Interdisciplinary Practices in Forensics within American Law Enforcement: The International Context

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Abstract—As forensic evidence has come to be of paramount importance within the American criminal justice system, it becomes pertinent to explore current standards, education, and training conducted within forensic investigation units who are actively engaged in crime scene recovery methods. After review of the current state of research within the field both domestically and internationally, an exploratory study was conducted through national surveying of American law enforcement agencies at the municipal, county, state, and federal level. Results indicate the need for reform though development of uniform standards, required educational levels, and enhanced interdisciplinary training in order to ensure the highest levels of documentation, collection, and preservation of forensic evidence. Recommendations regarding future research include evaluative procedures aimed at developing standardization, reforming required educational levels, evaluating available training programs, and increasing knowledge pertaining to the value of national certification.

Keywords-crime scene investigation; forensic investigation units; American law enforcement; interdisciplinary methods; international forensics

I. INTRODUCTION

A little over a decade into the 21st century, the forensic disciplines have made tremendous advancements that many never thought were possible 20 years ago, particularly within the United States. New techniques of investigation and analysis are constantly developed and refined. One new orientation attempting to gain footing within forensic investigation is the incorporation of all forensic disciplines into one multidisciplinary entity; many forensic experts from multiple disciplines and sub-disciplines have already been advocating for this approach [1]. Though the Forensic Science Foundation began the attempt to create tighter professional standards and multiple perspectives for forensic science experts in the early 1970's, the most recent development comes from the study funded through the National Institute of Justice (NIJ), published as Strengthening Forensic Science in the United States: A Path Forward in 2009 [2,3].

Two key components of the NIJ study relate specifically to the research proposed here. One was the instruction of the Forensic Science Committee to "make recommendations for maximizing the use of forensic technologies and techniques to solve crimes, investigate deaths, and protect the public", while the other stated they needed to "disseminate best practices and guidelines concerning the collection and analysis of forensic evidence to help ensure quality and consistency in the use of forensic technologies and techniques" [2]. Recognition was given to the fact that the multiple disciplines involving forensic science are separated; multiple types of practitioners with different levels of education and training, standards, performance, and professional culture hardly lends itself to promoting forensics as a united discipline [2]. Therefore, the need exists to develop ways of incorporation that manage to include the multitude of forensic disciplines. As forensic investigation units are the first point of contact with the evidence, this area lends itself well as the point at which to begin this incorporation. Assessment of the current state of standards, education, and training within these units can allow for broader knowledge of what interdisciplinary practices are already known and what methods can be introduced in order to further enhance the collection, documentation, and preservation of forensic evidence.

II. REVIEW OF THE LITERATURE

A. Overview

As the research proposed here is a relatively new development, literature directly pertinent to the methodology of the study is rare; therefore, reviewing the literature pertaining to the development, standards, and techniques of crime scene investigation as well as the role

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of forensic evidence in the American courtroom can help clarify why this study is relevant to the current state of forensic field methodology. Additionally, examination of forensics in comparison to other countries can help one understand where the United States stands in terms of forensic investigative technique and interdisciplinary incorporation.

1) Development of Crime Scene Investigation

Crime scene investigation in the field has taken on new meaning, as during the first part of the 20th century it was largely ignored. As forensic science held the focus of the law enforcement community, little attention was paid to the chain of evidence. A brief review of forensic science proves beneficial to underlie why crime scene field techniques have become so significant in an investigation.

Forensic science rests on the assumption that two indistinguishable marks must have been produced by a single object, therefore leading scientists to link crime scene evidence to one specific person and exclude all other possibilities [4]. Origins are mostly European, with the first major book describing the application of scientific disciplines to criminal investigations written by Hans Gross in 1893, earning him the title "founder of scientific criminology" [5]. The first forensic laboratory was established in 1910 by Edmond Locard- as an important early scholar in the field, he established what has come to be known as "Locard's exchange principle", which states that whenever two persons or objects make contact each leave some sort of trace evidence behind [5,6]. During the same time period, Sir Bernard Spilsbury became renowned in England as an expert witness in medicolegal evidence and investigation; his analysis and expertise in the field of death investigation was heavily relied upon during criminal trials throughout the early 20th century, with some considering him the first "crime scene investigator" [7].

Historically, three major scientific systems were utilized to identify criminals: anthropometry, in which anthropometric measurements and anthroposcopic traits were utilized to describe an individual; dactylography, the study of fingerprints, which underwent several interpretations by separate systems but focused on the ridges present on hands and feet; and Deoxyribonucleic acid (DNA), the structure of which was discovered by James Watson and Francis Crick in the early 1950's. DNA was introduced as a method of identification in criminal investigation by Alec Jefferys and colleagues in 1985, when the realization was made that the structure of certain genes are completely unique to an individual [6].

The advent of DNA typing and its uses in identification was a significant development for the forensic sciences and influenced a tremendous change in admissibility of expert testimony; utilization of a statistical approach based on population genetics theory and empirical testing provided a sound scientific basis that withstood admissibility standards within the courtroom, discussed in detail further on [4].

Once criminalistics and forensic science had firmly entrenched itself into law enforcement and criminal investigation, it became more important to recover multiple pieces of evidence that were often ignored before [8]. However, this responsibility fell to patrol officers who had little or no formal evidence collection training, resulting in potentially valuable evidence being left at the scene; to counter this, the trained criminalist would be sent out in the field, but due to cost and other responsibilities of the criminalist in the laboratory, the development of positions for evidence technicians and crime scene investigation officers occurred [8]. Eventually, these specialized positions became the norm in law enforcement agencies nationwide and developed into the crime scene investigators seen today.

Modern criminal investigation focuses on physical evidence recovered from the scene of a crime; subsequent analysis of this evidence provides a scientific foundation on which to build a criminal case that will withstand courtroom scrutiny [9, 10]. Crime scene investigators specialize in the processing of a crime scene and gathering forensic evidence; they should have the ability to recognize, photograph, organize, and collect evidence, and ideally are the first to arrive at the scene [9]. Three main roles played at the scene are ensuring that the evidence stays contaminant-free, is fully documented, and follows the chain of custody at all times [11]. Reliance and cooperation with the Medical Examiner and/or Coroner is also commonplace, as information gained at the scene of the crime could prove beneficial to establishing manner of death, be it natural, homicide, suicide, accident, or undetermined [3,12].

Crime scene investigators today also face an everincreasing problem, as the media has significantly impacted the criminal justice system. Development and widespread consumption of shows such as CSI, NCIS, Criminal Minds, etc. have perpetuated multiple myths about forensic science, in turn dramatically increasing the expectations of jurors, judges, and attorneys- this has created what is known as the "CSI effect" [13,14]. One study conducted determined that 26.5% of participants would not convict a person without some type of scientific evidence [13]. Shows such as CSI influence a general perception that there is always an ample amount of evidence at a crime scene and that the technician just needs to find it, but this is not always the case [13]. Furthermore, the prevalence of criminal investigation on television shows has had an impact on the knowledge of criminals when committing a crime; though many techniques are fictional,

some are represented correctly, allowing criminals to erase trace evidence that could have otherwise been collected [15].

Developments have occurred rapidly within modern crime scene investigation. As of 2011, over 400 units were dedicated specifically to forensic investigation [15]. New ideas and techniques continue to emerge- for example, in the quest to establish new methods of identification, usage of Atomic Force Microscope (AFM) imaging has been developed as a method of examination which can provide images of fingerprints on bullet cartridges [6]. Remote sensing utilizing infrared, magnetics, electromagnetics, and ground penetrating radar has begun to emerge and has gained increasing acceptance by criminal investigators; these methods can alleviate understaffed departments and reduce the time spent on searches, raising the probability of locating evidence of prime interest [16]. Furthermore, the incorporation of some anthropological methods has already begun to occur; archaeological visual foot search methods have been implemented into crime scene search patterns (such as line, strip, grid, and spiral patterns), resulting in efficient and effective pedestrian searches for surface remains [6,15,17,18].

2) *Standards/techniques in Crime Scene Investigation*

Literature pertaining to this section focuses exclusively on the documentation, collection, and preservation of evidence with additional consideration paid to chain of custody. Reference [6] illustrates the standards involving the processes of securing the crime scene and controlling the evidence, and states the following:

- As rapidly as possible, identify the boundaries of the crime scene and secure it;
- Defining the scene requires officers to make sure they also identify possible or actual lines of approach to, and flight from, the scene and protect themselves also;
- Maintaining crime scene control is a crucial element in the preliminary investigation;
- Separate any potential combatants;
- Set up a physical barrier to protect the scene, prevent contamination or theft of evidence and for your own safety;
- Maintain a crime scene entry log of persons coming to and leaving the scene" [pp. 42-43]

Parts of these guidelines are extremely critical to crime scenes involving forensic evidence, as securing the scene and preventing contamination are of particular importance when protecting the legitimacy of evidence. The authors also provide a list of supplies and equipment available for crime scene processing, though there is significant variation in what is actually utilized.

Documentation is very important at the scene; beginning with a rough, shorthand record, it expands into the crime scene entry log, administrative log, assignment sheets, incidence/offense report, photographic logs, sketches, and evidence recovery logs [6]. Reference [19] describes documentation as the most important step in the processing of a scene, and place emphasis on taking effective notes for a written record to be referred to later. Aside from videotaping and recording the scene, sketches are considered vital, starting with a rough sketch that will later be redrawn and finished; measurements are obtained by identifying two fixed points (either through triangulation, baseline, or polar coordinates) and taking all measurements in relation to those established points [19]. Every piece is considered essential when proving continuity within chain of custody. Considering this in regards to evidence collection, crime scene investigators must do the following: identify each item of evidence they collected and handled, describe the location and condition of the evidence at the time it was collected, state who had contact with and handled the evidence, state when and at what time the evidence was handled, declare under what circumstances and why the evidence was handled, and explain any changes that may have been made to the evidence [6]. When collecting evidence, Reference [19] states that while no rigid order exists for the process, some types of evidence should be given priority- for example, evidence that is transient, fragile, or could be easily lost. Each piece should be immediately placed in an appropriate primary container and then into a secondary container which must be completely sealed with tamper-resistant tape [19]. Furthermore, each new item should be packaged separately to effectively prevent the chance of cross-contamination [19]. As lesser amounts of evidence are needed due to improvements within forensic analytical techniques, proper collection and packaging of evidence is critical; certain advanced laboratory techniques are rendered impossible if the evidence becomes lost or contaminated [6,19].

As crime scene investigation is highly focused on recovering biological evidence, correct collection and preservation is very important. One primary example of the importance of preservation can be seen with DNA evidence, now considered by many legal entities to be the evidence of choice and supported through extensive success in case history [15]. With that comes significant concern in protecting DNA as it is transported from the field to the laboratory. DNA is subject to degradation immediately following the perimortem period; being a relatively weak molecule, it degrades rapidly in an environment- and time-dependent manner, and is subject to bacteria, fungus,

chemicals, ultraviolet light, etc. [6,20]. When recovered at the crime scene, DNA may be contaminated or destroyed by the inexperienced or improperly trained investigator, either through incorrect collection or preservation methods; this would lead to inadmissibility in the courtroom [6]. Therefore, preservation of these types of evidence at the scene becomes paramount to ensure the reliability of subsequent laboratory results.

3) *Role of Forensic Evidence in Courtroom Proceedings*

Admissibility and quality of evidence is the main concern when a case enters judicial proceedings. A brief overview of the evolution in forensic evidence admissibility will show the importance that the investigator is required to place on documentation, collection, and preservation of evidence. A need to evaluate expertise while at the same time being dependent on it creates tension that shapes the way in which courts admit forensic scientific evidence; an ever-increasing role of said evidence in criminal prosecution meant that refinement of admissibility requirements needed to occur [21,22]. Instead of focusing on the evidence presented, when conflicting conclusions were provided by medical experts, their qualifications and the certainty with which their opinion was expressed typically became the subject of discussion, as opposed to the reasoning that connected the facts to the conclusions [21].

Subsequently, the "Frye Rule" [23] became the first effort to standardize admission of forensic evidence and increase objectivity in forensic testimony, stating that scientific evidence must have general acceptance in the field with which it is associated; however, this test was rarely discussed or analyzed until the establishment of the Federal Rules of Evidence (FRE) in 1975 [21,24,25]. Due to inconsistencies in interpretation of Frye, the Federal Rules of Evidence became the first standardized guidelines regarding forensic evidence and its use in criminal proceedings, intensifying and reevaluating the decisions of Frye (25,26). However, as a common law rule still applied, inconsistencies existed until the ruling given in Daubert v. Merrell Dow Pharmaceuticals in 1993 [24].

Daubert set the standard that testable, replicable, reliable, and scientifically valid methods must be utilized when processing forensic evidence and must provide justification for a specific scientific opinion; this was essentially to prevent court cases from becoming a battle of the experts, and kept a trial decision from being based on the experts as opposed to the evidence [17,25,27]. In addition, Daubert led to the decision that the Federal Rules of Evidence superseded Frye and that one acceptance rule was not enough. Therefore, after the Daubert decision, significant changes were made to the Federal Rules of Evidence, with many new evidence guidelines being applied; for example, FRE Rule 702 was expanded and emphasized the relationship between data and the methods used to obtain that data rather than the credentials of the expert giving testimony [17]. Furthermore, FRE Rule 702 set specific guidelines for satisfying the rule, stating that evidence must be testable by the scientific method, published in a peer-reviewed journal, have established reliability and error rates, and methods or opinions that were generally accepted within the related scientific community [25].

Two other cases have been essential for the interpretation of Daubert- General Electric Co. v. Joiner [28] and Kumho Tire Co. v. Carmichael [29]. In Joiner, it was argued that methodology and conclusions are not completely separate from each other as mentioned in Daubert, and experts must explain how the methodologies have led to their conclusion; for Kumho, the Supreme Court ruled that Daubert's general reliability requirement applied to all expert testimony as opposed to only scientific knowledge, that science is too complex to evaluate with only one set of standards, and that experts could develop theories based on their observations and experience, applying those theories to the case [4,24,27]. From this, Daubert, Joiner, and Kumho have been established as a "trilogy" that significantly impacts the admissibility of expert witness testimony [24].

Some disciplines can be problematic within the courts due to their reliance on a combination of traditional scientific methodologies and observational methodologies, such as case study evaluations or casework experience [27]. Moreover, due to the variances within the multiple forensic disciplines, the threshold of admissibility may not be equal for some areas, as one may be more sophisticated with more sensitive equipment, have more developed methods, or be able to control for more difficult variables [27]. One consistency, however, is seen when evaluating admissibility in regards to the "weight" of evidence; that is, its accuracy and believability in terms of procedures followed through the rules of evidence [10]. This points to the chain of custody- an essential part of evidence admissibility. Chain of custody specifically applies to any evidence that has been collected and subject to expert analysis, e.g. a blood sample or material from a bodily specimen [10]. Every person who comes in contact with the evidence must be documented and hold the ability to testify to their handling of the evidence in court; if not, the chain is broken and the evidence is generally inadmissible [10]. By following stringent documentation, collection, and preservation standards, questions regarding chain of custody can readily be answered and preserve the integrity of the evidence.

4) Forensics in an International Context

One of the biggest developments regarding a push for standards within other countries comes from the Parliament of the United Kingdom within the Science and Technology Committee in 2013; this regulation on quality standards and forensic science in court directly relates to the problems being encountered currently within the United States, and addressed by the NIJ study mentioned previously [30]. Specifically, the regulation states that "quality standards in forensic science are integral to the criminal justice system: without them, there may be a greater risk that those guilty of crime may escape justice or that innocent people could be convicted" [30]. While forensics in a laboratory context is the center of the discussion, mention is made of the initial contact with the scene, examination of the scene, and recovery/preservation/transport of evidence as an area where standards are needed. Standards are also advocated for in relation to expert evidence and expert witnesses; as there is nothing like the Daubert and Kumho criteria previously mentioned due to the fact that no admissibility test for forensic evidence currently exists, the admissibility of expert testimony has been repeatedly questioned [30]. While advocating for standards, the United Kingdom is pushing ahead in the forensic context while still in development of certain laws and regulations already present within the United States.

Reference [31] brings forth another relavant study, which examines the systems of police education and training in Europe. While not specifically forensic focused, it does call attention to the educational and training differences throughout the European Union. Unlike the "police academy" within the United States, law enforcement experiences can be gained through educational outlets in various degrees and subject fields. In 12 out of the 17 surveyed countries, the authors report the availability of a higher professional police education [31]. One important note should be made with the componenents of basic police training- criminalistics, crime scene investigation, criminal evidence handling, and documenting are all mentioned. Therefore, within this sample, law enforcement were exposed early on to at least a basic understanding of how to treat a forensic-related scene; this is mostly underrepresented in American "police academies" [31]. From the examination conducted by the authors, they conclude there is a signficant need to define standards of police education and training throughout Europe.

Reference [32] identifies what the author calls the "four pillars" of effective policing in Central and Eastern Europe: cooperation, training, education, and research, making a distinct argument that incorporation of multiple perspectives may shape the future of European and International Policing. Specifically, the author states that cooperation must begin to take place within the European Union, as well as higher standards for training and education. Finally, the need for further research in all areas mentioned above was described in order to assess where cooperation and incorporation of multiple methods from an international perspective can occur and work to develop and refine current practices in policing.

B. Literature Findings

The literature highlights the importance given to chain of custody on several levels; even a brief gap in proof can discredit the evidence in the eyes of the court [22, 33]. Compromising the integrity of the evidence can have devastating effects on the strength of a case in court; specifically, one must be able to prove through chain of custody that the evidence has neither been contaminated nor lost in processing, typically through an inventory, log, and signature sheet that detailed those who have come in contact with the evidence [9, 34]. An interesting observation can be made in regards to the "standards" for crime scene investigation. Though a myriad of material existed for techniques and methods, no true "standards" were set in stone across the discipline. Techniques, methods, and materials varied from author to author, even within a small time period (or in the same year); while they were similar, they were not consistent enough to suggest that every scene was being managed the same way. From this, it could be assumed that the lack of set standards could potentially prove detrimental and may be an area in which attention should be focused. While some could argue that this may be due to variability in the types of scenes encountered and that flexibility is a necessity due to this variability, a set protocol is still needed to guide and direct the complex processes occurring during a crime scene investigation.

Furthermore, throughout the literature, one can identify a definite need to address the lack of interdisciplinary advocacy and incorporation within the field of forensics. Standards regarding documentation, collection, and preservation are necessary; though they are mentioned in Europe, the United States has neglected this area of research. Law enforcement within Europe are already receiving training in areas related to forensic investigation outside of the typical "specialized" forensic training members of designated forensic units receive.

Moreover, the literature guides one to one simple premiseevery case is in need of multiple eyes from multiple perspectives. Utilizing this approach is advocated by many scholars, who contend that all forensic disciplines must work for strict quality assurance through proper training, method validation, accreditation, certification, etc. and follow best practices in order to protect the validity of evidence [1, 22, 27, 33]. Forensic science concerns the

collection of multiple sources of evidence, and is therefore intrinsically interdisciplinary; emphasis and advocacy is placed on interdisciplinary teams in regards to criminal investigation, as those collecting evidence at the scene must be aware of how to recognize and preserve multiple types of evidence for expert analysis [15]. Concerns regarding evidence have increased steadily since the establishment of the Daubert criteria, and while the focus on proven qualitative methods has led to improvement regarding field investigation, there is more to be done [17]. Finally, as a well-prosecuted homicide case relies on excellent detective work, structured chain of command, wellconceived operational plans, use of forensic experts, adherence to detailed methods of evidence collection, and custody processing, every effort should be made to ensure that a scene is being managed in the best possible way [15].

Therefore, the purpose of the current research is to collect baseline information on the use of forensic field methods, training of personnel, and knowledge/implementation of forensic standards within law enforcement; this information will be useful in determining where municipal, county, state, and federal law enforcement agencies within the United States are in terms of advanced methods of documentation, collection, and preservation of evidence. No prior research has yet to address these issues within American law enforcement agencies. Therefore, this research is a preliminary assessment of the "state of the field". Utilization of the methodology proposed herein may prove beneficial if applied in an international context. Analysis will be descriptive and will serve as the basis for further research that will promote the highest standards of evidentiary evidence collection within this profession.

III. METHODS

A. Sample and Inclusion/Exclusion Criteria

The sample for the survey questionnaire was drawn from the National Directory of Law Enforcement Administrators (45th ed.). Potential participants for the survey included municipal, county, state, and federal agencies within the United States. Only agencies serving a population of 250,000 or more were chosen for the sample, with the exception being states that do not have this population density in municipal or county jurisdictions. In those cases, the top three populated cities/jurisdictions were selected.

For the municipal category, both metropolitan and city/county agencies were included. As the District of Columbia is identified as a metropolitan department, it fit the criteria for inclusion as a municipal agency. Hawaii, due to size, had only two agencies classified as municipal, and is the only other exception to the three agency criteria for the municipal category. All agencies designated in the county category were Sheriff's offices, with two exceptions; Alaska did not have a Sheriff's office and listed the Alaska State Troopers instead, and Connecticut is completely absent from this category as the directory did not list any county agencies. Federal agencies were selected from Federal Bureau of Investigation (FBI) regional field offices for each state based off of the most populated city (if a field office was present). Below are the totals by category for agencies sent the survey questionnaire:

- Municipal: 173
- County: 278
- State: 50
- Federal: 38
- TOTAL: 539

Exclusionary criteria were necessary to preserve the validity of the data and were established after all responses had been received. No federal agencies returned the survey, requiring exclusion from the final sample total. Some surveys were returned as undeliverable; due to time constraints, they were not mailed again, and therefore excluded from totals. Finally, respondents who did not fill out the survey correctly (e.g. those who stated they had a forensic unit, but stopped at the point where those agencies with no unit were directed to stop) were removed from the sample to keep results from being skewed by the questions that were not answered. Below are those excluded from the sample and the final sample total:

- Federal agencies excluded: 38
- • Surveys returned to sender: 12 (4 municipal, 6 county, 2 state)
- • Surveys answered incorrectly: 11 (4 municipal, 5 county, 2 state)
- • FINAL TOTAL: 478

B. Survey Instrument

Surveys were mailed on January 23rd, 2014, with packets that included the following: a cover letter addressed to the highest ranking official of the agency, which explained the research being conducted; the survey questionnaire; and an addressed, stamped return envelope. Respondents were requested to return the survey by March 1st, 2014. Identifying data was collected but reserved for classification purposes only to protect the anonymity of the agency; this was specified on the cover letter and reiterated

before the signature line at the end of the survey. The survey instrument included 16 questions addressing standards, training, education, and certifications of an agencies forensic unit (if present). Those agencies without a forensic unit were asked the following: how often their agency encountered forensic related crime, who was responsible for handling those crimes, utilization of outside assistance, whether or not their agency performed laboratory functions, training regarding those laboratory functions, and whether or not anyone inside of the agency held a national certification in a forensic-related field. Supplemental discovery questions within the survey were utilized to identify potential areas for future research.

Stopping points were indicated within the survey, as certain responses to questions would exclude the agency from having pertinent answers to the remaining questions. Agencies who responded "yes" to having specialized forensic investigation unit were directed to question #2, while those agencies without a specialized forensic investigation unit were informed to continue and that their survey responses were complete at the end of question #1. If these respondents answered "Never" when asked how often their agency encountered forensic-related crime or "No" when asked if their agency performed any processing that could be considered a laboratory function, they were informed that they had completed the survey.

IV. RESULTS

Once the completed surveys were returned, the information was recorded into an electronic database built with FileMaker Pro Version 6. Frequencies were developed with IBM SPSS Statistics Version 22. Tables shown represent the percentages of responses given. Of the 478 agencies who received the survey packet and met the criteria for inclusion, 117 agencies were considered respondents, giving an overall response rate of 25%; when considering state representation, the overall national response rate was 82%. Table I illustrates the breakdown of responses by category.

TABLE I. BREAKDOWN OF RESPONSES BY CATEGORY

	Agency Classification		
	Municipal	County	State
Total Sent	165	267	46
Total Sent	51	55	11
Return Rate	31%	21%	24%
National Response Rate	57%	59%	22%

Fig. 1 shows the respondent percentages in terms of population served. Populations are grouped by those respondents serving residents at or below the number shown, with the final variable of 5,000,001 representing populations above that threshold. Most agencies within the sample served populations containing 500,000 to 750,000 residents.

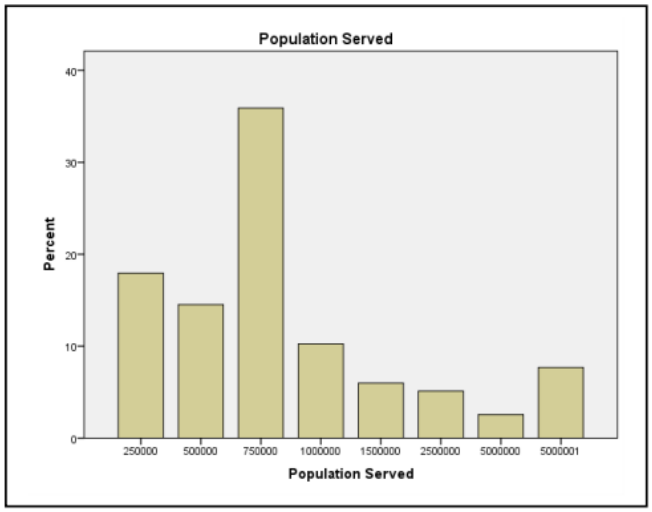

Figure 1. Response Rate in terms of Population Served.

Question #1 was directed at whether or not the agency maintained a specialized forensic investigation unit. The majority of participants answered "yes", and this is represented in Table II. The 26.5% without a specialized forensic unit answered a series of questions pertaining to how forensic investigation was handled within their agency. For these 31 agencies, results are presented in terms of the majority. 48.4% responded that they encountered forensic crime on an occasional basis. Outside assistance was typically utilized to complete any forensic investigation encountered. Some type of forensic processing was completed by the agencies, and those responsible for performing those laboratory functions received specific training in techniques and practices of forensic evidence collection. Most agencies did not have a member of their department nationally certified in a forensic related field. Data pertaining to these results can be seen in Table III.

TABLE II. SPECIALIZED FORENSIC UNIT?

Yes	73.5% (86)
No	26.5% (31)
TOTAL	100.0% (117)

TABLE III. RESPONSES FOR AGENCIES WITHOUT A SPECIALIZED FORENSIC UNIT

	Utilize outside assistance	Any forensic processing	Specific training	National certification
Yes	93.1% (27)	67.9% (19)	76.2% (16)	5% (1)
No	6.9% (2)	32.1% (9)	23.8% (5)	95% (19)
TOTAL	100.0% (29)	100.0% (28)	100.0% (21)	100.0% (20)

A. Standards

For the 86 respondents who did report having a specialized forensic investigation unit, the remainder of the survey was completed. Over half of the respondents reported having a set policy on standards and/or best practices on investigative processes in the field, with responses shown in Table IV.

TABLE IV. POLICY ON STANDARDS AND/OR BEST PRACTICES?

Yes	75.3% (61)
No	24.7% (20)
TOTAL)	100.0% (81)

B. Education

Respondents were then asked a series of questions pertaining to the academic education of unit members. Most agencies required a High School Diploma or General Education Diploma (GED) in their hiring practices, while they preferred those who hold a Bachelor's degree. To examine how prevalent academic degrees are within their units, respondents were asked if anyone in the unit possessed an Associate's degree or Certificate, Bachelor's degree, Master's degree, or Doctoral degree. 54.3% of respondents had at least one individual in their unit possessing an Associate's degree or certificate; 84% reported a Bachelor's degree, 46.9% reported a Master's degree, and 7.4% reported a Doctoral degree. Data representing these results are shown in Tables V and VI.

TABLE V. RESPONSES RELATED TO EDUCATION

	Require	Prefer
High School Diploma/GED	57.0% (49)	21.2% (18)
Associate's or Certificate	12.8% (11)	15.3% (13)
Bachelor's	29% (25)	52.9% (45)
Master's	1.2% (1)	10.6% (9)
Doctoral	0.0% (0)	0.0% (0)
TOTAL	100.0% (86)	100.0% (85)

TABLE VI. DOES ANYONE IN THE UNIT POSSESS A

	Associate	Bachelor	Master	Doctoral
Yes	54.3% (4)	84% (68)	46.9% (38)	7.4% (12)
No	45.7% (37)	16% (13)	53.1% (43)	92.6% (75)
Total	100.0% (81)	100.0% (81)	100.0% (81)	100.0% (81)

C. Training

Respondents were then asked a set of questions pertaining to training within their forensic investigation unit. At 73.5% the majority of agencies reported that individuals within the unit attended some type of specific training provided by the department prior to entering the field. 59.9% reported that yearly training was required, with 51% reporting that this training was the same or similar to the original training administered. For the 34 respondents who did not require yearly training, 15.1% reported that they did require attendance at some sort of routine training, though the subsequent question directed at the frequency of that training was not typically answered. Training provided outside of the department was encouraged by 99% of respondents; however, only 24.7% had a requirement for attendance at an outside training program. From those agencies that either encouraged or required training programs, 90.2% reported that this training was funded by the department. Table VII shows the data representing these results.

TABLE VII. RESPONSES RELATED TO TRAINING

	Dept. Training Provided	Yearly Training Required	Same as Dept. Training	Required Routine Training	Outside Training Encouraged	Outside Training Required	Dept. Funding for Outside Training
Yes	73.5% (61)	59.5% *50)	51.0% (25)	39.4% (13)	99.0% (84)	24.7% (19)	90.2% (74)
No	26.5% (22)	40.5% (34)	49.0% (24)	60.6% (20)	1.0% (1)	75.3% (58)	9.8% (8)
TOTAL	100.0% (83)	100.0% (84)	100.0% (49)	100.0% (33)	100.0% (85)	100.0% (77)	100.0% (82)

The following question contained multiple training areas, and respondents were asked whether or not members of their forensic investigation unit had received training in those areas. Combining interdisciplinary methods and traditional crime crime scene methods led to the following list of training areas utilized within the survey: azimuth baseline mapping, ballistics, bloodstain pattern analysis, Combined Index DNA System (CODIS), crime scene mapping, DNA recovery, fingerprint analysis, forensic anthropology, forensic botany, forensic entomology, forensic odontology, geographic information systems, toolmark identification, Total Station mapping, trace evidence collection, and zooarchaeology. Specifically, this list was developed from field techniques that impact the effectiveness of documentation and collection as well as analytical methods that require correctly preserved evidence to produce valid results. Reported answers indicated that bloodstain pattern analysis was the area in which most respondents were trained in, at 87.1%; this was closely followed by DNA recovery (84.7%) and trace evidence collection (83.5%). Respondents indicated little to no training in the areas of forensic odontology (8.2%), forensic botany (7.1%), and zooarchaeology (3.5%). Forensic entomology, at 35.3%, was the highest reported interdisciplinary training area. More traditional forensic methods had higher rates of responses, while the interdisciplinary methods had relatively low response rates.

Ballistics, bloodstain pattern analysis, crime scene mapping, DNA recovery, fingerprint analysis, and trace evidence collection are grouped as the areas that most units received training in; this leaves azimuth/baseline mapping, CODIS, forensic anthropology, forensic botany, forensic entomology, forensic odontology, GIS, toolmark identification, Total Station mapping, and zooarchaeology grouped as areas which most units do not receive training in. Respondents were also asked whether or not they utilized outside assistance to complete investigations involving these training areas; 92.9% reported yes, with most listing other agencies, specific units, private resources, and universities. Data illustrating the most common answers for each training area is shown in Table VIII, with percentages regarding utilization of outside training in Table IX. For respondents with units that contained both sworn and civilian members, agencies were asked whether or not a differentiation existed between the forensic training received by sworn officers as opposed to civilian members of the unit. Of the 55 agencies that answered this question, the majority of respondents indicated that there was no difference in the training received. Percentages representing this data are shown in Table X.

TABLE VIII. SPECIFIC TRAINING AREAS

	Training Received and Percentages
Azimuth Baseline Mapping	No (37.6%)
Ballistics	Yes (50.6%)
Bloodstain Pattern Analysis	Yes (87.1%)
Combined Index DNA System (CODIS)	No (32.9%)
Crime Scene Mapping	Yes (75.3%)
DNA Recovery	Yes (84.7%)
Fingerprint Analysis	Yes (75.3%)
Forensic Anthropology	No (25.9%)
Forensic Botany	No (7.1%)
Forensic Entomology	No (35.3%)
Forensic Odontology	No (8.2%)
Geographic Information Systems	No (15.3%)
Toolmark Identification	No (40.0%)
Total Station Mapping	No (48.2%)
Trace Evidence Collection	Yes (83.5%)
Zooarchaeology	No (3.5%)

TABLE IX. UTILIZE OUTSIDE ASSISTANCE?

Yes	92.9% (78)
No	7.1% (6)
TOTAL	100.0% (84)

TABLE X. SWORN VS. CIVILIAN TRAINING?

Yes	36.4% (20)
No	63.6% (35)
TOTAL	100.0% (55)

TABLE XI. RESPONSES FOR AGENCIES WITHOUT A SPECIALIZED FORENSIC UNIT

	National Certification Encouraged	National Certification Required
Yes	68.3% (56)	8.1% (7)
No	31.7% (26)	91.9% (79)
TOTAL	100.0% (82)	100.0% (86)

Lastly, respondents were asked questions regarding national certifications in the forensic disciplines. While 68.3% of respondents had units who encouraged national certification, only 8.1% of those agencies required national certification. Data showing these responses is shown in Table XI.

V. DISCUSSION AND RECOMMENDATIONS

Utilization of forensic evidence in courtroom proceedings will continue to be a mainstay in the American judicial system for the foreseeable future, and therefore will

need consistent improvement and advancement in order to ensure justice is being properly served. Results presented from this study aim to bring attention to the ever-increasing role of interdisciplinary cooperation in order to ensure the validity and accuracy of forensic evidence, a concept that is already beginning to emerge on an international level. Working concurrently, multiple techniques that serve to improve documentation, collection, and preservation will aid in the development of a stable and trustworthy system in which forensic evidence is utilized.

Baseline results from this study show multiple inadequacies present within the current structure and processes of American crime scene investigation units. Required educational levels did not call for a college education, a rare finding in such a hard-science driven field. In addition, lack of discipline diversity as a result of not having college-educated unit members negatively affects the knowledge base of the unit as a whole.

In regards to training, while most units were provided specific training by the department prior to entering the field, training varied widely across agencies. Those agencies requiring yearly training were administering training that was the same or similar to what members had already received. For those agencies that responded "no" to a yearly training requirement, the majority of them did not require any routine training whatsoever. Lack of updated, diverse, and routine training is not conducive for a field that is still in constant development. No requirement for outside training means that unit members are only exposed to the perspectives and techniques of their department, causing stagnation in unit development and eventually leading to antiquation of methods in the same way as a lack of updated, diverse, and routine training. Training areas vary widely from department to department, and while classic methods were identified most often, a complete lack of extremely relevant forensic disciplines was present. Furthermore, the absence of requirement for national certification is troubling. A surprisingly significant 31.7% did not even encourage their members to obtain national certification. With no official recognition in the discipline, unit members being called as witnesses (expert or otherwise) lessen their abilities in the eyes of the court.

As this data was gathered through a pilot study, multiple recommendations can be made for the direction of future research. Reasonable response rates indicate that an even larger sample may be able to be obtained, allowing for data to be gathered on units/agencies serving smaller populations; furthermore, this has implications for utilizing this study in other countries, as solid response rates for larger units indicates amenability that may cross over in an international context. A closer examination of individual standards and/or best practices on a state-by-state basis could lead to the possibility of incorporating these standards into a statewide requirement, which might increase the likelihood of national standards being developed. Subsequently, development of national standards could lead to an easier flow of information between the international forensic community and encourage the exchange of new developments and information. Educational deficiencies could be explored even more through examining units who have college education requirements as opposed to those who do not; observations could include identifying differences in documentation, collection, and preservation of evidence, and whether or not that has had a direct impact on the forensic cases those respective units have been involved in. For training, individual program evaluations of a specific agency may identify deficiencies that could then be rectified to improve the quality of departmental training unit members are receiving. Additionally, evaluation of outside forensic training programs across the United States could prove beneficial to observe their success in education and development, as well as their impact on those who attend them; furthermore, studies could be conducted that compare these training programs to evaluations of those present abroad. Finally, this study sets the stage for similar research to be conducted in other countries, creating the possibility of international comparison and cooperation within forensic practices.

As forensic science evolves, those who investigate forensic-related crime should evolve as well. By gaining awareness of multiple disciplines, identifying and rectifying deficiencies in standards, education and training, and conducting specific evaluations, forensic investigators can be as successful as possible in their documentation, collection, and preservation of evidence in the field. Opening international communication on these topics can allow for immense knowledge to be gained on the most cutting-edge methods as well as an understanding of how techniques work in multiple jurisdictions. Being that the goal of forensic evidence is to identify and convict a criminal, all should be working to develop the most viable way of ensuring that evidence is of the highest quality. Further research into the findings presented in this study could prove extremely beneficial to the field of forensic science and crime scene investigation as a whole.

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