science/interdisciplinary-topics/working-groups/legacy-scientific-working-groups> (Accessed June 6, 2022).
30. [US] Federal Investigation Bureau: Privacy Impact Assessment for the Fingerprint Identification Records System (FIRS) Integrated Automated Fingerprint Identification System (IAFIS) Outsourcing for Noncriminal Justice Purposes — Channeling; 2008; <https://www.fbi.gov/services/information-management/foipa/privacy-impact-assessments/firs-iafis> (Accessed May 26, 2022).
31. Durose M, Burch AM, Walsh K, Tiry E: Publicly Funded Forensic Crime Laboratories: Resources and Services, 2014; US Department of Justice (Office of Justice Program): Washington, DC; <https://bjs.ojp.gov/content/pub/pdf/pffclrs14.pdf> (Accessed May 26, 2022).
32. [US] National Research Council: *Strengthening Forensic Science in the United States: A Path Forward*; National Academies Press: Washington, DC; 2009; https://www.researchgate.net/publication/275214356_Strengthening_Forensic_Science_in_the_United_States:_A_Path_Forward (Accessed May 26, 2022).
33. Edwards H, Gotsonis C: Strengthening Forensic Science in the United States: A Path Forward, Statement before the United States Senate Committee on the Judiciary; 2009; <https://www.judiciary.senate.gov/imo/media/doc/09-03-18EdwardsTestimony.pdf> (Accessed May 26, 2022).
34. National Commission on Forensic Science; <https://www.justice.gov/archives/ncfs> (Accessed May 26, 2022).
35. The Organization of Scientific Area Committees for Forensic Science; <https://www.nist.gov/organization-scientific-area-committees-forensic-science> (Accessed May 26, 2022).
36. Butler JM: An Update on Strengthening Forensic Science in the United States: A Decade of Developments (a conference review); *Forensic Sci Rev* 32:90; 2020.
37. Virginia Department of Forensic Science; <https://www.dfs.virginia.gov/org-chart/> (Accessed May 26, 2022).
38. [US] Bureau of Alcohol, Tobacco, Firearms and Explosives: National Integrated Ballistic Information Network; <https://www.atf.gov/firearms/national-integrated-ballistic-information-network-nibin> (Accessed June 13, 2022).
39. Kerrigan S, Savage M, Cavazos C, Bella P: Thermal degradation of synthetic cathinones: Implications for forensic toxicology; *J Anal Toxicol* 40:1; 2016.
40. American Board of Forensic Toxicology: ANAB Accredited Labs; <https://abft.org/anab-accredited-labs/> (Accessed May 5, 2022).
41. American Board of Forensic Toxicology: Directory Search; <https://abft.org/certificants-directory/> (Accessed May 5, 2022).
42. ANSI National Accreditation Board: Directory of Accredited Organizations; <https://search.anab.org/> (Accessed on May 5, 2022).
43. [US] Federal Investigation Bureau (Laboratory Services): CODIS — NDIS Statistics; <https://www.fbi.gov/services/laboratory/biometric-analysis/codis/ndis-statistics> (Accessed on May 5, 2022).
44. International Association for Identification: Latent Print Certification; https://www.theiai.org/latent_print.php (Accessed on April 5, 2022).
45. Ron Smith; Personal communication; Ron Smith Associates: Collinsville, MS; April 6, 2022.
46. Skip Palenik; Personal communication; Microtrace LLC: Elgin, IL; April 15, 2022.

Femicide in Greece: A Phenomenon on the Rise^a

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The Global Scene

Homicide and Femicide

Regarding global statistical data, the UN Office on Drugs and Crime (UNODC) has identified *homicide* (i.e., murder of any individual human) as the leading cause of death among young adults [1]. Although men are generally more often the victims, they are also much more often the murderers (90%). In cases of *domestic homicide* (i.e., murder of any individual by a relative, a permanent partner, or a cohabitant — thus sharing a relationship of dependence, trust, or influence with the victim), women are more likely to be murdered by a person in their close environment [1–3]. More specifically,

- The overall homicide rate of male victims has been estimated at 81%;
- For domestic homicide, female victims accounted for 64%; and
- 82% of domestic homicides were committed by intimate partners.

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Regarding *femicide* (i.e., murder of a female individual by an intimately related person, or death of a female individual resulting from gender-related harmful practices), UNODC estimated an annual femicide rate of 43,000 in 2013 (accounting for one-third of all homicides) reporting a female victim in one in seven overall homicides. Approximately 87,000 femicides were recorded in 2017, with 58% being perpetrated by a family member and 34% (30,000) by a close partner [2]. However, accuracy of these statistics is limited, as the above-mentioned figures emerged from a limited number of countries with data availability. Nevertheless, violence against women has been recognized as a global public health issue by the World Health Organization (WHO) [4].

Femicide — Current Understanding

According to recent literature, femicides can be classified into the following categories: (a) intimate partner femicide; (b) family (non-intimate) femicide; (c) femicide in the context of war, genocide, and armed conflict; (d) female sex selection, and (e) “witch-hunting”.

- **Intimate partner femicide** represents the majority of cases in which the killer often has a sense of ownership over the victim that is rooted in rigid stereotypes of gender inequality, as well as identifiable cognitive psychological deficits on the part of the perpetrator to accept the notion that the victim and themselves can live separately freely [5,6];
- **Family (non-intimate) femicide** is perpetrated by other relatives and can be further divided into different subtypes: honor killing, when the family perceives the victim's behavior as humiliating to the honor of the family; dowry death, associated with interpersonal conflict on dowry disputes; and femicide-suicide, relating to femicide followed by the suicide of the killer;
- **Femicide in the context of war, genocide, and armed conflict** in which females are systematically victimized, mass raped, and/or killed with the intent of humiliating the enemy [5];
- **Female sex selection** refers to the reduction of female individuals in the global sex ratio, due to pre- and postpartum sex selection through infanticide, starvation, and neglect based on gender discrimination (preference for sons instead of daughters, as has often been practiced in high-population countries like China and India) [5,7];
- **“Witch-hunting”** cases are mostly found in India, Nepal, the Pacific Islands, and Tanzania; they are attributed to superstition, acquisition of land/property, and refusal to mate [5].

Femicides have been hypothesized to stand for the fatal endpoint of an unknown ongoing history of domestic violence, as the level of exposure has been theorized to be a strong measure for examining the victim-perpetrator relationship. This is determined by considering variables

related to lifestyle and situational exposure, being reflective of the amount of contact or vulnerability to harmful elements experienced by the victim [8,9]. No single cause for femicide exists, however, as it is rooted in a complex interaction of risk factors, including the condition and behavior of the involved individuals, their way of relating to each other, as well as the presence or absence of dedicated services [5]. Published research has identified interpersonal or marital conflicts as direct risk factors as well as jealousy and the perpetrator's negation for separation among the main themes underlying femicide, especially among young adults, while the theme of illness (either mental or physical, concerning either the perpetrator or the victim) was identified to play a major role among older victims [8,10]. Low verbal IQ and alcohol/substance abuse have been detected among strong risk factors for the culmination of expressed violence, as well as economic instability, while socioeconomic status and education have been listed as dependent interrelated factors [10]. In particular, an inverse relationship has been identified between education and the expression of all forms of domestic violence. Furthermore, the psychological theme of emotional dependence is found to be dominant in victim-perpetrator relationships, tending to occur more on the part of the perpetrator. In addition, a history of exposure to some form of childhood abuse in the family of origin is a risk factor for both perpetrator and victim. The latter has been observed to be associated with higher odds of perpetrating crimes in the context of domestic violence during adulthood. Children having been victimized or having witnessed domestic violence may be more likely to accept violence as a reasonable way of resolving interpersonal conflicts. In the context of dominance, males whose upbringing has taught them that females are not as respected as themselves are more likely to exert forms of violence against females during adulthood, while similarly, females having witnessed domestic violence during childhood may face a higher probability to be victimized [11]. According to the Directorate for External Policies of the European Union, femicide victims are most often characterized by the following risk factors:

- History of attempted strangulation (major risk);
- Pregnancy coupled with being in a violent relationship;
- Being perceived as "dishonored" in a way (being victimized in other crimes such as rape); and
- Gathering other factors of vulnerability (such as low educational levels).

Furthermore, history of previous domestic violence between the same individuals is the most frequently observed risk factor at an interpersonal level, as well as conflict with in-laws. The risk escalates further with the presence of any offspring from a previous relationship [5].

Context and gender are major components to be examined when analyzing femicide. In the data presented in the present commentary, under the justification for the protection of personal data, the Domestic Violence Unit of the Hellenic Police Headquarters provided nationwide data with details only about the victim-perpetrator relationship, age, and gender of victims. Regarding categorizations of victim-offender relationships, domestic violence victimization is the most common compared to all other health problems among pregnant women even compared to preeclampsia and gestational diabetes. Furthermore, all forms of domestic violence occur in same-sex couples, and the rates of victimization are estimated to be similar to that of heterosexual females. A higher occurrence of victimization, however, is noted among (biological) males cohabiting with males (including transgender people) compared to males cohabiting with females. Regarding the elderly, risk factors playing a significant role in the expression or toleration of violence are neurocognitive pathologies, such as dementia, social isolation, and a common living victim-perpetrator situation (longer exposure) [11].

At a communal level, risk factors comprise:

- The approval of aggressive masculinity;
- Derogation of the role of women;
- Loosened social bonds in neighborhoods exerting poorer social control over violent behavior and resulting in the isolation of vulnerable individuals;
- Traditional communities adhering to patriarchal rules that determine gender and sexual behavior; and
- The lack of dedicated protection services [5].

At a broader societal level, risk factors include:

- Perceived impunity for perpetrators;
- Low victims' access to the judiciary system;
- Deficit of measures to bridge the gender inequality gap;
- War and conflict settings;
- Defects in firearms policies; and
- The endorsement of women's role (along with renunciation of traditional roles, entry into the labor market, and increasing rates of estrangement and divorce) in previously traditional societal systems [5,12].

Respectively, femicide perpetrators most frequently exhibit the following characteristics:

- Alcohol and substance abuse;
- Violating a protection order after exerting domestic violence;
- Mental health disturbances; and
- Unemployment and other factors that contribute to tension and instability [5,13].

During recent years, there has been ongoing research into what differentiates a killer between brain function

and enactment of the crime. Neuroimaging studies have indicated that individuals manifesting violent and antisocial behavior present with brain structural deviations in brain areas corresponding to critical cognitive control and emotion. Reduced gray-matter volume related to psychopathic traits and more general impairments in behavioral control and decision-making has been identified primarily in the orbitofrontal cortex, temporal cortex, and limbic areas [14–16]. A study on homicidal juvenile offenders disclosed gray-matter reduction in the mediolateral anterior temporal lobe and insula when compared to same-age counterparts having perpetrated other serious crimes [17]. A recent study by Sajous-Turner et al. demonstrated the impact of diffuse decrease in gray-matter volume affecting brain regions involved in emotional processing, behavioral control, executive function, and social cognition, possibly indicating the pathophysiological and developmental underpinnings of psychopathic traits, thus differentiating homicidal and violent nonhomicidal conduct [18]. The latter may hold significant clinical implications as it may reflect the possible susceptibility which, upon interaction with social and environmental factors, may predict violent outcomes, particularly homicide.

Trends in Greece

In Greece, a gradual fall was recorded in national homicide rates from 2014 (0.98%) to 2018 (0.92%) according to the latest data published by the national Statistical Authority, with the exception of specific regions (Crete and Attica), where, contrariwise, homicide rates have followed an upward trend [19]. In Greece, the phenomenon of femicide received great publicity during 2021, particularly a sharp rise that was noted by the press at a national level and especially those perpetrated by intimate partners [20].

Study Methodology and General Findings

The authors of the present study focused on the investigation of the phenomena of domestic homicide and femicide, within the Greek population in order to (a) ascertain whether increased media coverage of such crimes actually took place and (b) explore their potential associations with any identifiable risk factors. The study was conducted by examining the latest 11-year archive of the Hellenic Police authorities. National police records dating from 2010 to 2021 for homicide ($n = 1,370$) and domestic homicide ($n = 236$) were extracted and assessed.

From the data obtained from the official Greek police authorities, a downward trend was recorded both for homicide and total domestic homicide cases, while there

was a significant increase in the percentage of domestic homicides over total homicides and domestic femicides. The average prevalence of domestic homicides in Greece was 18.2% of the total homicides (an average of 19.7 domestic homicides per year), but 2021 was the year with the highest figure ever recorded in domestic homicides (with 34 domestic homicides), accounting for 38.2% of total homicides, which was an unprecedented number, followed by 2018 ($n = 24$; 23.8%). It was thus revealed that the rate of domestic homicides in Greece compared to the total number of homicides escalated significantly over the years and peaked sharply in 2021 (p -value < 0.05), while 2012 was the year with the lowest rate of domestic homicides in relation to the total number of homicides (7.8%). Based on classification by victim gender, a gradual decline was observed in total murders of both male and female victims as well as domestic homicides victimizing men. These findings were completely inverse to the number of domestic femicides—which had escalated steadily over the years, surpassing domestic homicides of men from 2012 onwards, while rising steeply in 2021 (**Figures 1 and 2**).

Regarding domestic homicides of 2021 and victim-offender relationships, in particular, the available data indicated that among male victims, the majority were

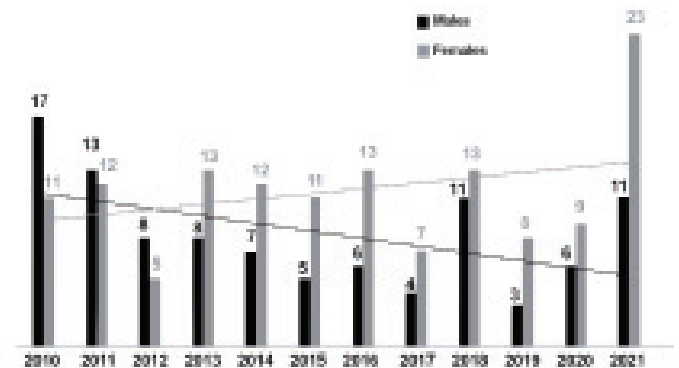


Figure 1. Victims of domestic homicide during the period 2010–2021 in absolute numbers, sorted by victim gender.

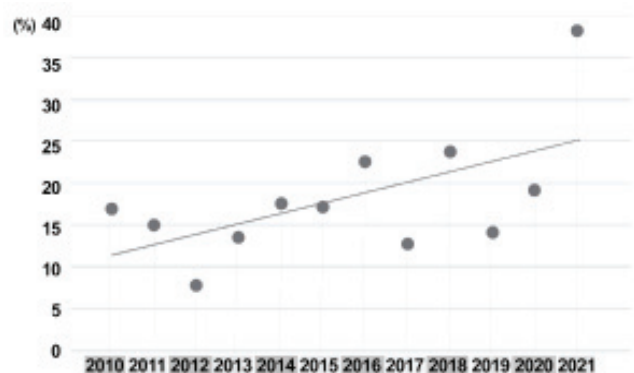


Figure 2. Proportion (%) of domestic homicide cases within overall homicide cases, sorted by year (2010–2021).

children (sons) of the killers followed by parents (fathers), while female victims were predominated by spouses followed by mothers and permanent partners of the perpetrators. The majority of male victims were middle-aged adults between their late forties and sixties, followed equivalently by other age-groups, while female victims were predominated by the 45–69 age group, followed by females age 35–45. Furthermore, it was noted that the age group 0–7 consisted solely of male victims, while only females comprised the age groups 18–21 and 30–35. With reference to offenders, a preponderance of male offenders was again observed in the 45–69 age group, followed by males age 35–45, while female offenders mostly comprised the age-group >75 years (Figures 3–5).

Femicides

Greece experienced an upsurge in femicides during 2021 despite the declining trend in the overall crime rate, inevitably receiving great publicity and attention. This is in line with the limited femicide statistics available for 2021 at a worldwide level. According to the Canadian Femicide Observatory for Justice and Accountability (CFOJA), 92 homicides were recorded in Canada during the first half of 2021, compared with 78 for the same period in 2020 and 60 in 2019 [21]. In Mexico, where homicide rates have been consistently high over time, domestic-violence femicides as well as all crimes were described to have followed a U-curve trend during the pandemic, as they decreased during the lockdown period of the COVID-19 pandemic and then rose to prepandemic levels by October 2021 [22]. In 2021, UNODC stated that national tendencies in femicide are often characterized by instability. Estimating femicide prevalence is a challenging process, as well, because data collecting and sharing is fragmentary in many countries. Therefore, UNODC stated the most recent reliable global estimates correspond to the year 2017 when 87,000 femicides took place (58% perpetrated by intimate partners and family members) [5,23]. Moreover, 44% of femicide victims were estimated to have visited a hospital

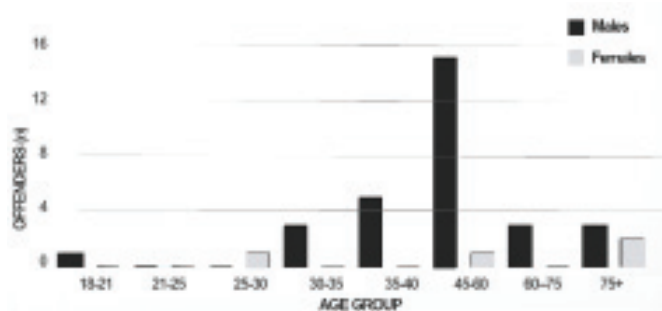


Figure 3. Offenders in domestic homicide cases (Article 299 of the Greek Penal Code in combination with Law 3500/06) for the year 2021, sorted by gender and age group.

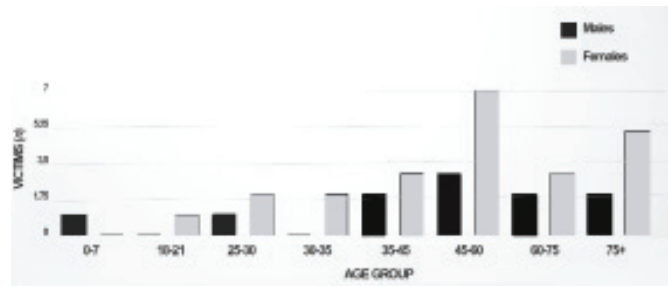


Figure 4. Victims in domestic homicide cases (Article 299 of the Greek Penal Code in combination with Law 3500/06) for the year 2021, sorted by gender and age group.

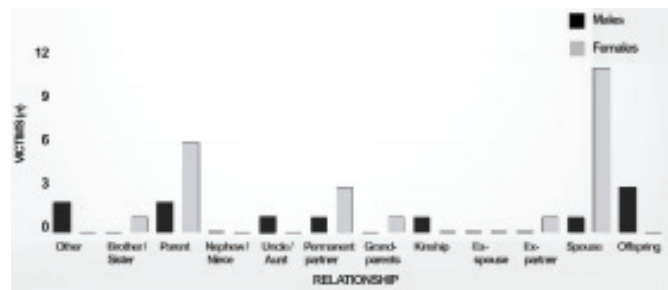


Figure 5. Victim–offender relationships in domestic homicide cases (Article 299 of the Greek Penal Code in combination with Law 3500/06) for the year 2021, sorted by gender and age group.

emergency department within two years prior to their murder regarding issues related to the aftermath of domestic violence [11]. The Directorate for External Policies of the European Union in its latest briefing stated that since the SARS-CoV-2 pandemic outbreak, as health and financial apprehension has increased domestic frictions, emerging data have been portraying a diverse picture of trends that is difficult to interpret [5].

Regarding escalating Greek statistics on femicide, one possible interpretation may be that the economic and human crisis experienced by the population of the country has led to instability and experienced stress contributing to the increased expression of violence and delinquency. Risk factors that are assumed to be potentially involved range from increased press coverage of femicides through patterns of imitation, social distancing, and solitariness during the COVID-19 pandemic, along with a longer duration of interpersonal exposure between cohabitants, the worrying socioeconomic situation experienced by Greek citizens (financial stressors), as well as the increased levels of alcohol and substance consumption (often inside residences due to prolonged restrictive measures related to catering and entertainment implemented even after the cessation of lockdown) [24–26]. The Directorate for External Policies of the European Union in its latest briefing also highlighted as an additional factor that women with abusive partners had to face isolation from relatives and

friends and disruption of their access to basic services when resources were shifted toward COVID-19 cases [5]. According to UNODC, however, global data on the impact of COVID-19 containment measures on femicide rates still remain unclear, while more countries may follow a similar trend regarding the phenomenon [23]. The authors of this commentary aim to highlight femicide as the gravest current issue to be interpreted and addressed both at a national and a global level along with its intertwined individual, relational, communal, and societal parameters. Collecting, analyzing, and sharing data is pivotal for the investigation of the phenomenon of femicide, as well as designing evidence-based policies that can effectively prevent potential victims from being at risk.

References

1. United Nations Office on Drugs and Crime: *Global Study on Homicide — Homicide Trends, Patterns and Criminal Justice Response*; United Nations: Vienna, Austria; <https://www.unodc.org/documents/data-and-analysis/gsh/Booklet2.pdf> (Accessed March 1, 2022).
2. United Nations Office on Drugs and Crime: *Global Study on Homicide — Gender-Related Killing of Women and Girls*; United Nations: Vienna, Austria; 2019; https://www.unodc.org/documents/data-and-analysis/gsh/Booklet_5.pdf (Accessed March 1, 2022).
3. Van Dijk JJM: *The World of Crime: Breaking the Silence on Problems of Security, Justice and Development Across the World*; pp 157–158; Sage Publications: Thousand Oaks, CA; 2008.
4. Caman S, Kristiansson M, Granath S, Sturup J: Trends in rates and characteristics of intimate partner homicides between 1990 and 2013; *J Crim Justice* 49:14-21; 2017.
5. Corradi C: Femicide, its causes and recent trends: What do we know? (For the European Parliament's Subcommittee on Human Rights); European Union: Brussels, Belgium; November 22, 2021; [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/653655/EXPO_BRI\(2021\)653655_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/653655/EXPO_BRI(2021)653655_EN.pdf) (Accessed May 10, 2022).
6. Weil S, Corradi C, Naudi M (Eds): *Femicide Across Europe: Theory, Research and Prevention*; Policy Press: Bristol, UK; 2018.
7. Bongaarts J, Guilmoto C: How many more missing women? *The Lancet* 386(9992):427; 2015.
8. Sorrentino A, Guida C, Cinquegrana V, Baldry AC: Femicide fatal risk factors: A last decade comparison between Italian victims of femicide by age groups; *Int J Environ Res Public Health* 17:7953; 2020.
9. Turvey BE, Freeman J: Victim lifestyle exposure; In Turvey BE (Ed): *Forensic Victimology*, 2nd ed; Chap 6; Academic Press: Waltham, MA; 2014.
10. Capaldi DM, Knoble NB, Shortt JW, Kim HK: A systematic review of risk factors for intimate partner violence; *Partner Abuse* 3:231; 2012.
11. Huecker MR, King KC, Jordan GA, Smock W: Domestic violence (Updated February 10, 2022); StatPearls Publishing: Treasure Island, FL; <https://www.ncbi.nlm.nih.gov/books/NBK499891/> (Accessed May 10, 2022).
12. Stamatel J, Ratajczak K, Hoekstra R: Do gun policies really protect women? A cross-national test of the relationship between gun regulations and female homicide victimization; *J Mediterr Knowl* 5(1):19; 2020.
13. Sajous-Turner A, Anderson NE, Widdows M, Nyalakanti P, Harenski K, Harenski C, Koenigs M, Decety J, Kiehl KA: Aberrant brain gray matter in murderers; *Brain Imaging Behav* 14:2050; 2020.
14. De Oliveira-Souza R, Hare RD, Bramati IE, Garrido GJ, Azevedo Ignácio F, Tovar-Moll F, Moll J: Psychopathy as a disorder of the moral brain: Fronto-temporo-limbic grey matter reductions demonstrated by voxel-based morphometry; *Neuroimage* 40:1202; 2008.
15. Ermer E, Cope LM, Nyalakanti PK, Calhoun VD, Kiehl KA: Aberrant paralimbic gray matter in criminal psychopathy; *J Abnorm Psychol* 121:649; 2012.
16. Tiihonen J, Rossi R, Laakso MP, Hodgins S, Testa C, Perez J, Repo-Tiihonen E, Vaurio O, Soininen H, Aronen HJ, et al.: Brain anatomy of persistent violent offenders: more rather than less; *Psychiatry Res* 163:201; 2008.
17. Cope LM, Ermer E, Gaudet LM, Steele VR, Eckhardt AL, Arbabshirani MR, Caldwell MF, Calhoun VD, Kiehl KA: Abnormal brain structure in youth who commit homicide; *Neuroimage Clin* 104:800; 2014.
18. Sajous-Turner A, Anderson NE, Widdows M, Nyalakanti P, Harenski K, Harenski C, Koenigs M, Decety J, Kiehl KA: Aberrant brain gray matter in murderers; *Brain Imaging Behav* 14:2050; 2020.
19. Hellenic Statistical Authority: Greece in Numbers; 2021; <https://www.statistics.gr/greece-in-figures> (Accessed March 1, 2022).
20. Michaelson R, Sidiropoulou M: A woman murdered every month: Is this Greece's moment of reckoning on femicide? *The Guardian* November 10, 2021; <https://www.theguardian.com/global-development/2021/nov/10/a-woman-murdered-every-month-greeces-moment-of-reckoning-on-femicide> (Accessed March 1, 2022).
21. Canadian Femicide Observatory for Justice and Accountability (CFOJA); <https://www.femicideincanada.ca/> (Accessed April 3, 2022).
22. Hoehn-Velasco L, Silverio-Murillo A, de la Miyar JRB: The great crime recovery: Crimes against women during, and after, the COVID-19 lockdown in Mexico; *Econ Hum Biol* 41:100991; 2021.
23. United Nations Office on Drugs and Crime: Killings of women and girls by their intimate partner or other family members: Global estimates 2020 (Data 3 Matters, 11/2021); https://www.unodc.org/documents/data-and-analysis/statistics/crime/UN_BriefFem_251121.pdf (Accessed April 5, 2022).
24. Harris-Papaioannou S: Violent crimes on the rise in Greece; *Greek Reporter* July 9, 2021; <https://greekreporter.com/2021/07/09/violent-crimes-greece/> (Accessed March 1, 2022).
25. Dlamini NJ: Gender-based violence, twin pandemic to COVID-19; *Crit Sociol* 47:583; 2020.
26. Karakasi MV, Sismanidou R, Spourita E, Dimtsis A, Karakasi AI, Bakirtzis C, Pavlidis P: The emotional burden of the SARS-CoV-2 pandemic on medical students in Greece; *Psychiatriki* 32:328; 2021.

Upcoming Events

- 2022 International Association of Bloodstain Analysis European Conference**
(https://www.iabpa.org/2022_european_conference.php)
July 9, 2022; Bush House
London, UK
- 2022 Annual Scientific Meeting & Clinical Lab Expo**
(<https://meeting.aacc.org/>)
July 24–28, 2022; McCormick Place Convention Center
Chicago, IL, US
- International Association for Identification — 106th Educational Conference**
(<https://www.theiai.org/>)
July 31–Aug. 6, 2022; CHI Health Convention Center
Omaha, NE, US
- American Society of Questioned Document Examiners/Southwestern Association of Forensic Documentation Examiners Joint Meeting**
(<https://asqde.weebly.com/conference.html>)
Aug. 8–10, 2022; Hyatt Regency Riverwalk
San Antonio, TX, US
- IACP Impaired Driving & Traffic Safety Conference**
(<https://www.theiacp.org/IDTSconference>)
Aug. 21–23, 2022; Grand Hyatt Riverwalk
San Antonio, TX, US
- T2022 — 23rd International Council on Alcohol, Drugs and Traffic Safety Conference**
(<https://t2022.org/>)
Aug. 28–31, 2022; De Doelen (Concert Hall & Convention Centre)
Rotterdam, The Netherlands
- TIAFT 59th Annual Meeting of the International Association of Forensic Toxicologists**
(<https://www.versaillespalaisdescongres.com/en/programme/>)
Sept. 5–8, 2022; Versailles Palais des Congrès
Versailles, France
- 25th Symposium of the Australia and New Zealand Forensic Science Society**
(<https://www.anzfs2022.com/>)
Sept. 11–15, 2022; Brisbane Convention and Exhibition Centre
Brisbane, Australia
- Midwestern Association of Forensic Scientists — 2022 Annual Meeting**
(<https://mafss.net/2022-Des-Moines-Meeting>)
Sept. 11–16, 2022; Des Moines Marriott Downtown
Des Moines, IA, US
- IFDAT 2022 — Annual International Forum for Drug and Alcohol Testing Conference**
(<https://www.ifdat.com>)
Sept. 18–20, 2022; Imlauer Hotel Pitter
Salzburg, Austria
- 20th International Congress of Therapeutic Drug Monitoring and Clinical Toxicology**
(<https://www.iatdmct2022.org>)
Sept. 18–21, 2022; Clarion Congress Hotel Prague
Prague, Czech Republic
- Northwest Association of Forensic Scientists — 2022 Annual Conference**
(<http://nwafs.org/wordpress/fall-meeting/>)
Sept. 26–30, 2022; Kimpton Hotel Vintage Portland
Portland, OR, US
- Robert F. Borkenstein Course on "The Effect of Drugs on Human Performance and Behavior"**
(<https://bcahs.indiana.edu/drugcourse/index.html>)
Sept. 26–30, 2022; Kimpton Monaco Hotel (Hybrid)
Philadelphia, PA, US
- 2022 International Conference on Forensic Nursing Science and Practice**
(<https://www.forensicnurses.org/page/2022AnnualConference>)
Sept. 28–Oct. 1, 2022; Sheraton Dallas Hotel
Dallas, TX, US
- Southwestern Association of Forensic Scientists — 44th Annual Conference** (<http://swafs.us/>)
Oct. 2–6, 2022; M Resort Spa Casino
Henderson, NV, US
- SCIX 2022 — Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies**
(<https://facss.org/event-3326055>)
Oct. 2–7, 2022; Cincinnati Marriott at River Center
Covington, KY, US
- National Association of Medical Examiners**
(<https://www.emedevents.com/c/medical-conferences-2022/national-association-of-medical-examiners-name-2022-annual-meeting>)
Oct. 14–18, 2022; Fairmont Dallas
Dallas, TX, US
- International Association of Chiefs of Police 2022**
(<https://www.theiacpconference.org/>)
Oct. 15–18, 2022; Kay Bailey Hutchison Convention Center
Dallas, TX, US
- Northeastern Association of Forensic Scientists — Annual Conference**
(<https://www.neafs.org/additional-annual-meetings>)
Oct. 17–21, 2022; Conference & Event Center Niagara Falls
Niagara Falls, NY, US

**IX International Conference on Novel
Psychoactive Substances**

(<https://www.novelpsychoactivesubstances.org/>)

Oct. 24–26, 2022; Panama Convention Center
Panama City, Panama

**2022 International Association of Bloodstain
Analysis Annual Conference**

(https://www.iabpa.org/2022_annual_conference.php)

Oct. 24–28, 2022; Dana Hotel on Mission Bay
San Diego, CA, US

**Society of Forensic Toxicologists —
Annual Meeting**

(<https://soft-tox.org/meeting>)

Oct. 30–Nov. 4, 2022; Huntington Convention Center
Cleveland, OH, US

**ISHI 33: International Symposium on
Human Identification**

(<https://www.ishinews.com/>)

Oct. 31–Nov. 3, 2022; Gaylord National Harbor
Washington, DC, US

**3rd International Caparica Conference in
Translational Forensics 2022**

(<https://www.forensics2022.com>)

Nov. 14–16, 2022; Hotel dos Capuchos
Caparica, Portugal

**21st International Congress of the European
Society of Toxicology in Vitro**

(<https://estiv.org/congress2022/>)

Nov. 21–25, 2022; Meliá Sitges
Barcelona, Spain

**American Academy of Forensic Sciences —
75th Annual Meeting**

(<https://www.aafs.org/>)

Feb. 13–18, 2023; Rosen Shingle Creek Hotel &
Convention Center
Orlando, FL, US

**American Society of Forensic Odontology —
Annual Meeting 2023**

(<https://coatconnect.com/medical-conferences/american-board-of-forensic-odontology-abfo-annual-meeting-2023>)

Feb. 13–18, 2023; TBD
Orlando, FL, US

PITTCON Conference and Expo

(<https://pittcon.org/exposition/>)

March 18–22, 2023; Pennsylvania Convention Center
Philadelphia, PA, US

**DATIA 2023 — Annual Meeting of the Drug &
Alcohol Testing Industry Association**

(<https://datia.memberclicks.net/>)

March 21–25, 2023; Bally's Hotel
Las Vegas, NV, US

**International Association of Chemical Testing —
2023 Annual Conference**

(<http://iaconline.org/>)

April 16–21, 2023; Charleston Marriott
Charleston, SC, US

**American Society of Forensic Laboratory Directors —
50th Annual Symposium**

(<https://www.asclfd.org/asclfd-annual-symposium/>)

April 30–May 5, 2023; Renaissance Austin Hotel
Austin, TX, US

**Southern Association of Forensic Scientists —
2023 Annual Meeting**

(<https://safs1966.org/annual-meeting/>)

April 24–28, 2023; Lodge at Gulf State Park, a Hilton Hotel
Gulf Shores, AL, US

California Association of Criminalists Seminar

(<https://www.cacnews.org/events/seminar/seminars.shtml>)

May 8–12, 2023; Whitney Peak Hotel
Reno, NV, US

**Mid-Atlantic Association of Forensic Scientists —
2023 Annual Meeting**

(<https://www.maafs.org/annual-meeting>)

May 16–19, 2023; DoubleTree by Hilton Hotel
Baltimore, MD, US

**The Association of Firearm and Tool Mark
Examiners — 54th Annual Training Seminar**

(<https://afte.org/meetings/annual-seminars>)

May 21–26, 2023; Renaissance Austin Hotel
Austin, TX, US

**176th American Psychiatric Association —
Annual Meeting** (<https://www.psychiatry.org/psychiatrists/meetings/annual-meeting>)

May 20–24, 2023; Moscone Center
San Francisco, CA, US

**71st ASMS Conference on Mass Spectrometry
and Allied Topics**

(<https://asms.org/conferences/annual-conference>)

June 4–8, 2023; George Brown Convention Center
Houston, TX, US

**23rd Triennial Meeting of the International
Association of Forensic Sciences**

(<https://iafs2023.com.au/>)

Nov. 20–24, 2023; International Convention Centre
Sydney, Australia

ADVANCING THE PRACTICE OF FORENSIC SCIENCE IN THE US — UPDATE

The Practice of Forensic Nursing Science in the United States

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The forensic aspects of nursing have long existed by serving victims of violence — both the living and the dead. In the 17th century, nursing was not considered a science and midwives filled this role, testifying in court on matters of virginity, pregnancy, and rape. Two centuries later, Florence Nightingale established the first attributes of forensic nursing when caring for service members wounded in war. During the 1970s nurses began volunteering at rape crisis centers and were finally being acknowledged for their expertise by the mid-80s. In the year 1991, forensic nursing was recognized by the American Academy of Forensic Sciences and in 2022 voted by the Academy as the 12th forensic science discipline.

Forensic health care assumes a pivotal role in both hospital and community settings by assisting persons who are victims of crime-related trauma, abuse, violence, liability, and accidents. Clinical forensic medicine merges both scientific knowledge and the criminal justice system, integrating the nursing process with public or legal proceedings in cases of trauma and/or death resulting in intentional or unintentional injury.

^aDr. Joyce Williams, RN, received her Doctor of Nursing Practice degree from the University of Tennessee in forensic nursing. Focusing on injury prevention, her research includes swabbing of the mouth for forensic DNA and reducing combat morbidity and mortality through improved protective armor for military members. She is an active member of the Disaster Mortuary Operational Response Team (DMORT). As a fellow in the American Academy of Nursing, she serves on the expert panels on violence and on quality health care. She chairs the forensic nursing subcommittee of the Organization of Scientific Area Committees (OSAC), and the Forensic Nursing Science Section in the American Academy of Forensic Science (AAFS). She is a reviewer for the *Journal of Forensic Nursing* and *Journal of Doctoral Nursing Practice*. Additional service includes the Maryland Human Trafficking Task Force Victim Services Committee, the Baltimore County Human Trafficking work group, educator for medical providers on identification and protocols to use with trafficked individuals, and Board member — Partnership for a Safer Maryland.

As criminal clinical investigators, forensic nurses improve justice and health outcomes to individuals impacted by violence. Expert care for these patients includes direct services to individuals with precise clinical assessment recognizing subtle and serious injuries and managing victims of crime-related trauma, abuse, and maltreatment. They provide consultation expertise to nursing, medical, and law-related agencies, and expert testimony in court [1].

In the United States, forensic nurses most frequently work in hospitals, community antiviolence programs, coroner's and medical examiner's offices, correctional institutions, and psychiatric hospitals. Furthermore, their scientific knowledge provides a magnitude of opportunities available for clinical practice, advocacy, advancing research, and education in academic centers. The specialist in forensic nursing science has become a potent influence in the rule of law and provides a collective intelligence for practice and research.

Who Are Forensic Nurses?

Forensic nursing specialty roles and subspecialties apply forensic health care in the scientific investigation of trauma, death related to injuries of abuse, violence, criminal activity, liability, and accidents [1]. Forensic nursing roles have evolved through the collaborative efforts of medicine, nursing, and the law transforming how the medicolegal management of forensic patients is executed. Beginning as the most recognized specialty role, sexual assault nurse examiner, the forensic nurse addresses the comprehensive needs of the sexual assault patient by assessing, evaluating, diagnosing, and implementing holistic care to restore and promote bio-psycho-social health to a victim. As one of the most frequently committed crimes in the United States, the need for qualified sexual assault medical forensic examiners (SAMFEs) is high. The first SANE programs began in Minneapolis, MN, Memphis, TN, and Amarillo, TX. SANE (sexual assault nurse examiner) programs were designed to prioritize the holistic well-being of survivors.

In this role a comprehensive clinical forensic examination is performed on any victim reporting to a health care facility with a complaint of sexual assault, rape, child abuse, elder abuse, intimate partner violence, or human trafficking; the exam is followed by evidence collection and documentation of injuries, education, and counseling. This level of care provides physical, emotional, forensic, and legal support that continues to benefit victims long after they have left the medical facility.

In the mid-1950s, Hildegard Peplau started the first graduate program for clinical nurses specializing in psychiatric mental health at Rutgers University (New Brunswick, NJ). This program marked the beginning of the Psychiatric Mental Health Nurse Practitioner (PMHNP) role. Forensic psychiatric nurses work with individuals and families that have mental health needs, often in situations involving violent crime or abuse. They are experts in communication skills treating patients who have experienced physical or emotional trauma. They also provide advice to child patients on how to find safe outlets to cope with trauma. Forensic psychiatric nurses excel in therapeutic interventions working with children experiencing regressive behaviors. Besides victims and victim's families, the forensic psychiatric nurse evaluates and treats criminal offenders in institutions who may be mentally ill.

Correctional forensic nurses provide healthcare to those incarcerated within the criminal justice system in a variety of settings such as jails, prisons, and juvenile detention centers. The responsibilities in each setting differ due to length of incarceration, population, and types of acute and chronic disease management.

As of 2020, the International Association of Forensic Nurses (IAFN) database reveals approximately 959 programs in the United States that offer SANE care compared to 20 programs in 1991. SANEs have been found to improve survivors' experiences while seeking care after a sexual assault.

The clinical arena is expanding rapidly for the forensic nurse and will continue to do so. Besides sexual assault patients, many cases involve child abuse, elder abuse, trauma, psychiatric, risk management, human rights violations, medical error, and tissue and organ donation.

The forensic nurse hospitalist provides comprehensive, medicolegal care to patients receiving treatment for trauma-related injury and questionable death in the acute care setting. Known as a transformational leader in health care today, this position offers scientific forensic consultation to patients who have experienced intentional or unintentional trauma. The role is vital to advance system-wide policy and educational efforts within the hospital setting [2].

Interpersonal violence is recognized as a criminal and social problem both in the United States and internationally. Crimes become social injustice problems often due to power and control or status and can be exacerbated by substance abuse. Societies may consider the crimes of child abuse and interpersonal violence a private family matter.

Internationally, communities are gaining momentum exchanging information and educating healthcare providers, law enforcement experts, and government officials in strategies to prevent crime using forensic science principles. The responsibility as a forensic nurse is to incorporate transcultural nursing perspectives with respect

to the ethical and moral dimensions of human care and healthcare practices of diverse cultures. They work in areas of human rights addressing the dynamics of archaic cultural traditions and religious practices that pose threats in society. Examples are female genital mutilation, honor killings, the incarceration of rape victims, and the lack of education for women and girls.

As countries establish initiatives pertaining to forensic nursing, they will be able to address major issues of prevalent crime, interpersonal and sexual violence, and the need to ensure human rights for women and children where they have been limited by cultural norms. After Kenya's initial COVID-19 lockdowns lifted and schools reopened, many female students didn't return. The reasons: the family couldn't afford it and most common was that they were pregnant. According to Bloomberg Businessweek [3], the consequences of girls leaving school increased chances of adolescent marriage, female genital mutilation, and pregnancy. Teen pregnancy rates in some Kenyan counties tripled in the first months of the pandemic, according to aid groups.

By the year 2030, nearly 20% of Americans will be 65 years of age with almost half of hospital stays represented by this older cohort. With this increase in this population, the practice of forensic nursing gerontology will thrive.

Not all forensic patients are living. Medicolegal death investigation responsibilities fall to different roles (e.g., medical examiner, coroner, medicolegal death investigator), and the specific scope(s) of these roles vary by state [4]. They work closely with crime scene investigators. Trauma may lead to death in healthcare facilities or private homes. The forensic nurse death investigator or forensic nurse coroner may be one of the first on the scene of a crime to analyze the scene, conduct body examinations, collect appropriate evidence, take crime scene photographs, and document findings. The forensic nurse investigator must scrutinize what precipitated the death and all other aspects related to the incident and then determine the necessary steps as outlined by state statutes.

Among the first documented disaster responses (involvement) to a manmade event are military nurses on the front line medically serving casualties of war. Today, the National Disaster Medical System (NDMS) is the leader in disaster response, identifying various specialties to respond when local resources are insufficient to meet the needs of the communities' disaster needs.

As part of NDMS, Disaster Medical Assistance Teams provide high-quality rapid-response medical care when public health and medical emergencies overwhelm state, local, tribal, or territorial resources. Forensic nurses in NDMS work several positions effectively — leading teams, managing logistics, providing exceptional care, and

serving in headquarters for the organization. As specialists they create disaster plans for communities and work in mobile morgues, where their medicolegal expertise serves to document injuries on the deceased; additionally, they work with the families of the dead as victim information specialists. Inclusion of forensic nurses on disaster preparedness teams amplifies the sensitive work involved when providing services for the dead.

Forensic nurses deploy as members of the Disaster Mortuary Operational Response Team (DMORTs) to support local mortuary services on location, working to quickly and accurately identify victims. As part of the process, the victim information center meets individually with families to obtain antemortem data, medical/dental records of victims, and DNA reference samples. The role includes providing technical assistance and consultation on fatality management and mortuary affairs.

Forensic nurses skilled in disaster risk management serve the public collaborating with community leaders on plans for prevention, preparedness, and response and recovery to determine a community's needs. The aim is to reduce potential damage and suffering. Prevention addresses causal factors and manageable risks while mitigation specifically refers to actions taken that can lessen the severity of a disaster's impact. Well-coordinated responses to disasters require prior planning. Disaster plans identify organizational resources, designate roles and responsibilities, create procedures and policies, and determine activities that improve disaster readiness. Community outreach mainstays are:

- Raising awareness about potential hazards and how to address them;
- Educating the public about how to properly prepare for different types of disaster; and
- Strengthening prediction systems

Levels of Practice

The practice of forensic nursing affords unprecedented opportunities to improve the global response to those affected by abuse and violence. In addition to undergraduate nursing training, generalist forensic registered nurses are specifically trained to provide comprehensive medicolegal management with demonstrated competency in the performance of the forensic medical examination of victims and suspects as part of an investigation, using forensic science to recover evidence, treating and educating patients, providing crisis intervention to patients, and referring patients to ongoing programs. They may be called to testify in court as a fact witness or as an expert.

The forensic clinical nurse specialist is an advanced forensic nursing role that requires a graduate degree in forensic nursing. Responsibilities of the forensic clinical

nurse specialist often include evaluating perpetrators in a case, workplace-related injuries, medical malpractice, automobile accidents, food and drug tampering, and medical equipment defects. They also develop and implement policies relating to various forensic issues and healthcare; conduct research in forensic nursing science; evaluate patient outcomes and engage in educating others about forensic nursing and evidence-based practices. They serve as consultants whether as a forensic attorney, nurse scientist, or investigator, and serve as administrators and consultants to local, state, or federal government and nongovernment institutions and organizations [5].

Forensic medicine has long been recognized as a respected component of public health; consequentially, forensic nursing is also an integral component of public health. Screening for violence is a minimum standard of care with policies and procedures to train professionals to identify and manage all patients seeking care for physical and emotional trauma [6,7]. Florence Nightingale appreciated that cramped quarters and overcrowding plus poor ventilation and sanitation were causes of death for British soldiers; she used statistics and diagrams in her analysis to underscore the root causes that led to army reform as well as health and social reform globally. A pioneer of nursing and a reformer of hospital sanitation methods, she pushed for reform of the British military health-care system, changed the design of hospitals, and developed the field of preventive medicine determined to stop contamination and the spread of infections and disease by implementing handwashing and other hygiene practices, as well as workplace safety. Following in her footsteps, the forensic nurse epidemiologist identifies biological and environmental threats to the health and safety of community populations, then mines the data to control and combat infectious diseases. They are contributing partners in gathering statistical data, which form the basis for predicting health crises and developing both preventive and interventional strategies.

The advanced practice forensic nurse is a specialist in risk management. The role encompasses identification and evaluation of risks as a means to reduce injury to patients, staff members, and visitors within an organization. They proactively work to create safety within an organization and to prevent incidents. They are involved in medical error root cause analysis to improve nursing practice. The work performed impacts research and policy that affects the human response to violence, injury, trauma, accidents, neglect, abuse, exploitation and victimization. They apply the legal requirements required and report injuries according to case law for incidents of injury, disability, and death associated with forensic events, as well as interpersonal violence.

The Changing Landscape for Forensic Nurses: Role Expansion

Research is an essential component of evidence-based practice. Some areas include advancing technologies in evidence collection research — this could be determining time since assault or recovering a DNA profile, or it could be where to swab for the ultimate yield of DNA for an area of the body. Another example is the work of Ann Wolbert Burgess, at Boston College (Boston, MA), who focused on developing ways to assess and treat trauma in rape victims, improving and revolutionizing the healthcare of at-risk populations.

The role of a forensic nurse injury analyst contributes to research regarding morbidity and mortality in clinical settings — determining intentional from unintentional wounding in cases of child abuse, trauma, interpersonal violence, accidental and industrial injuries, and more. The probes into chronic traumatic encephalopathy research have provided evidence leading to important changes for sports injuries and close contact physically. Neurodegenerative disease resulting from repeated blows to the head from assaults, military combat, or other traumatic brain injuries has influenced advancements in medical treatment interventions and improvements in protective equipment for sports as well as soldiers in conflict zones. The military values prevention efforts to keep the force safe. Since 2005 a team of forensic analysts utilized a multidisciplinary team approach including forensic nurses to improve personal protective equipment and related combat equipment for soldiers and sailors.

Forensic nurses also provide beneficial analysis for policy and practice within the emergency medical services (EMS). As public and private agencies, the need for highly trained professionals is acute. Trauma systems and hospital trauma centers including specialty care centers are positioned to integrate with other services and systems intended to maintain and enhance the community's health and safety. EMS operates at the crossroads between health care, public health and public safety. Forensic nurse trauma response specialists serve communities providing expert trauma care, identifying and documenting injuries while preserving evidence. They provide acute care as well as follow-up services ensuring that the needs of the patient are met from entry into the system through rehabilitation.

The range of potential roles for the forensic nurse suggests the prospects are abundant. Countless opportunities exist in federal and state governments as well as the private sector such as policy sponsors and lobbyists. Various governmental agencies highlight suitable positions where forensic nurses would add expertise to their missions of safety and prevention of injuries in populations (**Figure 1**).

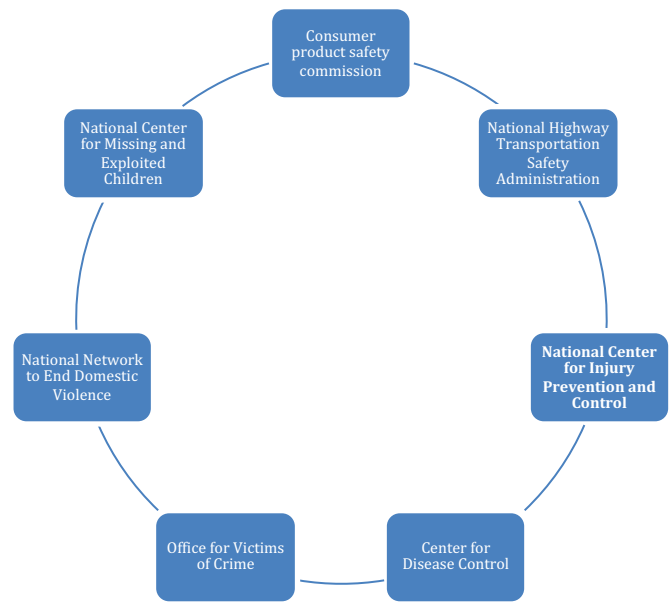


Figure 1. Governmental agencies

- **Consumer Product Safety Commission.** The CPSC, an independent agency of the US government, seeks to promote the safety of consumer products by addressing “unreasonable risks” of injury, developing uniform safety standards, and conducting research into product-related illness and injury;
- **National Highway Transportation Safety Administration.** The NHTSA enforces vehicle performance standards and partnerships with state and local governments; reduces deaths, injuries, and economic losses from motor vehicle crashes.
- **National Transportation Safety Board.** The NTSB analyzes the information gathered to piece together a sequence of events and determine what happened to cause the accident. This report provides a description of the accident, a review of the investigative analysis, and a determination of probable cause;
- **National Center for Injury Prevention and Control.** An arm of the Center for Disease Control, the NCIPC guides national efforts to reduce the incidence, severity and adverse outcomes of intentional and unintentional injury in the United States and provides leadership in preventing and controlling injuries;
- **Office for Victims of Crime.** The OVC is committed to enhancing the nation’s capacity to assist crime victims and oversees programs and grants for service providers and other professionals;
- **National Network to End Domestic Violence.** The NNEDV is the leading voice for survivors of domestic violence and their allies. In 1994, it led efforts to pass the landmark **Violence Against Women Act (VAWA)**; and
- **National Center for Missing and Exploited Children.** The nation’s nonprofit clearinghouse and comprehensive reporting center for all issues related to the prevention of and recovery from child victimization, the NCMEC leads the fight against abduction, abuse, and exploitation.

As the role of forensic nurses expands, academic centers provide education to nursing students from undergraduate to graduate nurses in the concepts and practice of forensic nursing science and forensic health. Topics focus on injury prevention, engineering aspects of trauma and pathology, victimization, and leadership and management roles. Coursework encompasses criminal activity, traumatic events, treatment of victims and perpetrators, and scientific investigation.

Forensic nursing has evolved since the 70s expanding from the individual through system to population health. Joint venture with the eleven other forensic disciplines as recognized by the American Academy of Forensic Science (i.e., Anthropology, Criminalistics, Digital & Multimedia Sciences, Engineering & Applied Sciences, General, Jurisprudence, Odontology, Pathology/Biology, Psychiatry & Behavioral Science, Questioned Documents, and Toxicology) supports and advances patient outcomes. With the inclusion of “Forensic Nursing” as the newest recognized discipline of the Academy, the future of forensic nursing will expand. The combination of nursing plus engineering represents a new, convergent discipline, transdisciplinary interface. The nurse and engineer have the unique capability of working at a level of substantial depth in a modified approach uniting two separate disciplines [8]. Forensic professionals’ vision of an emerging career space circumscribed by the term, “STEMpathy”, originally coined by Friedman [9], as the concept that combine science, technology, engineering, and math (i.e., STEM) with human empathy, or caring.

Partnerships among providers of healthcare and practitioners of engineering are not new, and historically these partnerships have produced highly successful outcomes, including: the development of the pacemaker (1958); the computed tomography (CT) scanner (1970); and slow-release medicines (1980), among many other technologies [10]. The use of inter-disciplinary, multi-disciplinary, or cross-disciplinary approaches will further expand the role of forensic nursing.

Conclusion

Forensic nursing science is an evolving profession that is gaining traction and expanding. Forensic practitioners contribute to communities by advancing direct and indirect services to victims caught in the surge of violence in today’s world. According to Janet Barber, MSN, RN, it’s all about

relevancy. Forensic nurses distinguish themselves using not only their unique knowledge of the nursing process and proficiencies, but also their experience in the legal system, to obtain occult forensic details as a scientist allowing the facts to speak the truth. As healthcare professionals, forensic nurses are positioned to meet the needs of our environment where episodic terror, gun violence, pandemics, and rage are ever present. Forensic nurse experts are a valuable asset for healthcare, interfacing with federal, state, and local organizations and nonprofit agencies. Forensic nursing began as a more singular movement; the discipline has revolutionized into a paramount force without limitations.

References

1. Lynch VA: Forensic nursing science; In Hammer R, Moynihan RM, Pagliaro EM (Eds): *Forensic Nursing: A Handbook for Practice*; p 3; Jones & Bartlett Learning: Burlington, MA; 2013.
2. Berishaj K, Boykand C, Reinink K, Lynch V: Forensic nurse hospitalist: The comprehensive role of the forensic nurse in a hospital setting; *J Emerg Nurs* 46:286; 2020.
3. Filipovic J: The lost girls of Covid; *Bloomberg* (US Edition) January 5, 2020; <https://www.bloomberg.com/news/features/2022-01-06/how-covid-is-impacting-young-girls-and-women-around-the-world> (Accessed May 13, 2022).
4. Drake S, Thone C, Foster M, Porta C, Pickens A: Medicolegal death investigator workplace safety hazards: A scoping review of the literature; *J Forensic Sci* 67:44; 2021.
5. Lynch V, Duval J: *Forensic Nursing Science*, 2nd ed; Chap 1: Evolution of forensic nursing science (p 8); Mosby Elsevier: St. Louis, MO; 2010.
6. [US] Centers for Disease Control and Prevention: Violence prevention; <https://www.cdc.gov/violenceprevention/index.html> (Accessed May 13, 2022).
7. Cerulli C: Addressing intimate partner violence and helping to protect patients (Quick Safety 63); *The Joint Commission* January 2022; <https://www.jointcommission.org/-/media/tjc/newsletters/quick-safety-63-addressing-ipv-final-1-10-22.pdf> (Accessed May 13, 2022).
8. Smith Glasgow ME, Colbert A, Viator J, Cavanagh S: The nurse-engineer: A new role to improve nurse technology interface and patient care device innovations; *J Nurs Scholarsh* 50:601; 2018.
9. Friedman TL: From hands to heads to hearts; *New York Times* (Online) January 4, 2017; <https://www.nytimes.com/2017/01/04/opinion/from-hands-to-heads-to-hearts.html> (Accessed June 4, 2022).
10. Oerther DB, Glasgow ME: The nurse+engineer as the prototype V-shaped professional; *Nurs Outlook* 70:280; 2022.

Center for Statistics and Applications in Forensic Evidence Update

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The Center for Statistics and Applications in Forensic Evidence (CSAFE) was created in 2015 in response to the national effort to infuse statistical thinking and rigorous, science-based standards into forensic practice. CSAFE is a National Institute of Statistics and Technology (NIST) Center of Excellence focusing on pattern and digital evidence. We collaborate with more than 80 researchers across nine universities to drive solutions to support our forensic community partners with accessible tools, open-source databases, and educational opportunities. CSAFE features initiatives in research and training designed to move research from CSAFE into forensic laboratories and courtrooms. With a focus on probability and statistics for pattern and digital evidence, CSAFE transfers results into practice.

Current Research Initiatives

The information below highlights a sample of current research initiatives led by the CSAFE team. Additional accomplishments in other forensic science disciplines will be discussed in subsequent issues of *Forensic Science Review*. Visit the CSAFE website www.forensicstats.org to learn more about our research and educational opportunities. CSAFE advancements are founded on strong collaborations with the forensic science community. If you would like to partner with CSAFE, please contact us at www.forensicstats.org/contact.

CSAFE Develops Shoe Scanner to Gather Population Footwear Data

One of the biggest obstacles to developing quantitative and probabilistic methods for footwear impression evidence is that gathering data on the reference population or populations is incredibly difficult — the footwear used changes as new shoes are released, but also due to weather, geography, and other factors.

CSAFE researchers at the University of Nebraska-Lincoln and Iowa State University are addressing these problems by developing and deploying a scanning device called the Modeling And Inventory of Tread Impression System (MANTIS) to capture population footwear class characteristics (**Figure 1**). In addition, they are developing statistical software that will automatically identify class characteristics and other comparison features.



Figure 1. The MANTIS Optics Scanner was designed to take real-time images of a person's footwear as it comes in contact with the scanner's cover plate.

The MANTIS Optics Scanner takes real-time images of the shoe as it comes in contact with the scanner cover plate. It synchronizes a series of cameras to create a detailed image of the shoe from multiple angles, recording the tread pattern for later comparison and analysis. Cameras housed in the scanner body capture the shoe side and sole with minimal additional details about the wearer. The scanner's cameras are tuned so that details more than 12 in. from the surface are not in focus. The cameras capture from 8 to 15 megapixels using four cameras located in the housing unit. The research team has deployed an outsole scanner outdoors on the Iowa State University campus in Ames, IA, to collect information on the frequency of outsole patterns. So far, nearly 2,000 outsole images have been collected. The team will soon extend the scanners' deployment to outdoor and indoor public areas in Ames and Lincoln, NE. Eventually, the collected data and associated metadata will be made available to the public in an online database that will serve as a resource for researchers and practitioners. The researchers also hope to work with law enforcement partners in other locations to expand the scope of this project, testing the scanner in different populations and applications.

During the data collection period, the researchers manually annotate the collected images, identifying different class characteristics that may interest examiners and researchers. The annotated images will be used to train automatic feature recognition models, allowing the models to automatically identify features for images gathered by the scanner without the significant amounts of human effort required for manual annotation. Annotated images will also be made publicly available, serving as a resource for additional machine learning research in footwear class characteristics.

The research team discussed this project during a recent CSAFE-hosted webinar. View the webinar recording at www.forensicstats.org/blog/portfolio/mantis.

CSAFE Develops an Open-Source Tool for Handwriting Analysis

Document examiners are often asked to determine the source of a handwritten document, including ransom notes, faked legal documents, and other such papers, where the information about the source is contained in the handwriting itself rather than in the document's content.

At present, document examiners rely on visual comparisons and subjective assessments of the similarity between two handwriting samples. They focus on attributes such as the width and length of loops, the crossing of t's, or the overall slant of the characters to determine whether a specific person might have been the author of the document. Several automated systems capable of extracting writing features for comparison between documents are available; however, they are expensive, and their algorithms are proprietary.

CSAFE researchers are developing tools to aid handwriting and document examiners in their evaluations. Their approach is to treat handwriting as a collection of graphical objects from which features can be extracted. These features are hypothesized to be informative about the document's writer and can be used to compute a probability of authorship within a closed set or open set of potential authors of the questioned document.

The CSAFE team has published an open-source program called *handwriter* that outputs glyphs, or geometric representations of handwriting. They are currently working on extending the capabilities of *handwriter* by including a clustering function, a function to decompose writing into words rather than character-level graphs, and creating a simple user interface.

The program is hosted in CRAN, the Comprehensive R Archive Network, and has met the strict publishing quality criteria. A detailed tutorial and steps on how to install *handwriter* are available at <https://csafe-isu.github.io/handwriter>.

The statistical modeling approach depends on the forensic question of interest. When the goal is to identify the most likely author of a questioned sample from among a closed set of potential authors, the researchers use a Bayesian hierarchical approach that outputs a probability of writership for each writer in the set. The researchers found this approach could predict the correct writer of a questioned document with large associated posterior probabilities and with a high degree of accuracy when the true writer was actually in a closed-set list of known writers.

The researchers have also worked on extending the closed-set model to an open-set of potential writers by developing a score-based likelihood ratio (SLR) methodology using a random forest for writership analysis.

Although no algorithm can replace an experienced document examiner, it can aid the examiner by providing a quantitative assessment of the similarity between two handwritten documents. The researchers' goal is to develop a tool that can be used alongside the traditional examination, resulting in an objective, transparent, and reproducible outcome.

In a recent webinar, Alicia Carriquiry, CSAFE director, discussed her team's work on handwriting analysis. The recording is available at www.forensicstats.org/blog/portfolio/handwriting-analysis-at-csafe.

Researchers Revisit Black Box Studies to Look at Effect of Inconclusive Findings on Error Rate Estimates

CSAFE researchers revisited several of the most cited black box studies on firearms examination, investigating the treatment of inconclusive results.

For each black box study, the researchers calculated the error rates from the study results using standardized methods. They also assessed the impact of the study design and treatment of inconclusives on the calculated error rates. These studies varied in structure, having closed-set or open-set data, and were also conducted in different regions, either in the United States and Canada or in Europe.

The researchers found that one of the most relevant differences was how each study treated inconclusive results. There were three main ways the inconclusive decisions were treated in calculating error rates. The first option was to exclude the inconclusive from the error rate. The second option was to include the inconclusive as a correct result. And the third option was to include the inconclusive as an incorrect result.

The authors proposed a fourth option on how to treat inconclusive decisions. They suggested treating the inconclusive results the same as eliminations, and the error rates would be calculated for the examiner and the process separately.

After inspecting the studies, the researchers found that examiners tended to lean toward identification over inconclusive or elimination. In addition, they were far more likely to reach an inconclusive with different-source evidence, which should have been an elimination in nearly all cases. They also found that process errors occurred at higher rates than examiner errors.

Furthermore, they discovered that study design issues create a bias toward the prosecution. In many study designs, it is not possible to calculate an error rate for eliminations, but it is possible to calculate an error rate for identifications. This asymmetry is due to the difficulty in determining how many nonmatch comparisons examiners completed during study designs where there are multiple known sources in the same kit.

Based on their assessment of the currently available studies, there is significant work to be done before confidently stating an error rate associated with different components of firearms and toolmark analysis. In particular, there is a need for studies that are large (many examiners and many evaluations) and meet specific design criteria.

This study was presented during a CSAFE-hosted webinar. Watch it at www.forensicstats.org/blog/portfolio/treatment-of-inconclusive-results-in-error-rates-of-firearm-studies.

Insights Series Gives Forensic Science Community the Key Takeaways from CSAFE Research

CSAFE launched its *Insights* series to provide research results relevant to the forensic science community. The publications feature high-level highlights of selected areas of CSAFE research.

Insights are designed for forensic professionals to stay up to date and have actionable steps or informed knowledge about each study's impact. Examiners, lawyers, judges, or crime lab directors can read an Insight and immediately facilitate meaningful conversation about pressing forensic science issues. All relevant algorithms, databases, and other resources are linked in the text for further exploration.

Each two-page Insight and companion webpage features an overview of the research project, the goals or hypothesis tested, the approach and methodology used by the research team, key takeaways for practitioners, and future work.

CSAFE will add more Insights to the series as researchers continue to publish their research results. More than 20 Insights have been published already and are available at www.forensicstats.org/insights. Below is a sampling of the Insights available on the CSAFE website.

- Judges and Forensic Science Education: A National Survey (forensicstats.org/blog/2021/04/21/insights-judges-and-forensic-science-education-a-national-survey);
- Mt. Everest—We Are Going to Lose Many: A Survey of Fingerprint Examiners' Attitudes Towards Probabilistic Reporting (forensicstats.org/blog/2021/04/22/insights-mt-everest-we-are-going-to-lose-man);
- Implementing Blind Proficiency Testing in Forensic Laboratories (forensicstats.org/blog/2020/10/01/insights-implementing-blind-proficiency-testing-in-forensic-laboratories); and
- Statistical Methods for the Forensic Analysis of Geolocated Event Data (forensicstats.org/blog/2020/07/13/insights-statistical-methods-for-the-forensic-analysis-of-geolocated-event-data).

Researcher-Practitioner Collaboration

Researchers are looking for practitioners to collaborate on CSAFE Studies. Forensic practitioners looking to become involved in CSAFE research can now find a list of research opportunities in the American Society of Crime Laboratory Directors (ASCLD) Forensic Research Committee's (FRC) Researcher-Practitioner Collaboration Directory. The directory connects researchers who have ongoing projects to practitioners who want to participate in research studies. Each project listing in the directory includes a summary, the support requested from participants, estimated time involved, and deliverables. To request to collaborate, practitioners can contact the principal investigator.

CSAFE currently has six projects in the directory (**Table 1**) that could use support from forensic practitioners or law enforcement personnel. The projects and principal investigators are listed below. More information about these projects can be found in the FRC Researcher-Practitioner Collaboration Directory at www.asclcd.org/researcher-practitioner-collaboration-directory.

Table 1. Current CSAFE projects that could use support from forensic practitioners or law enforcement personnel

Project name	Principal investigator	Hosting institution
Blind Proficiency Testing	Robin Mejia	Carnegie Mellon University
Characterization of Footwear in Local Populations	Susan VanderPlas	University of Nebraska-Lincoln
Forensic Processing at Crime Labs	Brett Gardner	University of Virginia
Handwriting Evaluation	Alicia Carriquiry	Iowa State University
Mobile App Evidence Analysis	Yong Guan	Iowa State University
StegoAppDB: Reference Database with Variational Sources for Mobile Steganography Image Forensics	Jennifer Newman	Iowa State University

NEW BOOKS AND BOOK REVIEWS

New Forensic Science Books

- Atlas of Forensic and Criminal Psychology*
B.-N. Tiffon
CRC Press: Boca Raton, FL, US; 2022
- Child Abuse and Neglect*, 3rd ed
M. L. McCoy, S. M. Keen
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Conducting Interviews with Child Victims of Abuse and Witnesses of Crime — A Practical Guide*
M. Cyr
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Convictions Without Truth—The Incompatibility of Science and Law*
R. Schehr
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Critical Forensic Studies*
R. Julian, L. Howes, R. White
CRC Press: Boca Raton, FL, US; 2021
- Cyber Security and Digital Forensics: Challenges and Future Trends*
M. M. Ghonge, S. Pramanik, R. Mangrulkar, D.-N. Le, Eds
Wiley-Blackwell: Somerset, NJ, US; 2022
- Data Sleuth: Using Data in Forensic Accounting Engagements and Fraud Investigations*
L. Wietholter
Wiley-Blackwell: Somerset, NJ, US; 2022
- Disaster Victim Identification in the 21st Century: A US Perspective*
J. A. Williams, V. W. Weedn, Eds; D. H. Ubelaker, Series Ed
Wiley-Blackwell: Somerset, NJ, US; 2022
- Digital Forensics and Internet of Things: Impact and Challenges*
A. Gehlot, R. Singh, J. Singh, N. R. Sharma, Eds
Wiley-Blackwell: Somerset, NJ, US; 2022
- Evidence and Procedures for Boundary Location*, 7th ed
D. A. Wilson, C. A. Nettleman, W. G. Robillard
Wiley-Blackwell: Somerset, NJ, US; 2021
- A Field Guide to Ghost Guns for Police and Forensic Investigations*
R. E. Walker
CRC Press: Boca Raton, FL, US; 2021
- Food Chemistry: The Role of Additives, Preservatives and Adulteration*
M. Sen, Ed
Wiley-Blackwell: Somerset, NJ, US; 2021
- Forensic Chemistry*, 3rd ed
S. Bell
CRC Press: Boca Raton, FL, US; 2022
- Forensic Genetic Approaches for Identification of Human Skeletal Remains: Challenges, Best Practices, and Emerging Technologies*
A. Ambers, Ed
Academic Press/Elsevier: Waltham, MA, US; 2022
- Forensic Interventions for Therapy and Rehabilitation: Case Studies and Analysis*
B. Winder, N. Blagden, L. Hamilton, S. Scott, Eds
Routledge/CRC Press: Boca Raton, FL, US; 2021
- Forensic Mental Health Assessment in Criminal Contexts — Key Concepts and Cases*
N. K. Kaufman, S. S. Bush, N. R. Schneider, S. J. Hicks
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Forensic Psychology*
N. Gredecki, P. Turner, Eds
Routledge/CRC Press: Boca Raton, FL, US; 2021
- Forensic Psychology*, 3rd ed
D. A. Crighton, G. J. Towl, Eds
Wiley-Blackwell: Somerset, NJ, US; 2021
- Forensic Science — A Sociological Introduction*; 2nd ed
C. Lawless
CRC Press: Boca Raton, FL, US; 2022
- Genetic Surveillance and Crime Control — Social, Cultural and Political Perspectives*
H. Machado, R. Granja
Routledge/CRC Press: Boca Raton, FL, US; 2021
- Global Perspectives on Interventions in Forensic Therapeutic Communities: A Practitioner's Guide*
G. Akerman, R. Shuker, Eds
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Investigating Sexual Assault Cases*, 2nd ed
A. S. Chancellor
CRC Press: Boca Raton, FL, US; 2021
- Managing Client Emotions in Forensic Accounting and Fraud Investigation*
S. Pedneault
Wiley-Blackwell: Somerset, NJ, US; 2021
- Manual of Forensic Taphonomy*, 2nd ed
J. T. Pokines, E. N. L'Abbe, S. A. Symes, Eds
CRC Press: Boca Raton, FL, US; 2021
- Methodologies and Challenges in Forensic Linguistic Casework*
I. Picornell, R. Perkins, M. Coulthard, Eds
Wiley-Blackwell: Somerset, NJ, US; 2022
- Mildred Trotter and the Invisible Histories of Physical and Forensic Anthropology*
E. K. Wilson
CRC Press: Boca Raton, FL, US; 2022
- Network Forensics — Privacy and Security*
A. Bijalwan
CRC Press: Boca Raton, FL, US; 2021
- Psychopathy and Criminal Behavior: Current Trends and Challenges*
P. Marques, M. Paulino, L. Alho, Eds
Academic Press/Elsevier: Waltham, MA, US; 2021
- The Routledge Handbook of Archaeoethnology — Bioarchaeology of Mortuary Behaviour*
C. J. Knüsel, E. M. J. Schotsmans, Eds
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Sexual Abuse Within the Church — Assessment, Intervention, and Prevention*
C. Burkey, M. C. Braswell, J. T. Whitehead
Routledge/CRC Press: Boca Raton, FL, US; 2021
- Trauma-Informed Forensic Practice*
P. Willmot, L. Jones, Eds
Routledge/CRC Press: Boca Raton, FL, US; 2022
- Visual Culture and the Forensic Culture, Memory, Ethics*
D. H. Jones
CRC Press: Boca Raton, FL, US; 2022

Book Review

Crime Scene and Digital Forensics: A Holistic View

Anthony C. Ijeh, Kevin Curran, Eds
CRC Press: Boca Raton, FL, US; 2021

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Professors Anthony C. Ijeh and Kevin Curran are the co-editors of *Crime Science and Digital Forensics: A Holistic View*. Prof. Ijeh^a has held faculty positions at the University of Buraimi in Oman and the American University in the Emirates, Dubai. His research and publications focus on the area of digital public goods as they apply to services in the private, public, and third sectors. Prof. Ijeh's experience includes government and industry as well as academics. He was on the Microsoft Dynamics Academic Alliance Advisory Council for EMEA (a designation given to a set of countries in Europe, the Middle East, and Africa for business purposes), reviewed articles for journals including *Journal of Behavioral Health Services Research*, and serves on the editorial board for various publications. As a former acting dean and program director, Prof. Ijeh has been widely recognized for his contributions to cyber security innovation by way of his publications and his awards from E-Synergy, Institute of Electrical and Electronics Engineers IEEE), Institute of Engineering and Technology (IET), and Royal Academy of Engineering (RAENG).

Prof. Curran^a is the group leader of the Cyber Security/Web Technologies Research Group at Ulster University in Northern Ireland. He also serves on the advisory board of the UK Cyber Security Council and Northern Ireland Civil Service Cyber Leadership. Prof. Curran is recognized for his work on cyber security evidenced by over 800 publications. Furthermore, he has been interviewed as a technology expert more than 1,500 times by outlets including the BBC, ITV, Wired, South China Morning Post, CBC, CNN, Daily Mail, Sputnik News, NY Times, Huffington Post, Techcrunch, and many more.

^aEditors' background information are based on those provided by the publisher available in: <https://www.routledge.com/Crime-Science-and-Digital-Forensics-A-Holistic-View/Ijeh-Curran/p/book/9780367322557>.

Crime Science and Digital Forensics: A Holistic View is a collection of articles on digital forensics practices and crime scene investigative methods from the viewpoint of crime science. The book also features dialogue on information security techniques for protecting data from unauthorized access and manipulation. This volume comprises 12 chapters, organized in the three areas of crime science, digital forensics, and cyber security.

Part 1: Crime Science includes four chapters: (1) Unraveling the Notre Dame Cathedral Fire in Space and Time: An X-coherence Approach; (2) Using Gesture Recognition to Prevent Drowning: A Crime Science Perspective; (3) Modelling Criminal Investigation: Process, Quality and Requirements; and (4) Digital Investigation and the Trojan Defense, Revisited.

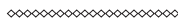
In Part 1, science/technology has been applied to the crime scene. In Chapter 1, the authors evaluate the methods for spatially and temporally classifying images of the Notre Dame Cathedral fire incident. The project shows the visualization of the dataset and creates a structured dataset by constructing a unified space so that the result of the inferred information is in a collective coherent system, which helps the investigation of the blaze incident. In Chapter 3, the authors apply scientific principles such as reliability and validity to scale the quality of a criminal investigation. The result demonstrates how the hypothetico-deductive approach gives tools and methodologies for exercising a reliable and valid investigation.

Part 2: Digital Forensics comprises the next four chapters: (5) Law Enforcement Agencies in Europe and the Use of Hacking Tools During Investigations: Some Legal Informatics, Civil Rights and Data Protection Issues; (6) Mobile Forensics — Tools, Techniques and Approach; (7) Digital Forensics of Cyber-Physical Systems and the Internet of Things; and (8) Social Media Crime Investigation and Forensic Analysis.

Chapter 6 discusses the exponential increase in digital evidence from numerous digital devices. The objective of the digital evidence process is to extract the pieces of evidence from the devices without any tampering. As such, guarding the integrity of mobile-device evidence is a significant concern. Many mobile apps store their enormous data on cloud storage, which causes another hurdle from the perspective of digital forensics. Mobile malware is another forensic challenge that may put evidence integrity at risk. Some anti-forensic tools are used for data hiding, and artifacts data wiping is used to distract from forensic investigation. As suggested in the chapter,

it is very significant to comprehend that digital devices and OS vendors could come from different nations and therefore international collaboration is needed.

In Chapter 8, the author indicates that enormous activities on social media provide a haven for cybercrimes and antigovernment or antisocial events. The author categorizes the social media platform as follows: "Social Networks", "Media Sharing Networks", "Discussion Forums", "Consumer Review Networks", "Blogging and Publishing Networks", "Sharing Economy Networks", and "Anonymous Social Networks"; they could be used for tools for the following cybercrimes: "Reconnaissance", "Fake Profiles/Identity Theft", "Social Engineering Attack", "Fake News", and "Malicious Content". The author concludes that the evidence collected from digital devices may not be enough for forensic investigation. He urgently advocates assistance from social media service providers to the law enforcement professions. Intricate jurisdiction issues, mutual support accordance, and bilateral agreement are portrayed as serious hurdles in social media investigation. The author says that concerns such as highly encrypted and anonymous messages and fake profiles could lead to another crucial issue; he concludes that the impact and dangers of social media are devastating and there is no simple and quick forensic solution.



Part 3: Cyber Security comprises the final four chapters: (9) Bayesian Networks and Cyber-Crime Investigations; (10) The Future of Democracy in a Cyber-Security Framework; (11) Is It a Cyber Security Strategy for Social Development? and (12) NATO’s Current and Future Cyber-Defense Adaptability.

In Chapter 10, the authors provide an integral view pertaining to cyber security and cyber democracy; they raise serious concerns about the future of democracy in a new cyberspace domain and era. The authors cover several factors, theories, and considerations: "between the progress of technology and the fine balance between the risk of limited freedoms to increase of surveillance cyber-authoritarian and the important necessity of civil protection in cyber-space". Furthermore, the chapter highlights the complete necessity of cyber security in a post-COVID-19 environment, inside the framework of new handling and working in the virtual world. As the authors urge, "It should be an education based on values, humanities, and classics, else we run the risk to end up

with high technology subjects instead of cyber-citizens and ... a high technology totalitarian dystopia instead of the cyber-democracy that we deserve".

In Chapter 12 the author reviews NATO’s policy on cyber security and its adaptability to current and emerging difficulties. The COVID-19 pandemic has pushed the global rapid move to a pace that makes us fully dependent on virtual tools, which might cause some threats so we need to improve our operational and tactical agility, adaptability, and flexibility. As suggested by the author, "We need to go beyond traditional methods of operations and with its future operations. More so in the field of cyber defense and security, which constitutes one of NATO’s defense pillars".

This chapter analyzes the policy of defense within its cyber security framework and shows the necessity and need of a military cyber defense policy. Regarding the war between Russia and Ukraine, the chapter stresses a crucial concern over NATO’s ability for cyber defense. It concludes that in a post-COVID-19 global pandemic, our world should be more interconnected than ever before: "Cyber-Defence at NATO is expected to become an even more important pillar at NATO". It is even very true during this wartime between Russia and Ukraine.



Overall, this book is designed as a new stage for demonstrating new approaches to dealing with crime science, highlighting digital forensics and delivering cyber security. Such insights would enhance our awareness of the growing pervasiveness of cyber crimes and showcase how to deal with digital evidence and implement the existing technological solutions in cyber security. It provides innovative ways for criminal data analysis and crime prevention through AI autonomous new tech as well as a collection of quantized scientific research in crime scene applicable science, digital forensics, and cyber security strategies and policy frameworks. As technology becomes advanced and easier to deploy in an increased number of discrete, everyday communications, the scope for issues of forging/deleting a trail of digital data that can be used for individuals’ identity is getting more vital.

This book serves as a great venue for those who are interested in the study of combined disciplines to deal with new crime scene science/technology applications, digital forensics, and cyber security.

COMMENTARY

Quality Systems for Forensic Science — Fit for Whose Purpose?

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As the reader will learn from the bio, I had the privilege of being a senior executive manager of a forensic group for 20 years. Perhaps uniquely, during my entire career I stayed active as a caseworker and maintained case authorization which, in my view, kept me firmly grounded in the realities of what was going on in the laboratory. Indeed, the final challenge I set myself before retirement was to lead a review of our quality system [18]. The driver for this review was my perception that our quality system had become unwieldy, too complex, and too detailed, and that our staff were not really engaging with the quality system other than as a form of compliance and avoiding personal risk. The primary goal of this review was to re-engage staff with the quality system through a shared ownership of the review and its outcomes. I regret to say that I do not think we wholly achieved our goal.

The motivation to write this commentary was the invitation in recent years by my former organization, the AFP forensic group, to talk to several new member forensic induction programs. The AFP was concerned that new staff needed to understand why there was a quality system and what it was intended to achieve. I was asked specifically to explain how the quality system evolved and why it is important to them as individuals as well as at an organizational level.

Hence, the focus of this commentary is to take a different look at quality systems from the perspective of whether it is fit for the purpose of servicing the people most affected by it, the staffers who have to deliver the service. What this commentary is not is an in-depth academic review of quality. If readers want the latter, I would enthusiastically point them in the direction of the book *Quality Management in Forensic Science* by Sean Doyle [2].

Fit-for-Purpose — The Traditional View

As Doyle [2] states, to determine whether or not an object is fit-for-purpose, the purpose must first be clearly defined. Doyle suggests that the most important “intended



James Robertson's career in forensic science began in 1976 as a lecturer in the forensic science unit at the University of Strathclyde, Scotland; in 1985 he migrated to Australia to join the Forensic Science Centre in Adelaide, South Australia. With an academic background in botany, he had developed interests in trace evidence — particularly botanicals, fibers, hairs, and soil. Unusually for the time, the university conducted casework. James then spent five years in Adelaide as a senior case officer before taking up a position in late 1989 as the head of the forensic group with the Australian Federal Police (AFP). Over the following 20 years he transformed the AFP from modest beginnings to an internationally respected group. Along this journey he introduced quality systems and gained the group its first accreditation in 1996. Upon his retirement from the AFP, James joined the University of Canberra as a Professorial Fellow in 2010; he retired from teaching in 2019. He is now an emeritus professor where he maintains his lifelong interest in research. Over his long career he has edited, co-edited, and authored several books on DNA, fibers, and hairs, as well as over 200 academic papers. He is editor emeritus of the Australian Journal of Forensic Sciences (AJFS) and is on the editorial board of several journals. He has contributed to several major enquiries into wrongful convictions in Australia and Canada. James is a former president of the Australian Academy of Forensic Sciences (AAFS) and vice president of the Australian and New Zealand Forensic Science Society (ANZFSS) and is an honorary life member of both organizations. He is a former chair of the Senior Managers of Australian and New Zealand Forensic Laboratories (SMANZFL), chair of the Australian Standards forensic committee, and chair of the advisory committee to the National Institute of Forensic Sciences (NIFS). His service to forensic science and professional bodies has been recognized in the Australian honors system with the Public Service Medal (PSM) and a Member of the Order of Australia (AM). He is an honorary doctor of the University of Canberra.

purpose” for forensic science is to meet the requirements of law enforcement and justice, ultimately ensuring the judicial process is fair and that the outcome is safe. He does make the point that the danger in the responsive nature of forensic science is that fit-for-purpose may be seen by some as securing a conviction. This of course has been at the very center of problems in some cases of wrongful conviction where parties have lost sight of the purpose of the criminal justice system. Following the wrongful conviction of Guy Paul Morin in Canada [6], the Ontario Crown prosecution policy defined the purpose of a criminal prosecution as “not to obtain a conviction; it is to lay before a jury what the Crown considers credible evidence relevant to what is alleged to be a crime — it should be done firmly and pressed to its legitimate strength, but it must also be done fairly” [6].

Doug Lucas, in a commentary in this journal [7], talks about the “intended application” in criminal cases being to assist in resolving an issue “beyond a reasonable doubt”. The UK Forensic Science Regulator’s Codes of Practice and Conduct [3] states that the first duty of practitioners is to “the court and to the administration of justice”. This is also encapsulated in many codes of practice for expert witnesses. Barclay and McCartney [1] have framed forensic science as “the interpretation of results in the individual context of each case” and argue that this places forensic scientists at the center of an open process of criminal investigation. Willis [22] has also stressed that increased emphasis is needed on the purpose of the examination and the interpretation of the findings in context. Wilson et al. [24], in looking at how forensic science is used in a military exploitation context, argue that a fit-for-purpose quality management system needs to balance the intelligence and potential prosecution objectives without compromising timeliness or stifling innovation. Clearly the focus for forensic science is fit-for-purpose for the end user or customer.

Of course, in England and Wales (not the whole of the UK) they took the whole concept of customer to the point of turning their public service forensic organization into a commercial entity. In a 2012 paper [17] I drew attention to the change in the philosophy of the then Forensic Science Service as evidenced by their mission statements in 2004 before they were commercialized to their mission statement in 2005 as they embraced a more commercial reality. In 2004 the mission statement read as follows:

To support crime detection, the conviction of offenders and the exoneration of the innocent. It reflects our position as an impartial provider within the Criminal Justice System and the community where our services are as available to the defence as they are to the prosecution.

In 2005 the mission statement had changed to the following:

To retain and reinforce our leading position as the principal provider of forensic science to the UK criminal justice system (UKCJS) and use this platform to become the leading provider world-wide, thereby enhancing long term shareholder value.

We now know that far from becoming a worldwide leader, the FSS was closed down by the UK Government, resulting in a reduction in size of the forensic market, and a significant move of forensic supply back into police and under police management. From a quality perspective, this has not been a good outcome because few of the police providers have achieved accreditation for their forensic groups. The Forensic Science Regulator for England and Wales, Gillian Tully, stated in her departing 2020 annual report that it was projected that only around 30% of police forces will have at least one of their Crime Scene Investigation hubs accredited by October 2021 [5]. Of course, lack of accreditation does not equal having no form of quality system in place, but, in the absence of formal accreditation, there is simply no way of assessing the state of development or maturity of systems that may be in place. Many of the police forces now have in-house forensic services that go well beyond crime scene examination. Tully points out that other areas of forensic endeavor were even less advanced than crime scene examination. By contrast any provider of forensic services outside of the police must hold relevant accreditation.

This begs the question of whether forensic services would be better served if they were outside of police control or management. Recommendation 4 of the so called NAS report [8] stated that

“to improve the scientific basis of forensic science examinations and to maximize independence from or autonomy within the law enforcement community, all public forensic laboratories and facilities should be removed from the administrative control of law enforcement or prosecutors’ offices”.

I have written previously on this topic [12,14] concluding there was no simple answer to this question. I have always taken the view that all aspects of forensic science need to be considered and not a narrower laboratory perspective. In the real world, disciplines such as crime scene, fingerprint, and firearms examinations usually reside in police organizations. This is unlikely to change. Hence, the important challenge is to have these disciplines covered by the same quality systems and accreditation as laboratories. This is the situation in Australia. In my view the issue is less about independence and rather about im-

partiality. The best way forward to achieve this across all sectors of the CJS is through improving the professional partnerships between scientists, police, and lawyers with a system focused on relevant issues being contested [13].

In summary, the traditional view of fit-for-purpose has placed the customer as the central player but as we have seen there is not one customer to satisfy. At least in the adversarial criminal justice system, forensic science is either administered within a police organization or the work is submitted to a laboratory through a policing or investigative agency. Hence, there are the needs of at least two major customers to consider:

- Forensic science has first to service the needs of investigators. That should never be confused with telling investigators what they may believe they want to hear. However, let me be quite clear, I reject the suggestion that it is in some way inappropriate for forensic scientists to support investigations. This is simply illogical.
- Clearly the second “customer”, or group of customers, are lawyers, judges, and ultimately, in jury trials, the members of a jury. Although we all like to point out that what differentiates forensic science from “other science” is having to go to court to give evidence; the reality is that most of the work of forensic science never sees the inside of a courtroom.

The one group of people who do not seem to have been considered in this fit-for-purpose equation is forensic practitioners. This was not the intention of those of us who were involved in introducing quality management and systems to the forensic world. The next section explains how quality and accreditation were introduced in the Australian context.

A Bit of History — The Role of SMANZFL and NATA in Australia

A common misconception is that forensic science was late to the table in adopting quality systems. Doyle [2] devotes a complete section to the history in the development of quality management in forensic science. The important timeline is that the first version of ISO 9000 quality management did not appear until 1987. ISO Guide 25 was the basis for testing laboratories until replaced by ISO 17025 in 1999. As Ross and Neuteboom [19] point out, the American Society of Crime Laboratory Directors (ASCLD) developed an externally peer-reviewed accreditation program in the 1970s well before any relevant ISO standard existed. This program was run through the ASCLD Laboratory Accreditation Program (ASCLD/LAB). By the late 1970s the then Home Office Forensic Science Service in England and Wales had developed “A Guide to Quality Assurance in Forensic Science” [10].

When I moved to South Australia in 1985 to join the Forensic Science Centre in Adelaide, I had followed Bill Tilstone from Strathclyde University, who had taken up the role of director of the Centre. Bill brought with him knowledge of ASCLD-LAB and used this as a platform to evolve the Adelaide laboratory as a quality leader. During my five years in Adelaide, I played a small part in this process helping to develop case submission and sexual assault forms, formal case files and other documentation, as well as writing the fiber and hair manuals. Bill also led the development of the Senior Managers of Australian and New Zealand Forensic Laboratories (SMANZFL) group. Established in 1986, this group represented the laboratory aspects of forensic science and, importantly, the “police” forensic sciences such as crime scene, fingerprints, and ballistics. At that time document examination was also largely part of police forensic groups. This differentiated the Australian approach from the rest of the world. Another key development was the establishment in 1992 of a National Institute of Forensic Sciences (NIFS). NIFS was funded under a cost-sharing arrangement by Police and the Australian Government Department of Attorneys General. For a fuller coverage of the history and evolution of NIFS the reader is referred to a review in this journal by Wilson-Wilde [25].

The important point is that NIFS and SMANZFL worked in a close relationship to advance many aspects of forensic science in our region over the next three decades. One of the first achievements of this relationship was the development of an accreditation system for Australia. By this time, I had moved to the AFP and was a member of SMANZFL. Our wish was to have a system based on genuine third-party inspections and audits while recognizing the rather unique aspects of forensic science. To achieve the latter, we wished to partner with ASCLD-LAB in collaboration with our own National Association of Testing Laboratories (NATA), who were responsible for accreditation in Australia. It is important to note that these initiatives were driven by the industry, not players in the criminal justice system. Some of our early discussions were “testing” as we challenged NATA’s view of the world, especially around how to accredit police forensic sciences such as crime-scene work and how to deal with opinion evidence. In no small measure the leadership of the first director of NIFS, Alastair Ross, was critical in being able to successfully introduce a joint NATA-ASCLD-LAB accreditation scheme. For various reasons, not really relevant to this commentary, this joint scheme only lasted for one accreditation cycle before we moved to a stand-alone NATA scheme. The important thing was that we retained forensic specific requirements.

The Development of Quality Systems — The AFP Approach

Back in the AFPI had inherited a mainly police forensic group. I want to stress that there were many well-meaning and good people on staff. It is very easy to sound critical of the standards at that time. My comments are not aimed at individuals but rather the systems, or lack of systems, in place at that time and not restricted to the AFP group. For new practitioners in the world today it would be hard to imagine the forensic landscape in the late 1980s. In the AFP there were no formal case files with individuals maintaining their own lever arch files, which they considered their own property. Other than police forms, there was no system of formalized note-taking or authorized forms, and there was no system of case audit or review. Exhibits were located across multiple rooms with totally inadequate procedures for packaging, labelling, and security. Other than police Standard Operating Procedures, there were few documented protocols or methods. Training was on the job and there was no formal education framework. Proficiency testing was unheard of. There were exceptions and one of those in my organization was our document group who had well-developed systems in place. And of course, the AFP forensic group was dispersed across the continent, eventually having facilities in Adelaide, Brisbane, Canberra, Melbourne, and Sydney.

In some ways we were lucky as we did not have the pressure of introducing new systems overnight and were able to take time to develop our capabilities as we developed the building blocks that would lead to formal accreditation. Some of the key elements in our early journey were:

- A strong commitment to change and improvement from the most senior management of the AFP matched with a realistic budget
- No undue pressure to achieve in an unrealistic time-frame, and,
- Based on my Adelaide experience, knowledge of how a quality system could be created from scratch — put simply, if you don't know what you are trying to create you need to buy in this expertise.

We appointed one of our staff (John Horswell and later Chris Lennard) as our quality manager and developed our first strategic plan. The approach we used was to involve as many of our staff as possible in workshops to develop written protocols and methods, using this as a way to formally capture what we were doing and at the same time to question and improve what we were doing while educating our staff about the broader elements of creating a quality system. At the same time, we were developing a formal education framework leading to the award of a Diploma in Applied Science (Forensic Investigation) which was the forerunner of an Australian national qualification for

field forensic sciences [21]. A key aspect of our Australian approach was an emphasis on appropriate underpinning sciences such as biology, chemistry, and physics.

By 1995 we had in place all the elements of our quality system and achieved our first accreditation under NATA-ASCLD-LAB in 1996. So, what mistakes did we make and how would we have done it differently if we had the chance?

- We did not provide a template or single model for how to write and prepare our documents; hence, there was some lack of internal consistency between disciplines.
- Our original documents were too detailed and prescriptive. This was despite every effort being made to avoid this pitfall. In our aim to be thorough, we overdid the detail at the cost of protocols and methods being onerous to use, and in some cases, inflexible for real-life operations. This can result in taking shortcuts; consistency is lost.
- We included too much material in operating manuals that should have been in training manuals – this is the old trap of people who write manuals wanting to show how much they know. There needs to be a clear distinction between training and operational manuals.
- We under-resourced our quality team, preferring to share the load across our managers – the positive of this approach was greater ownership but at the cost of efficiency. There needs to be sufficient dedicated staff to deal with the mechanics of running a quality system balanced with ownership in the workplace.
- There needs to be a well-defined organizational responsibility for different elements of the overall quality system. Leadership has to come from the top!

If the quality system is to be fit for the purpose of supporting the staff who have to use it, the challenge with protocols and methods is to ensure that staff find them useful and, hence, use them. It was never envisaged that the system would remain static and not evolve and a key component of adopting a quality approach to the management of forensic science was to embrace the concept of continuous improvement. Quality was not meant to get in the way of innovation but simply to ensure that innovation resulted in improvements founded on sound science and appropriate validation, not individual preferences.

Of course, the role of internal and external audit for compliance is essential and should involve not only case file review but also observation of people actually performing tasks. In my experience the essential elements of protocols and methods will be followed where staff are well trained, have genuine organizational support, and embrace the highest levels of personal professional practice. Professional judgment has been encapsulated in Australian Standard AS 5388 — Forensic Analysis: Part 3: Interpretation [20], which states that

“professional judgement is central to transforming information into knowledge. Reliance on professional judgement is also a distinguishing feature of IOS 17020, which is available for the accreditation of crime scene examinations.” [2]

Where Are We Now — Where to in the Future?

For those of us who developed the quality and accreditation framework in the early 1990s, we envisaged a system that, as Willis [22] puts it, “moved from a situation where the powerful individual determined what tests were performed and what they meant without reference to anyone else”, resulting in many celebrated miscarriages of justice. Doyle [2] discusses many of these miscarriages of justice. As NicDaeid [9] has pointed out, relying exclusively on personal knowledge and experience is not enough. However, what we did not envisage was that, over time, we would have created a situation where documentation has become so detailed and prescriptive that it inhibits the central aim of quality — that of continuous improvement based on innovation. In addition, as Doyle [2] points out, we live in a world today of a “plethora of overdocumented standards” with the potential for a high risk of nonconformance. Is it any wonder that as John Thornton, in his foreword to Doyle [2], stated “This should be a journey commensurate with our professional obligations, not a reluctant march through enemy territory”? Which brings me back to why I am writing this commentary because, in my view, that is exactly how a very large number of forensic operatives view quality in the world today.

So, who is to blame or is the blame game going to change anything? Well, in a sense we are all to blame. We, and I mean forensic scientists, have allowed others to dictate and shape the system we operate under in ways we never intended. Adopting quality management was an initiative of the providers alone, not our customers [2]. Over time we have allowed a culture of risk avoidance to erode personal autonomy, burying ourselves in a plethora of micromanaged detail that stifles any desire to innovate and actively discourages using personal judgment under the excuse that accreditation does not allow it. The new ISO 17025-2017 places greater emphasis on the appropriate role of risk management, but this will make no difference unless there is a radical reset of the current framework based on a genuine acceptance of professional judgment as central to the role of the forensic scientist. I commented on this in an earlier publication [18], concluding that a quality system should provide reasonable protection to staff in a judicial context but cannot exclude all personal risk or displace the role of the expert. Indeed, the appropriate exercise of professional judgment should be expected of any forensic scientist. This requires an understanding of

risk and concepts of likelihood and consequence [15,23]. Wilson et al. [23] have developed a strategic forensic risk management system as a component of a forensic science system-of-systems approach. They point out that a risk-averse culture can result in organizational risk avoidance rather than risk management with an overreliance on the quality management system as a risk-management treatment [24].

My perception is that, over time, the engagement of more senior managers in forensic science has weakened to a point where there is a real lack of leadership, with the default position being it is in the hands of quality managers, often quite junior staff. Quality has to be owned by all levels and should be science-driven. Review processes are of course nonnegotiable, but they need to be focused on positive critique, not on trivial detail, and they should be based on evaluation and improvement, not just compliance. For the individual, it is not sufficient to be “just” an employee relying only on the rules as dictated by the parent organization. I have discussed forensic science as a true profession elsewhere [11,13], concluding that one of the underlying problems with forensic science is that we fall well short of meeting the characteristics of a profession.

In summary, if we want quality to be fit-for-purpose for the practitioners of forensic science and to be seen by practitioners as something useful that supports them in their day-to-day work, then several things need to happen.

- First, we need to see some genuine reengagement and leadership for senior managers of forensic science and retaking appropriate ownership of quality. Gary Pugh [4], in his first newsletter as the Forensic Science Regulator, has stated that the most significant change required to achieve an effective quality management system is “visible leadership and accountability from front line supervisors to Directors and Chief Officers”.
- Second, we urgently need to return to a more principle-based approach to protocols, in particular recognizing the role of the individual applying professional judgment with, as Willis [22] puts it, an “increased emphasis on the purpose of the examination and interpretation of the findings in context”.
- Third, without falling into the trap of a minimalist approach to accreditation, we need to recognize that accreditation is NOT the central goal of having a quality system — we have all too often been the architect of overengineering of documentation through inspectors who wish to impose their view of life rather than test against the standard.
- Fourth, and perhaps the most important, individuals need to stop expecting that the goal of quality and accreditation is to protect them as individuals against all risk and never getting it wrong.

A positive step in achieving the latter would be for forensic science to get serious about being a profession.

References

1. Barclay ADB, McCartney S: Forensic science and miscarriages of justice: Keynote speech at the 3rd National FORREST (Forensic Research and Teaching) Conference; Staffordshire University: Staffordshire, UK; September 5, 2007.
2. Doyle S: *Quality Management in Forensic Science*; Academic Press: London, UK; 2019.
3. [UK] Forensic Science Regulator (Andrew Rennison): Codes of Practice and Conduct for Forensic Science Providers and Practitioners in the Criminal Justice System; p 9; 2011; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/118949/codes-practice-conduct.pdf (Accessed November 14, 2021).
4. [UK] Forensic Science Regulator (Gary Pugh): Newsletter, Number 36; July 2021; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1001930/FSR_Newsletter_36_July_2021_Final.pdf (Accessed November 14, 2021).
5. [UK] Forensic Science Regulator (Gillian Tully): Annual Report (17 November 2019 – 16 November 2020); January 13, 2021; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/950087/FSR_Annual_Report_2019-2020_Issue_1.pdf (Accessed November 14, 2021).
6. Kaufman F: The Commission on Proceedings Involving Guy Paul Morin; Ontario Ministry of the Attorney General: Ontario, Canada; 1998.
7. Lucas DM: “Junk science” and “reasonable doubt”; *Forensic Sci Rev* 31:20; 2019.
8. [US] National Research Council: *Strengthening Forensic Science in the United States: A Path Forward*; The National Academies Press: Washington, DC; 2009; <https://www.ojp.gov/pdffiles1/nij/grants/228091.pdf> (Accessed November 14, 2021).
9. NicDaeid N: Who speaks up for forensic science? *Sci Justice* 50:111; 2010.
10. Periera M: Quality assurance in forensic science; *Forensic Sci Int* 28:1; 1985.
11. Robertson J: Forensic Science — A true profession? *Aust J Forensic Sci* 43:105; 2011.
12. Robertson J: Forensic science, an enabler or dis-enabler for criminal investigation? *Aust J Forensic Sci* 44:83; 2012.
13. Robertson J: Forensic science professions; In Bruinsma G, Weisburd D (Eds): *Encyclopaedia of Criminology and Criminal Justice* pp1820–1829; Springer Verlag: New York, NY; 2014.
14. Robertson J: Principles for the organization of forensic support; In Siegel JA, Saukko PJ (Eds): *Encyclopaedia of Forensic Sciences*, 2nd ed, Vol 3; pp 504–508; Academic Press: Waltham, MA; 2013.
15. Robertson J: Risk management; In Siegel JA, Saukko PJ (Eds): *Encyclopaedia of Forensic Sciences*, 2nd ed, Vol 3; pp 528–531; Academic Press: Waltham, MA; 2013.
16. Robertson J: Should forensic science services be independent of policing? A critical reflection; *Current Issues in Criminal Justice* 24:131; 2012.
17. Robertson J: Truth has many aspects; *Sci Justice* 52:62; 2012.
18. Robertson J, Metz H, Scudder N, Hodgson V: A quality system review: Australian Police Forensic and Data Centres; *Forensic Science Policy & Management: An International Journal* 1:209; 2010.
19. Ross A, Neuteboom W: Implementation of quality management from a historical perspective: The forensic science odyssey; *Aust J Forensic Sci* 53:359; 2019.
20. Standards Australia: Australian Standard. Forensic analysis. Part 3: Interpretation; 2013; https://shop.standards.ie/preview/315359656224.pdf?sku=120015_SAIG_AS_AS_251526 (Accessed November 14, 2021).
21. Stanley S, Horswell J: The education and training of crime scene investigators: An Australian perspective; In Horswell J (Ed): *The Practice of Crime Scene Investigation* Chapter 3 (pp 57–66); CRC Press: Boca Raton, FL; 2004.
22. Willis S: Accreditation — Straight belt or life jacket? *Sci Justice* 54:505; 2014.
23. Wilson LE, Gahan ME, Lennard C, Robertson J: Developing a strategic forensic science risk management system as a component of the forensic science system of systems; *Aust J Forensic Sci* 52:208; 2020.
24. Wilson LE, Gahan ME, Robertson J, Lennard C: Fit for purpose quality management system for military forensic exploitation; *Forensic Sci Int* 284:136; 2018.
25. Wilson-Wilde L: The state of forensic science in Australia and New Zealand; *Forensic Sci Rev* 33:2; 2021.