Science & Justice 59 (2019) 573–579

Contents lists available at ScienceDirect

Science & Justice

journal homepage: www.elsevier.com/locate/scijus

Scientific integrity in the forensic sciences: Consumerism, conflicts of interest, and transparency☆

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ABSTRACT

The goal of this paper is to discuss scientific integrity, consumerism, conflicts of interest, and transparency within the context of forensic science. Forensic scientists play crucial roles within the legal system and are constantly under various pressures when performing analytical work, generating reports based on their analyses, or testifying to the content of these reports. Maintaining the scientific integrity of these actions is paramount to supporting a functional legal system and the practice of good science. Our goal is to discuss the importance of scientific integrity as well as the factors it may compromise, so that forensic practitioners may be better equipped to recognize and avoid conflicts of interest when they arise. In this discussion we define terms, concepts, and professional relationships as well as present three case studies to contextualize these ideas.

1. Introduction

The forensic sciences are a series of applied disciplines focused on addressing issues relating to the legal system. Forensic science includes such medicolegal professions as forensic -pathology, -anthropology, -odontology, and -entomology, in addition to the more technically based specializations encompassed by criminalistics. However, more generally, *forensic science* can be defined as a "profession of scientists whose work answers questions for the courts through reports and testimony" [1,4]. The goal of the forensic sciences is to identify persons and objects, as well as establish their contextual relationships to other people, places, and objects, in order for the courts to determine their evidentiary value [1,2]. The judicial system accepts the results of these forensic reports, and through disinterested and unbiased observers (i.e., lawyers, jurors), establishes a narrative of events and causalities determining the nature, context, and legality of the given case/investigation [3–5]. While generally applicable to all of forensic science, this paper will focus on those medicolegal disciplines devoted to human identification and death investigation, typically within the purview of forensic -pathology and -anthropology (to include archaeology). The goals of these disciplines do not differ significantly from those of forensic science in general; however, they center more on determining the identity of unknown individuals, establishing the cause and manner of death, and estimating the time since death, or postmortem interval.

Forensic scientists in these disciplines can be called upon by any number of entities to provide their expertise on medicolegal matters. For example, outside of large municipalities that can offer full-time employment, forensic anthropologists are routinely contracted (typically on a case-by-case basis) by law enforcement agencies or medicolegal authorities (e.g., coroners/medical examiners) for their expertise. Other forensic experts may be contacted by law enforcement or lawyers to provide insight into legal cases either through analysis, interpretation, or as expert witnesses. These forensic scientists may be professors at academic institutions, employees of a consulting company, or even independent consultants contracted to perform a service relating to medicolegal matters. While these experts may be hired for their particular expertise by any number of parties, we argue that clarifying this relationship of who exactly is the customer of forensic analyses avoids conflicts of interest and maintains scientific integrity, both of which are essential to the scientific process.

This paper aims to discuss issues surrounding professional relationships within the forensic sciences [see also [6]]. In this treatment, the following questions are addressed: (1) who are the consumers of forensic services?, (2) for whom do forensic scientists actually work?, and, (3) who benefits from forensic science services? These questions are explored within the framework of *scientific integrity* as the unbiased, empirical, and ethical practice of scientific investigation [7]. While these issues are relevant to forensic sciences worldwide, the general

☆ This paper discusses the importance of scientific integrity as well as transparency, conflicts of interest, and consumerism within the forensic sciences, so that forensic practitioners may be better equipped to recognize and avoid conflicts of interest when they arise. These terms, concepts, and professional relationships are defined and presented in the context of consumerism in the forensic sciences. Three case studies are presented to contextualize these concepts.

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https://doi.org/10.1016/j.scijus.2019.06.010
Received 14 November 2017; Received in revised form 11 June 2019

Table 1
Definitions of terms in consumerism in forensic science.

Term	Definition	Example
Beneficiary	Interested parties benefitting from the forensic analyses	Families, communities, NGOs
Client	Requesting agency and/or funder of forensic analysis	Law enforcement, medicolegal authority
Consumer	Any agency or individual with a vested interest in forensic reporting	Clients, customers, beneficiaries
Customer	Entity for which the entire forensic system is working	The state, often represented by "The People/The Crown"
Producer	Entity producing analytical reports	Forensic scientist

construction of this discussion will center on common practices in the United States and Canada.

2. Consumerism and forensic science

Due to the public and legal nature of forensic science, as well as the impact of forensic results and reporting, it is important to identify the consumers of scientific reporting to ensure transparency and avoid conflicts of interest. Here, we approach the concept of *consumerism* as: the cultural context of the consumption of goods and services [8: 4]. Within this context, we define the terms consumer, client, customer, and beneficiary in forensic sciences as they relate to the producer (i.e., forensic scientist) of the good or service (i.e., scientific reports) being consumed (Table 1) [9].

Any agency or individual with a vested interest in the outcome of forensic reporting can be considered a *consumer* of the reports. Consumers can be clients, customers, or beneficiaries. The *client* is defined as the requesting agency and/or funder of forensic analysis and is typically law enforcement personnel/agency or the medicolegal authority. The client, within a medicolegal context, is often focused on the recovery of remains, the identification of the decedent, and the death investigation.

Here, we use the word *customer* to mean the entity for which the entire forensic and judicial systems are working. Generally, within the legal realm of the United States, the customer can be thought of as the State, or "The People" (as in "the people vs. the accused"). Here "The People", denotes the State that is representing the public at large, who benefit from the proper conviction of a crime, the proper use of taxpayer money, and the resulting benefits to society from a reduction in crime via the deterrents of the judicial system. In Canada, the legal system serves "The People" in a similar fashion, albeit via "The Crown." "The Crown" is a reference to the royal head of State, and the associated legal staff (e.g., assistant crown attorney, federal prosecutor) working at their discretion as part of the government to ensure social order for the State. In a very specific sense, the customer can be thought of as the victim of the crime, be it the individual who was killed, or the owner of the property that was stolen. However, this is not necessarily apart from the broader abstraction of "The People/The Crown." This is because medicolegal services involved in investigating and prosecuting the crime are attempting to do justice to this individual (i.e., the victim) via the State. That is not to say there are no other highly invested parties in these cases (e.g., the next of kin), rather, it is that these other parties should actually be thought of as beneficiaries of these forensic services, rather than customers themselves.

The relationship between producer and consumer can be complex, often with more than a single individual or agency consuming a good or service. It may therefore be more appropriate to use the term beneficiary [10]. *Beneficiaries* are agents (e.g., victims, families, communities, NGOs) that can be considered interested parties (i.e., stakeholders) in the investigation, benefiting from the forensic services provided and the resolution of the investigation to varying degrees. Pyrek [5] suggests that all parties involved with forensic science (e.g., the prosecutor, judge, jury) should be considered stakeholders in forensic science, with the forensic scientists being the "overlooked stakeholder."

Identifying the relationships between subject matter experts that produce forensic reports and the various consumers of scientific reporting is important as it generates transparency. Within the forensic sciences, *transparency* (of a laboratory or individual practitioner) can be thought of as functioning in such a way that outside consumers (customers and beneficiaries) can follow any actions that were performed during field or laboratory operations, or specific case analyses [11]. It is through transparency that potential conflicts of interest are identified, thereby ensuring the independence of scientific experts and their reports. Further, it is critical that these relationships be known to all involved throughout the process to maintain scientific integrity.

3. Scientific integrity and conflicts of interest in forensic science

Warner and Roberts [12: 381] note that "…scientific integrity has been characterized as a commitment to truthfulness, to personal accountability, and to vigorous adherence to standards of professional conduct". The basis of scientific integrity is the impartial, transparent nature of the scientific process, as well as the public's confidence in the scientific enterprise [7]. Within forensic science, maintaining scientific integrity is paramount. Forensic science must be impartial, unbiased, and transparent, as it is the role of the courts to use the evidence generated by forensic scientists to establish causality and burdens of proof. It is NOT the job of the forensic scientists to establish cause or intent; rather, forensic scientists report results of scientific testing and their interpretation of these results to the proper agencies for admission to the legal system.

Unbiased and impartial science is facilitated through transparent relationships. Within laboratory operations, quality assurance protocols and accreditations are forms of ensuring and documenting/presenting organizational transparency publicly. The importance of transparency within forensic science cannot be discounted as it ensures trust in the organization-stakeholder (i.e., consumer) relationship via disclosure, clarity, and accuracy [12].

A lack of transparency and clear working relationships can lead to conflicts of interest, which are the greatest threats to the maintenance of scientific integrity. *Conflicts of interest* can be defined as: "…a set of conditions in which professional judgment concerning a primary interest tends to be unduly influenced by a second interest (such as financial gain)" [13: 573]. Conflicts of interest are violations of researcher independence and ethics codes, and qualify as research misconduct [7]. Such issues often arise as the process of science and scientific reporting is performed by people within a society, which allows "social determinants and ideology" to introduce bias into the scientific process [14: 61–62]. As such, Krimsky [14: 62] argues that there are three principles that must exist in order to promote good science in society and avoid conflicts of interest: (1) scientists must be able to conduct research without unjustified restrictions by other authorities (e.g., sponsors, governments); (2) scientists must be able to report results on their own schedule (i.e., when the analyses are complete, when withholding results could cause harm); and, (3) parties with vested interests must not be involved in the scientific process, and any parties that attempt to disrupt the scientific process must be held accountable.

As discussed in [6], within forensic science there are a number of opportunities for research misconduct and conflicts of interest to arise, many of which result from public pressure, poor performance metrics,

and/or a compulsion to please or appease consumers, however bias can also arise from too much prior information about a case/decedent. Because of the potential bias that has been found to occur in cases where individuals are given leading or potentially biasing information prior to conducing their analyses, many individuals recommend that forensic scientists work "in the blind", or without contextual information [15–17].

Koppl [18] notes that "motivation bias" [also referred to as "pro-police bias" in [2]] can occur if there is too great a dependence on consumer satisfaction, which in turn can create a bias toward pleasing consumers (e.g., police agencies, prosecutors, communities) to stay funded. This motivation bias can also arise from issues relating to personal performance evaluations and future career opportunities. Additionally, a recent study found that forensic scientists (in this case, forensic psychologists and psychiatrists) tended to bias their findings toward the side of the legal team that retained their services, showing evidence for what the authors describe as an "allegiance effect" [19].

In order to combat violations of scientific integrity, Cooley [2] suggests six reforms to forensic science: (1) properly fund and train scientific staff, (2) increase funding for forensic DNA laboratories and analyses, (3) "forensic scientists need to be independent, free thinkers"[2: 422], which means there must be decreased interaction between forensic scientists and consumers in order to eliminate potential bias, conflicts of interest, and research misconduct, (4) forensic laboratories must have properly trained staff that meet minimum standards, with PhDs in related fields as a strongly encouraged minimum educational background, (5) forensic scientists must provide statistical support for their analytical conclusions, and (6) forensic scientists must conduct proactive systematic research in order to validate claims made in laboratory settings. The final two findings are particularly salient to forensic practitioners as they are also in line with the rules governing the admissibility of expert testimony in a federal court of law [as established in [20]].

4. For whom do forensic scientists work?

Broadly, the process of science denotes authority of a subject to the scientist, and good scientists should be considered impartial independent subject-matter experts [7]. The vast majority of forensic science laboratories, including medical examiners' offices and crime labs, are public services [see [1] for details]. While there are a number of different models for public-sector forensic science laboratories, these are operated by state or federal government systems and financed largely via community tax dollars.

In cases where private citizens want their own forensic testing done, which is often in addition to the freely provided public-sector testing, there are private forensic laboratories. These private labs provide services for a fee, and are primarily focused on DNA testing, although other specialty laboratories exist. In situations where a public-sector forensic laboratory requires a specialized analysis that is not already provided, they can contract out these services on a case-by-case basis. In either event, public or private sector testing, the analytical reports and potential testimony are generated for the courts in regard to a case or investigation.

To use forensic anthropology as an example, a smaller medical examiner's office may receive a case that requires the analysis of skeletal remains, which falls outside of the purview of forensic pathology [21]. This medical examiner's office contracts this case out to a consulting forensic anthropologist, who then writes a report based on their analysis. This forensic anthropologist is compensated[1] for their contracted services as a subject-matter expert through the medical examiner's office. The analytical conclusions of the forensic anthropologist may then inform the forensic pathology report, or may simply be used as a standalone document. Either way, these conclusions can be used to determine the legitimacy of a case in court by prosecutors, and may be used as the basis for future expert witness court testimony, all culminating in the resolution of a death investigation.

It should be noted that as employees of state or federally funded laboratories (including College/University laboratories), most forensic scientists are government-employed public servants. Ethical grounds for government employees and elected officials (e.g., district attorneys) originate with the concept of stewardship. In this context, *stewardship* can be considered to mean that in addition to their duties to ensure scientific integrity, these individuals have the additional responsibility of properly utilizing public funds for the good of the citizens they represent [14: 104].

Again, it is critical to outline these relationships to ensure the integrity of forensic scientific reporting. Forensic scientists should have a clear understanding of who is contracting their services and who is benefiting from these services, as this delineation of the *consumer-producer* relationship serves to ensure scientific accuracy, transparency, and consumer trust.

5. Rights of the dead and medicolegal death investigation

Within the context of scientific integrity and consumerism, it is also important to discuss how the rights of the dead fit into this model, and how we can work within this unbiased framework and still maintain these rights. As discussed by Rosenblatt [22: 942–943]: "a living person can suffer the worst violations of human rights and still possess those rights, the violation of the dead (i.e., the destruction of the remains) can render them permanently 'rightless' in a definitional sense". While human rights do not pertain to the dead, it is important to remember that decedents do have rights, and in fact, these *Rights of the Deceased* can be thought of as not just ethical responsibilities, but also the goals of forensic investigations [22: 950]. Following Rosbenblatt [22: 949], the deceased have three rights, (1) *Right to identity*, or the identification of unknown remains, (2) *Right to a marked burial location*, forensic services "relocate or 'repatriate' [remains] from unchosen places, to places selected and/or recognized by a community of mourners; restoring them to the physical and social worlds from which they were violently torn", and (3) *Right to care*, that is, forensic practitioners return remains of the deceased to their families who can care for them in a personal and culturally appropriate context.

Forensically, an unknown set of remains can be found by law enforcement, recovered by a forensic anthropologist, and identified by a medical examiner. Each step in this process is a critical component in the relocation of remains from an unchosen place of deposition, the restoration of identity, and the return of the remains to their next-of-kin for mortuary treatment. All of these analyses may be performed by different forensic specialists and in all cases without violating the scientific integrity of the scientific process. Further, the State benefits from such rights. The families of victims directly benefit from these actions, the deceased individual is identified and granted access to proper mortuary treatment, and the community in general can rest assured that should such tragedy befall them, they too can expect to be treated with such care and respect.

6. Case studies

In an effort to illustrate our argument, we present three case studies,

[1] Compensation may come in many forms, either through actual monies exchanged between parties, through university support, or other arrangements made between the forensic anthropologist and the medical examiner's office (e.g., access to resources or space within the office). In any event, the forensic anthropologist performs this service in exchange for some sort of compensation, money or otherwise.

or scenarios. These examples highlight the need for complete transparency and relational definitions within the forensic sciences to guarantee the veracity of reporting. The first case study outlines the relationship between consumers and forensic scientists in the Defense POW/MIA Accounting Agency (DPAA). The second serves to underscore the role of malfeasance and conflicts of interest that can arise when relationships are unclear, or expectations are unrealistic. The cases discussed in this scenario surround report falsification, although other outcomes may exist. Finally, the third case study examines the intrusion of outside parties (i.e., the government) on (forensic) science.

6.1. Case study 1 - Accounting for America's missing service members

The mission of the DPAA is to account for America's war dead. The DPAA was established in January 2015 from a merger of several U.S. Department of Defense (DoD) entities. The primary predecessor in terms of forensic anthropology and archaeology was the Joint POW/MIA Accounting Command (JPAC), which was formed in 2003 from a previous merger of the Joint Task Force-Full Accounting (JTF-FA) and the U.S. Army Central Identification Laboratory – Hawaii (CILHI). This lineage was created largely out of an effort that began in the 1970s to increase the scientific scrutiny and systematic recovery of service members' remains, initially from the Vietnam Conflict. The U.S. Government has a long history of accounting for its service members and war dead, largely due to the American Grave Registration Service/Command (AGRS/C). The AGRS/C was essentially a mortuary operation that also attempted to perform identifications of unknown remains and maintain custody of personal effects for return to the primary next-of-kin. These efforts have a long history of formation after every major US conflict since the US Civil War [23,24].

Currently, the DPAA is tasked with the search, recovery, and identification of US service members from past conflicts.[2] When remains of individuals are recovered, they are returned to one of the DPAA's forensic laboratories (DPAA West, in Hawaii or DPAA Offutt, in Nebraska) for forensic testing and examination. Once an individual is identified, the Casualty Service Office of the individual's service branch (i.e., Army, Navy, Air Force, Marines) is notified, which in turn notifies the primary next-of-kin of the deceased individual. The Casualty Service Office works with the primary next-of-kin to coordinate the final resting place of the identified service member as well as review of the identification case packet, which includes all the technical and summary reports.

Prior to the merger in January 2015, the actual customer of the U.S. past conflict accounting process was never defined. Many of the DPAA forensic analysts argued that the unaccounted-for service members were the customers, with the respective service branches and families being the direct beneficiaries of the accounting mission. Such a system ensured the scientific integrity of the mission and helped to avoid potential conflicts of interest. However, with the reorganization efforts and merger into the DPAA beginning in 2014, several changes occurred that are now part of the DPAA which may undermine those efforts by introducing conflicts of interest into the system.

As stated above, the DPAA was formed from the merger of different U.S. service member accounting groups (including the JPAC, the Defense Prisoner of War Missing Personnel Office [DPMO], and the Life Science Equipment Laboratory [LSEL]) into a single, new DoD agency. This new agency installed an Armed Forces Medical Examiner (AFME) as the identification authority (rather than a forensic anthropologist), and centered the accounting mission on family transparency and satisfaction, including the discussed use of family satisfaction as a metric (currently undefined) for accounting performance [25]. It was made clear during this re-organization that the family of the unaccounted-for service member was now to be considered the customer of this mission. This distinction is important as it allows families greater agency and authority within the accounting process, and ultimately the forensic analyses. Specifically, those families that are less happy with the progress of their cases, or those families with greater public or political visibility may now be able to have their respective cases investigated more quickly or at greater expense in order to increase their customer satisfaction. Much of this lobbying power of family groups and NGOs was the impetus behind the recent re-organization of the accounting community and the creation of the DPAA. Scientific procedures were considered substandard, not because they were bad science, but because they were not satisfying the lobbyist groups' demands for increases in identifications [26].

This model places the next-of-kin as the customer, which violates Krimsky's [14] principal of scientific independence from invested parties. Placing the family as the customer, as opposed to a primary beneficiary, jeopardizes the scientific integrity of the identification and ultimately the mission of identifying the fallen service members of the United States. This reorganization also begs the question that if the service members are not the customer of the mission, what role do they play?

6.2. Case study 2 - Falsifying forensic reports

Several reports over the last two decades have stressed the inadequacies of the forensic sciences within the United States with a focus on scientific flaws or lack of validation of many forensic methods [see 27,28]. There have also been isolated reports of forensic practitioners succumbing to pressures placed on them by these inherent flaws within the system, which have included large backlogs, pressure to perform, as well as lack of funds, support, and training.

In 2001, Fred Zain, the chief serology expert for West Virginia, was investigated for falsifying test results throughout his 16-year career [29]. In this case, Zain's testimony and analytical results led to the prosecution of several high-profile cases, which were beneficial to various prosecutors and judges [29]. This case may represent a conflict of interest in which expectations were high, or there was overt pressure to perform and provide particular scientific results. In order to maintain scientific integrity and avoid such conflicts it is imperative to allow scientists to work free from these pressures.

More recently, in 2012, Annie Dookhan, a forensic chemist in Massachusetts, was arrested for falsifying test results on suspected drug samples in a state-run forensic laboratory. Initial estimates claimed that as many as 34,000 cases could be affected spanning a period of two to three years [30]. In this case, the laboratory where Annie Dookhan worked had a tremendous backlog and she was found to test more samples than anyone else. Such a backlog in forensic laboratories is not uncommon in the United States, primarily attributed to the lack of funding relative to workload [29,30]. Unfortunately, this system presents the opportunity for conflicts of interest to arise, most notably, it can create immense pressure to perform both from within the system (e.g. supervisors, co-workers) and from without (e.g. the public).

While the vast majority of forensic science professionals are ethical and hardworking individuals following the standard operating procedures of their particular laboratory and the protocols of their discipline of expertise, occasionally the system of forensic investigation can lead to failures and opportunities for misconduct. These examples should serve as reminders to the forensic sciences that we need to maintain high ethical standards and working conditions to ensure such occasions for misconduct do not present themselves.

We argue here, that with a clear definition of roles within forensic sciences, some of these circumstances could be eliminated. For example, if beneficiaries, customers, and clients are clearly identified, and these roles adhered to, different metrics for success could be developed,

[2] Currently, past conflicts are defined as WWII, the Korean War, the Vietnam Conflict, the Cold War, and from the Iraq region. However, when necessary, the Agency and its predecessors have been involved with cases from the War of 1812, the U.S. Civil War, WWI, and on-going or recently completed conflicts

which would remove some of the pressure these forensic scientists may have felt. Additionally, this delineated structure would allow for deficiencies in training and funding to be more easily reported and identified.

6.3. Case study 3 - Government intrusions into scientific integrity

With the 2015 election in Canada, the concept of science and consumerism, at least at the government level, changed dramatically. Prior to the election, under the leadership of Prime Minister Stephen Harper, government scientists fell into a corporate/business model of science. This created an atmosphere where the customer of the scientist's work was the government agency bywhich they were employed. While this may make some sense, it also meant that the product of the work was being massaged and manipulated by the customer in order to conform to often contradictory governmental policies (violating scientific integrity). During this period, any scientific communication with a government-employed scientist needed to be vetted through a series of government agencies, which often resulted in the communication never actually occurring ,or with the communication actually being answered by a public affairs staffer rather than the scientist themselves. These policies were viewed by Canadian scientists as a "war on science" as it affected not only how they presented their research findings, but also the very nature of their research [31].

Violators of these restrictive rules were ostracized, and funding for publication, research, and conferences (i.e., continuing education) was cut. Additionally, the level of bureaucracy required for scientists to take part in outreach and scholarly dissemination such as presentations, conferences, and publication of their work was particularly onerous [32,33]. Many felt that these restrictions were not just wasting professional time and taxpayer dollars, but hurting science itself, with scientists from outside of Canada becoming hesitant to collaborate with Canadian scientists due to such restrictions on communication and publication [31]. Furthermore, the ostracization of any forensic body compromises the peer review process, which is a foundation of science and scientific integrity. Substandard practices go unnoticed, new methods go unlearned, and opportunities for misconduct increase in almost unconscious frequency as the scientists become insular and complacent due to the restrictions placed on them by the customer.

These policies eventually resulted in protests and massively supported letters to Canadian parliament, to end "burdensome restrictions on scientific communication and collaboration faced by Canadian government scientists" [31], as well as a report by the Canadian watchgroup Evidence for Democracy entitled: "*Can They Speak? An assessment of media policies in Canadian federal science departments for openness of communication, protection against political interference, right to free speech, and protection for whistleblowers*" [34]. This report generated a number of conclusions and recommendations, some of which were that "government media policies do not support open and timely communication between scientists and journalists, nor do they protect scientists' right to free speech" and that "Government media policies do not protect against political interference in science communication" [34: 3]. Both conclusions are clear evidence of breaches in scientific integrity, largely stemming from the customer (i.e., the Canadian government) being too involved in the scientific process. Further, Canada is not alone in these issues, in the United States an advocacy group called the Union of Concerned Scientists exists just to investigate and "stop political interference in government science" [35].

7. Discussion

While the general framework for this discussion of consumerism and conflicts of interest in forensic science has centered on Canada and the United States, these issues are relevant to forensic sciences in other locations. In fact, a clear delineation of these roles may be more salient outside of North America, particularly in areas where forensic services are largely provided by outside consulting agencies (e.g. portions of the United Kingdom). Additionally, it could be critical to define these roles in areas of mass disasters, war crimes, or human rights abuses where forensic services are needed. In these instances, there may be several interested parties all with a desire for a different outcome. Having a set of clear and defined roles, as described herein, may alleviate the potential for misconduct.

Within the United States, the forensic sciences are in the midst of a considerable overhaul based on recent revelations of significant issues within the field. The National Academy of Sciences Report [27: 19–33], after three years of research, generated 13 recommendations for the greater forensic science community:

1. Create a National Institute of Forensic Sciences (NIFS).
2. Standardize terminology and reporting practices.
3. Expand research on the accuracy, reliability, and validity of the forensic sciences.
4. Remove forensic science services from the administrative control of law enforcement agencies and prosecutors' offices.
5. Support forensic science research on human observer bias and sources of error.
6. Develop tools for advancing measurement, validation, reliability, information sharing, and proficiency testing and to establish protocols for examinations, methods, and practices.
7. Require the mandatory accreditation of all forensic laboratories and certification for all forensic science practitioners.
8. Laboratories should establish routine quality assurance procedures.
9. Establish a national code of ethics with a mechanism for enforcement.
10. Support higher education in the form of forensic science graduate programs, to include scholarships and fellowships.
11. Improve the medico-legal death investigation system.
12. Support Automated Fingerprint Information Systems (AFIS) interoperability through the development of standards.
13. Support the use of forensic science in homeland security.

Many of these recommendations are direct attempts to increase scientific integrity and decrease potential avenues for conflicts of interest.

As a response to the National Academy of Sciences Report, the National Institute of Standards and Technology (NIST) in conjunction with the Department of Justice (DoJ) established the Organization of Scientific Area Committees (OSAC). The OSAC was created in order to generate discipline-specific standards within the forensic sciences (replacing the previous system of Scientific Working Groups, SWGs). This organization is a positive first step toward establishing standards and guidelines for forensic science practitioners and their analyses. The products produced by the OSACs have little potential for enforcement alone. However, all standards and guidelines being produced by OSAC committees are expected to go through an accredited Standards Development Organization (SDO). The American Academy of Forensic Sciences (AAFS) itself recently developed the AAFS Standards Board (ASB), an accredited SDO, similar to other organizations such as the American Society of Testing and Materials (ASTM). The goal of the OSAC Subcommittees is to develop documents to be submitted to SDOs to ensure that the standards generated become enforceable and regulated by the forensic community whom they serve.

In 2015, United States President, Barack Obama, asked the President's Council of Advisors on Science and Technology (PCAST) "whether there are additional steps on the scientific side, beyond those already taken by the Administration in the aftermath of the highly critical 2009 National Research Council report on the state of the forensic sciences, that could help ensure the validity of forensic evidence used in the Nation's legal system" [28: x]. In response to this request, the PCAST generated a report published in 2016 titled: *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison*

Methods. The investigation by the PCAST reported finding two important gaps affecting the validity of forensic evidence in the United States: "(1) the need for clarity about the scientific standards for the validity and reliability of forensic methods, and (2) the need to evaluate specific forensic methods to determine whether they have been scientifically established to be valid and reliable" [28: x]. Importantly, this report focused on feature-comparison evidence, meaning "methods that attempt to determine whether an evidentiary sample (e.g., from a crime scene) is or is not associated with a potential 'source' sample (e.g., from a suspect), based on the presence of similar patterns, impressions, or other features in the sample and the source" [28: 1]. Because of this focus, the PCAST report specifically discusses issues regarding DNA, latent prints, and firearms analyses. Similar to the 2009 NAS report [27], the PCAST report generated eight recommendations which are simplified and presented below:

7.1. Recommendations to NIST and the office of science and technology policy (OSTP)

1. Assessment of foundational validity - "PCAST recommends that NIST be tasked with responsibility for preparing an annual report evaluating the foundational validity of key forensic feature-comparison methods, based on available, published empirical studies" [28: 124].
2. Development of objective methods for DNA analysis of complex mixture samples, latent fingerprint analysis, and firearms analysis - "NIST should take a leadership role in transforming three important feature-comparison methods that are currently subjective—latent fingerprint analysis, firearms analysis, and, under some circumstances, DNA analysis of complex mixtures—into objective methods" [28: 129].
3. Improving the OSAC process – The OSAC should have a formal Metrology Resource Committee at the level of the other three Resource Committees that should be composed of laboratory scientists and statisticians from outside the forensic science community. This committee should be "charged with reviewing each standard and guideline that is recommended for registry approval by the Science Area Committees before it is sent for final review the Forensic Science Standards Board (FSSB)" [28: 130].
4. Research and design strategy for forensic science – OSTP should coordinate the creation of a national forensic science research and development strategy that will address funding needs for research in the forensic sciences [28: 130].

7.2. Recommendations to the FBI laboratory

1. Expand forensic-science agenda at the FBI Laboratory – The FBI Laboratory should expand their forensic science capabilities, including the: development and expansion of research programs, use of black box methods, development of objective methods, implementation and promotion of proficiency testing, and improvement of transparency concerning quality issues in casework [28: 135–136].
2. Use of feature-comparison methods in Federal prosecutions – "The Attorney General should direct attorneys appearing on behalf of the DOJ to ensure expert testimony in court about feature-comparison methods" is scientifically valid, with assistance from the DOJ and NIST as needed [28: 140].
3. DOJ guidelines on expert testimony – The "*Uniform Language for Testimony and Reports*" should be implemented [28: 142].
4. *Recommendations to the Judiciary:*
5. Scientific validity as a foundation for expert testimony – When deciding on admissibility of expert testimony, Federal judges should take into account the appropriate scientific criteria for assessing scientific validity [28: 145].

These recommendations are wide ranging and largely focus on criminalistics and the more technical, rather than academic, forensic sciences. Additionally, the PCAST report often refers to issues of confirmation bias and conflicts of interest, and the need for non-forensic scientists to validate the work of forensic scientists due to these issues. While the current U.S. President and Attorney General do not appear to be interested in supporting or following the recommendations of the previous administration or this report, it does not mean that these recommendations are without validity or utility, or that these recommendations will not be pursued in the future. Further, the findings from this report demonstrate the need to address conflicts of interest in the forensic sciences and how issues of non-transparency are harming the scientific process within the courts.

8. Conclusions

Violations of scientific integrity and the introduction of conflicts of interest are some of the greatest challenges to forensic science today. We have argued here that along with such procedures as utilizing Krimsky's [14] three measures of good science, it is also important to identify the consumers of forensic science products. Toward this end, the following questions were addressed: (1) Who are the consumers of forensic services, (2) For whom due forensic scientists actually work?, and (3) Who benefits from forensic science services? We argue that (1) the consumers of forensic science can be broken into clients, customers, and beneficiaries (see Table 1), (2) regardless of the specific client, forensic scientists ultimately work for the customer, which is typically the State in North American practice (e.g., The People, The Crown), and (3) the beneficiaries of forensic services include the decedent, their family, the community served by the court, and the law.

Understanding the concepts of transparency and conflicts of interest allow forensic scientists to better avoid misconduct and maintain scientific integrity. Further, we argue that in tandem with these suggestions, forensic practitioners need proper funding and training to mitigate potential violations of scientific integrity. It is only through such transparency that the forensic sciences can progress as a field and address the concerns that have recently emerged in regards to scientific rigor.

Conflict of interest statement

The authors have no conflicts of interest involved with this submission or any work related to this submission.

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