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Interpol review of forensic science management literature 2016–2019

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ABSTRACT

This paper reviews and summarizes the forensic management literature from late 2016 to late 2019, covering laboratory decision making, business strategy, and industry identity and transparency. The review papers are also available at the Interpol website at: https://www.interpol.int/content/download/14458/file/Interpol%20Review%20Papers%202019.pdf.

1. Introduction

> *The collective pursuit of continuous improvement is powerful not only because of the performance gains it yields, but also, I think, because it's the only cultural value that could unify an organization as large and diverse as ours.*[1]
>
> George C. Halvorson – Harvard Business Review

Over a decade has now passed since the [1] report *Strengthening Forensic Science in the U.S.: A Path Forward* was published. This report, as in its title, gave the forensic science industry a path towards needed change which both inspired and frustrated the industry and its stakeholders. The criticisms contained in the NAS report were substantial, multifaceted, and were the first of their kind and collective significance to question the activities of forensic science broadly. The tone was set in the very first sentence in the preface of the report, stating "significant improvements are needed." This tone followed not only through the report but the next ten years of successes and some steps backward for forensic science since its publication.

The work towards criminal justice and litigation reforms, increases in peer-reviewed academic research on testing validity and laboratory management, a burgeoning acceptance of the economic and budgetary realities laboratories face, and the nearly universal acceptance of the importance of accreditation standards are something to be celebrated. However, the disbanding of the National Commission on Forensic Science (NCFS) in 2017, having only started in 2013, leaves room for concern about the United States government's commitment to the movement they have in part created. Additionally, the cessation of *Forensic Science Policy and Management: An International Journal* in 2018 has left a hole in academic research regarding laboratory and evidence management, which has just now started to be filled with alternative publications. These changes and governing instabilities beg the question, *who will lead forensics science if it is to be lead?*

The opening quotation provides some, albeit vague, guidance. Originally written for a hospital and healthcare management audience, the challenges faced in forensic science management are in many ways parallel to that of the medical field [2]. Transparency, error rates, the importance of academic research, and economic constraints are issues faced by both industries, and indeed were issues the NAS report called on forensic science to address. The forensic science industry's coming of age is continuing to develop as goals and areas for improvement both broadly and discipline specific within forensic science are outlined. As stated in McAndrew & Houck (2016), the forensic science industry's maturity is based in part on these developed goals being embraced systems-wide. Relevant performance data, as with Project FORESIGHT, can

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[1] George C. [70]; The Culture to Cultivate, Harvard Business Review, July–August Issue.

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be analyzed both internally and externally, with evidence-based action plans being created and implemented when performance is not within an acceptable benchmark. This creates a necessary feedback loop for a culture of continuous improvement [3]. Recognizing false positives, false negatives, and how they happen is necessary but often ignored feedback that can stabilize and calibrate the criminal justice system [4]. Progress has and is being made since 2009, but how the industry carries this momentum into the future and communicates it to external stakeholders is yet to be seen.

What follows is a review of forensic science management literature from late 2016–2019, documenting the academic research in the area of forensic laboratory management for the past three years for the 19th *INTERPOL International Forensic Science Managers Symposium* conference proceedings.

2. Themes in the literature

Determining what is and is not an article on forensic science management is not always obvious, and the word "management" is not always explicitly used even when it might make sense to do so, making retrieval from library article databases problematic. Additionally, given forensic science is a system within systems, topics or articles related to criminal justice more broadly might reasonably be included. How far one extends connections back to forensic science management in the decision to include an article for a review can be an idiosyncratic choice, leading to potential omissions. The cessation of *Forensic Science Policy and Management: An International Journal* has also left a temporary hole in potential outlets for scholarship of this kind, creating a noticeable reduction in readily available articles related to forensic science management. Finally, organizing dozens of articles into limited categories that make sense is an art. The ideas in these articles comprise a network of interrelated concepts, systems, and forces that live together in an ecosystem, and cannot easily be separated. For example, the potential for cognitive bias cannot be separated from ethics, although one might write about them separately. Therefore, category themes are necessarily limiting but relevant for the current purpose.

This review reflects three themes, being 1) tactical decision making, 2) business strategy, and 3) industry identity and openness. Although topics from previous reviews continue to be relevant, what scholars have chosen to focus on more recently has changed. The authors' view is that less attention has been given to accreditation issues, and more attention has been given to decision making, transparency, and computer technology. Readers are encouraged to read the referenced primary sources for more thorough details, and to find connections that the authors of this review may have omitted.

3. Tactical decision making

3.1. Human factors, cognitive bias, and decision making

The 2009 NAS report states "research has been sparse on the important topic of cognitive bias in forensic science—both regarding their effects and methods for minimizing them" [1] p. 124). Interest on this topic has thus unsurprisingly grown over the last 10 years, with several dozens cognitive bias studies pertaining to forensic science published since 2010 [5]. Other signs of progress exist inspired by the NAS report, including further work by the NCFS, a new international symposium titled the "International Symposium on Forensic Science Error Management" sponsored by the National Institute of Standards and Technology (NIST), as well as the creation of several working groups and university research centers sponsored by the National Institute of Justice (NIJ), including ones on handwriting and firearms [6]; [7,8]. However, a recent 2017 survey of 403 expert forensic scientists found a general lack of concern and perceived need for best practice procedures to minimize cognitive bias in forensic testing and analysis [9]. This lack of concern comes from a lack of acceptance of bias susceptibility [5,9]).

Sources of bias have been identified that can affect decision making in forensic laboratories, including the cognitive architecture and of the brain, training and motivation, organizational factors, base rate expectations, irrelevant case information, reference materials, and case evidence [10–12]. These sources of bias can be broad at the level of human nature, more specific at the institutional level, and even more specific at the case level. Given the possibility that bias can lead to wrongful convictions or incorrect exonerations [13], it is surprising that only a limited number of external, disinterested scholars have conducted studies on the various forensic science subfields to make an attempt at measuring an error rate [14]. [15]; as psychologists and not forensic scientists, begin to address this concern with a study on cognitive bias and the effects of irrelevant case information, and find that when fingerprint matching becomes more difficult, study participants become more vulnerable to biasing information, which in this study is DNA test results. When time pressures are introduced, the effects were magnified.

[11] suggest these problems can grow exponentially through a bias snowball effect. If multiple tests are to be conducted for a case in a linear fashion, bias can be transferred from one test to the next if results are shared, as in Ref. [15]. This becomes an especially challenging situation if one person rather than multiple forensic analysts are conducting these tests. Having a case manager or some system of context management and sequential unmasking would be one way to mitigate the bias snowball effect and improve decision making [11,12,15,16]. Additionally, and as suggested by the [1] report, laboratory error rates should be measured where appropriate both internally and externally in order to "temper" the strength any laboratory result has in the courtroom [14]. Finally, a blind peer review process of laboratories and laboratory technicians could also help provide information on decision making quality [16].

As stated above, sources of bias can come from a micro-level, that is, case information, or from a macro level, such as institutional factors [10–12]. The workplace environment for example has been a well researched area outside of forensic science as an institutional factor in decision making, but limited attention has been given to forensic science specifically. Given the unique challenges and stresses forensic scientists face, more attention could reasonably be given towards research in this area [10,15]. Other institutional issues related to bias include whether contextual information affects decisions of experts versus novices differently [17], and the various influences on jurors' perceptions of forensic expert testimony regardless of the objective information given [18]. It has become clear through a variety of sources that police are not routinely submitting sexual assault kits (SAKs) for testing but rather place the kits in evidence storage, sometimes for decades [19]. Campbell and co-authors (2017) review the problem of untested rape kits by and explore the reasons why police do not submit them, including environmental factors [20]. This issue is faced elsewhere, like Kenya, where [72] note that the general lack of specialist forensic knowledge necessary to strengthen and enhance service provision leads to unsuccessful approaches to help victims and provide support (2019).

3.2. The opioid crisis

The misuse and addiction to opioids has become a serious national crisis affecting public health, society, the economy, and forensic service providers [71]. In 2017, The White House Council of Economic Advisers [73] estimated the annual cost of the opioid crisis was 600% higher than previously estimated, with an annual cost of $504 billion or 2.2% of annual GDP [21]. For those states designated as “crisis states” (those with the highest per capita overdose deaths), the cost approached 15% of Gross State Product. Costs include loss of human life from overdoses, healthcare costs, substance abuse treatments, workplace productivity, and costs to the criminal justice system. The cost for the criminal justice system was estimated at roughly $8 billion [21].

As bad as this single estimate is, it provides only a snapshot view of the crisis and its ongoing effects. Moreover, the estimates do not consider the indirect costs borne by forensic laboratories, the main source of analysis for the drugs [22]. provided a more detailed examination of the direct and opportunity costs as laboratory resources are diverted to the opioid crisis. Speaker concludes that the resources required to address the opioid crisis must be “aimed at a moving target, rather than a focus in the rearview mirror” and estimates the target, offering some policy implications and guidance.

3.3. *Technology and decision making*

Up until the 1980s, the majority of laboratory recordkeeping and data management occurred manually in filing cabinets filled with paper, making data archiving, retrieval, and eventually regulatory compliance difficult [23]. Although computer laboratory information management systems (LIMS) existed in the 1970s, they were expensive and not widespread until the U.S. Food and Drug Administration (FDA) increased regulations requiring improved standards regarding the storage, retrieval, and retention of reports and laboratory data of non-clinical laboratories [23–25].

As costs of LIMS and computers generally have decreased [25], data is now one of the central concerns of the modern forensic science laboratory [26], with around forty different vendors of LIMS selling software with various capabilities to laboratories across the world [25]. These systems are intended to help a forensic scientist make better decisions by being able to access information in a more timely, convenient, or holistic way compared to manual paper based approaches. They also allow users to access information in a manner that may have never been requested through customizable queries, allowing flexibility [25].

Although a primary benefit of LIMS in decades past has been data archival and retrieval as well as and sequential or multiple evidence processing management [25], a movement towards the “intelligent analytical laboratory” is within reach as LIMS automation technology advances [26]. Cloud computing, blockchain technology, and the internet of things (IoT) where computers talk to themselves and “smart” laboratory equipment are all collectively changing the way decision making occurs. In the future laboratory decision making will likely be a computer process more so than a human process. These advances potentially solve some of the cognitive bias issues discussed above. If evidence tracking can occur through a blockchain, laboratory equipment can talk with other devices through the IoT, and outcomes data are stored automatically in the cloud through generated reports and data archival, the future laboratory technician may be more of a computer programmer or robotics manager observing machines and computers making decisions, reducing manual interventions and by extension the opportunities for human errors or potentially backlogs. Economic benefits, both tangible and intangible, are also likely to occur through direct cost savings and better customer service [25].

The importance of humans in the laboratory however will not go away. The 2018 disaster at University Hospitals Cleveland Medical Center’s fertility clinic laboratory is a tragic example of what can go wrong when humans are not paying attention and are over reliant on technology [27]. Recently unsealed lawsuit documents from Cuyahoga County Common Pleas Court show a series of human errors leading up to the loss of thousands of human embryos. Specifically, a laboratory director stopped remote daily temperature monitoring of freezer temperatures, an alarm failed to notify staff of temperature fluctuations (which was eventually noticed but left uninvestigated or corrected), and patient specimens were kept in one freezer rather than several which was knowingly going against best practices [28]. Laboratory decision making was clearly done poorly if at all in this case. If forensic laboratory automation is the future, which would lead to the outsourcing of some human decision making to technology, best practices regarding the human monitoring of equipment and sensors will need to be developed in a way so similar tragedies do not occur. Overreliance on technology that leads to destroyed physical evidence for a criminal case could not only be as devastating as the University Hospitals disaster, but could likewise lead to costly litigation against forensic laboratories if malfeasance can be proven.

There are other challenges that advances in these technologies create. As cities become smarter, and the internet of things (IoT) gathers ever increasing amounts of data from a variety of sensors, LIMS efficiency and ability to handle the volume of multimedia evidence will be ever important so humans can make sense of the data in order to make decisions and not be overwhelmed. [29] for example describes a system to increase the efficiency of storage and retrieval of multimedia forensic science data. LIMS systems will also have to comply with government regulatory standards on data security, and laboratories will have to choose LIMS vendors who are pre-certified to meet these standards [25]. Data security is a dynamic environment with ever changing threats that government regulators are not necessarily as quick to detect, so regulations much like accreditation should be thought of as minimum standards of quality. As [25] states, “ultimate responsibility for validation remains with the user.”

4. Business strategy

4.1. *The economic problem*

A fundamental concept in economics is scarcity, that an infinite supply of resources, goods, or services does not exist to fulfill all human desires. The problem then is deciding how to utilize these limited resources for seemingly unlimited wants. Necessarily trade offs occur. In an environment of austerity and budget cuts, increasing the budget for project A in a forensic laboratory likely means a lower budget for project B. As [30,31] both suggest, it is not necessarily in the best interest of a laboratory to use the “best” or most expensive and esoteric tests, if a less expensive but effective option is available. This is true for many industries, with public health laboratories being a useful comparison with forensic laboratories in various operational factors once standardized metrics are used, as with Project FORESIGHT [32]. A balance between cost and quality is in the laboratory manager’s best interest, as cost savings in one area could increase resources for another area of a laboratory.

One internal efficiency approach for dealing with this suggested by Refs. [2,33] is to prioritize resource use based upon a measure of return on investment (ROI). Specifically, they look at the ROI to society in analyzing backlogged SAKs and their addition to a DNA database. Both find the benefits to be positive and significant. [33] adds that the ROI can be dynamic and changing due to economies of scale effects, and suggests further study on potential cross-jurisdictional alternatives. Similarly [34], measure an ROI to DNA and argue that expenditure on DNA ought to be cost effective relative to alternative forensic techniques and their measurable benefits. Methodology is a primary way to improve effectiveness. For example, one study found that body fluids (blood and saliva) were the most efficient biological sources for DNA profiling, followed by clothing, with touched items being the least efficient [35]. Furthermore, successful recovery rate of a single source or a major DNA profile increased when items were sampled twice but not more than that and four to five items were optimal to reduce the workload and increase the number of DNA profiles added to a database [35]. This kind of research, along with other reports, like [36] on lean processes, can be used by laboratories to streamline workflow, improve efficiency, and increase effectiveness.

Increasing effectiveness, the laboratory's external outcomes for stakeholders, can reap outsized societal benefits. For example [33], uses FORESIGHT metrics to show that PulseNet, a national network of public health and food regulatory agency laboratories, returns $66.26 in societal benefits for every $1.00 spent on the system, a ROI of 6526%. Likewise, a number of researchers are turning to the societal ROI of forensic services. Unlike traditional policing approaches, like incarceration and additional police officers, DNA databases show tremendous returns to scale. Given the low marginal cost of a DNA profile, only a small decrease in crime is needed to justify the cost of a DNA database. [37] estimates that the marginal cost of preventing a serious offense is about $7600 using longer sentences and $26,300–62,500 using police officers but only $600 for DNA databasing. Given the competition for government funds during budget cycles, showing that a forensic laboratory offers a low-cost, high-outcome response to serious crime is a persuasive argument for providing more societal benefit per dollar allocated to it. [38] use data from Detroit, which used government funds to process 15% of the city's sexual assault kit backlog to demonstrate that testing all sexual assault kits is very cost-effective: $1641 spent on testing averts sexual assaults costing $133,484 on average. The authors also find that prioritizing stranger kits, where the victim does not know the assailant, does not improve performance; thus, a blanket approach to testing kits is recommended. [39] demonstrated that in Denmark adding a profile to the country's DNA database reduced recidivism by as much as 43% while increases the chance that an offender will be identified. They estimated that a 1% increase in the probability of detection reduced crime by more than 2%. The study identified additional social benefits that supported the reduced recidivism.

As laboratory improvements are made, or tests with a higher ROI are increasingly utilized, current queuing elasticity of demand estimates suggest further resources are needed [2,22,33]. Presently, for every completed SAK an additional 1.29 SAKs are submitted [2] suggesting that a dynamic response to resource constraints and prioritization are needed. In other words, if demand for laboratory outputs grows faster than the resources used to satisfy this demand, backlogs will grow, *ceteris paribus*.

[40] also describes a way to deal with scarcity in regards to processing dead bodies at border crossings in the European Union (EU). Immigrant bodies arriving at an EU border strain resources, present property right concerns over who owns the bodies, and could create an environment of disease and contamination. Several suggestions were made, some of which have been implemented including the creation of a DNA database in Athens, Greece as well as another identification and victim registration program in Italy [40]. suggests that scaling these projects up could provide increased benefits compared to a localized approach, a recognition of the benefits of economies of scale. In the U.S., scaling forensic service provision to a national level does not increase relative cost but neither local nor federal forensic laboratories are operating at an efficient scale, leaving room for strategic resource reallocation [41]. The policy implications of rapid DNA in Australia, including it application, market and vendor issues, validation, legal questions, integration to databases, and accreditation requirements are discussed by Ref. [42] and the policy issues in the use of forensic services in property crime in the End to End forensic project are reviewed by Ref. [43].

4.2. Management

Undeniably, there are many parts to management that can be considered as much art as science [30]. Laboratory employees, whether in academia, government, or industry are also not often trained specifically in management, since their educational training would likely be in science [31]. Additionally, many scientists do not have a desire to manage their colleagues [31]. As management issues are and continue to grow in complexity regarding accreditation, quality systems, data management, personnel management etc., training in forensic laboratory management remains important. Although helpful training in management exists, more discipline-specific training that focuses on the unique challenges of a laboratory is needed. [44] for example outlines a graduate training program in laboratory management and quality assurance for a cytopathology laboratory, in which students are directly involved in the laboratory management process as part of their training. [45] offered structured guidelines for how agencies can develop early- and mid-career leadership and professional programs to enhance the cognitive, leadership and social skills of entry level and mid-career field forensic personnel, especially crime scene examiners.

There are many management topics that could be written about and discussed, many of which have been written on in previous reviews. For this article, two topics stood out to the authors, personnel management and a systems approach. Properly applied, these management concepts have the potential to decrease cost, increase efficiency, and increase stakeholder satisfaction [46].

As forensic laboratory workloads continue to increase [10,46] the importance of balancing institutional needs with the needs of personnel grows [30]. There are several personnel management factors to consider and form strategies around that have the ability to change a laboratory culture for the better. [31] for example describes several factors, such as the physical design of the lab, the diversity of the workforce in terms of education and work ethics, soft skills, performance plans and appraisals, training and promotions, hiring and firing practices, conflict resolution, and communication. [30] add to this list and include creating well defined job descriptions, recognizing personality trait differences such as being a team player, motivation and retention plans, a policy manual, and having the correct number of staff. [10] focus specifically on managing workplace stress to improve decision making, and suggest flexible work schedules, exercise and healthy nutrition programs, as well as training in the technique of mindfulness. Given the unique work environment that many laboratory analysts experience (such as dealing with death regularly) these techniques may be especially helpful and important for managers to gain knowledge on [10].

A manager's understanding of systems is also an important laboratory management concept for this review. In other words, "an analytical laboratory is not an island" but rather operates as a part of the criminal justice systems [31,47]). Within an analytical laboratory structure there is also the possibility to have a "system of systems," in that a jurisdiction can decide whether to have a centralized laboratory that performs all of the main functions of forensic science or to have a decentralized system. Centralized laboratories have the ability to create knowledge transfers across divisions, decrease costs by sharing resources, and concentrate brain power, but may result in longer queues. Decentralized systems may be able to prioritize divisional priorities but will duplicate resources across the system as a whole leading to potential wasted resources and loss of knowledge transfers [31,46].

Several subsystems work to support laboratory operations as well, and can overlap. Accreditation, six sigma, quality management programs, financial and budgetary plans, regulatory compliance, etc., all serve to improve operations in a systematic way [30,46–48]; and [31]. Today the vast majority of forensic laboratories maintain accreditation, around eighty-eight percent [2]. This requires an adoption of a system of continuous improvement, i.e. a quality management program [30,48]. Six Sigma is one example of a quality management strategy that contains a systematic feedback loop for improvement [46]. LIMS and other technologies have the potential to automate parts of these systems, increasing quality and reduce cost [23,25,26,49].

5. Industry identity and openness

5.1. Regulation, standards, and accreditation

The 2009 NAS report described the forensic science industry as “undefined” and “fragmented” and called for national standards to guide the industry [8,50]. This was recognition of the fact that forensic science has been traditionally unregulated [51]. The absence of regulation, and by extension standards, has been one of the weaknesses of American forensic science [52], which could reduce the effectiveness of a quality management system [47]. Undeniably, how a laboratory targets quality through a quality management system would be questionable in the absence of specified standards. Forensic science is however a very interdisciplinary field with a dynamic institutional environment, so how standards develop is not obvious [53].

Regulation would be one option of achieving standardization that has been suggested for decades [52,54]. The office of Forensic Science Regulators in the United Kingdom is a recent example of a government regulator which provides minimum standards of quality. [52] suggests however that standards in the absence of testing validation are pointless, yet there is little incentive for validation in American forensic science. [6] agrees and suggests that the goal of advancing forensic science in America has been to first combat violent crime rather than achieve scientific validity. One might ask then whether regulations could be “fit for purpose” in establishing confidence in forensic science in the absence of confirmed testing validity [50].

With the diversity of laboratories both nationally and globally, formal regulation could also be too prescriptive in some instances. With a historical lack of interest by governments in regulating forensic science [52], self-regulation through accreditation could be an alternative. The [1] report suggests all forensic science service providers ought to be accredited, a potentially more flexible substitute to regulation.

A third option in achieving standards could be legal regulation through the court system, although the [1] report suggests that the courts have been “utterly ineffective” in addressing the validity or accuracy of forensic evidence used in courtrooms [1], p. 53). Other issues to consider related to standards include the accreditation of universities that teach forensic science [55], employee certifications [55], or standards of forensic bioethics [2]. A discussion about certification across a range of professions was related to a survey showing that most responding forensic practitioners favored mandatory certification [56]. A survey [57] indicated that laboratories preferred applicants and hires with a solid foundation in the natural sciences and specialized coursework in specific disciplines. Exposure to and familiarity with advanced curriculum content, critical thinking, and “refined professional skills” were preferred in candidates. This suggests a potential need for curricular review and revision at the undergraduate and graduate levels in forensic science educational programs, especially in the U.S. One paper reviewed the background, scope, and purpose of the Forensic Science Accreditation Board, its role in accrediting conformity assessment bodies, and its plans for participating in the continuing improvement of the forensic science practices [58].

5.2. Transparency and globalization

The forensic science industry has failed to promote a scientific culture, in which results are reproducible and errors are recognized and reported [14]. This was expressed in the 2009 NAS report, which called on forensic science to provide more transparency in their court room conclusions [50]. As forensic science becomes more self-aware and better defined [59], a movement towards transparency ought to create an environment conducive to a scientific culture that ensures “methodological rigor” [53]. A culture of “trust me I’m an expert” (*Ipse dixit*) is no longer acceptable [53] without scientific methodological validity. Internal and external proficiency tests that are publicly available would be a step towards transparency and create confidence in the consumers of forensic science service providers [14]. This would not improve forensic science, but close the gap of ignorance in the accuracy of forensic science conclusions for specific testing regimens used in the courtroom [14]. [15] for example, in an experimental setting, measured the error in fingerprint matching when contextual information was introduced.

The new academic journal *Forensic Science International: Synergy* is another valuable contribution to transparency, where forensic scientists in an open access publication can communicate on a variety of big picture questions that define the practice and management of forensic science [60]. *Forensic Science International: Synergy* is the first Gold Open Access journal in forensic science, meaning that the articles are free to download and use in perpetuity [61]. A section of this journal covers policy and management issues, replacing the discontinued journal *Forensic Science Policy and Management: An International Journal* which published manuscripts on those topics.

The sharing of data standards that allow for the communication of information across LIMS systems is an additional example of transparency [25]. Specific examples in the pharmaceutical sector include the Allotrope Foundation and the Pistoia Alliance. These organizations work to share data and knowledge on technology, and to foster collaboration across competitive pharmaceutical companies to benefit patients and society [26].

A final interesting display of transparency is the use of field-deployable analytical tools [62]. Forensic science is opening up to more operators with the use of mobile forensic technologies or a “lab-on-a-chip,” reducing the mystery of how forensic results are determined. This will result in a greater use of forensic technologies not only in the field, but also in courtrooms as evidence. [62] argues that how laboratories react to this will determine whether forensic laboratories go the way of Kodak. Embracing technology, the digital transformation, knowledge spillovers, or forensic intelligence and crime prevention are all areas laboratories could capitalize on to maintain their relevance and value [62].

The 2009 NAS report was globally relevant even if it was written for the American situation [50]. Some disciplines, like document examination, used the report as an opportunity to assess practitioners, their readiness for certification, and ways to deal with weaknesses [63]. The trend towards globalization seen in most industries since World War II is also true for forensic science and is another example of openness. Although [64] describes many differences across countries in their provision of forensic science services, forces exist to move forensic science globally together. Accreditation [64], the International Organization for Standardization (ISO) standards [51], and INTERPOL guides [65] among other forces leads to a generalization of best practices and the creation of a common language used across international borders. Though country sovereignty will ultimately maintain global heterogeneity [66,67], there has been much work towards an international forensic science standard, the most significant being ISO standards [51]. These common standards, whether ISO or alternatives, can be especially important when natural or human disasters occur, requiring cooperation between two or more countries [40,65,68,69].

6. Conclusion

Ten years have now passed since the NAS gave the forensic science industry a "path forward." If a culture of continuous improvement is embraced, as suggested in the opening quote to this paper, the industry ought to remain on the "path forward" for the foreseeable future. Where it winds up, and what regulatory environment it will operate in the future will largely be determined by the progress made in creating a scientific culture and defining standards of operation. Federal oversight and control can be unpredictable, yet any advance by government in controlling forensic science will largely be determined by the extent the industry embraces and works towards the goals outlined in the [1] report. As suggested by McAndrew and Houck (2016), failure to do so will result in decisions made for the industry rather than by the industry, and the path forward could pass by. By focusing on continuous improvement, or an acceptance of an attitude that things can always be done better, federal oversight growth may be stalled which is arguably better for forensic scientists who wish to determine their own destiny and identity.

Disclaimer

This is a republication in journal form of a conference proceeding that was produced for the 19th Interpol Forensic Science Managers Symposium in 2019 and was originally published online at the Interpol website: https://www.interpol.int/content/download/14458/file/Interpol%20Review%20Papers%202019.pdf. The publication process was coordinated for the Symposium by the Interpol Organizing Committee and the proceeding was not individually commissioned or externally reviewed by the journal. The article provides a summation of published literature from the previous 3 years (2016–2019) in the field of forensic science management and does not contain any original, experimental data. Any opinions expressed are those solely of the authors and do not necessarily represent those of their agencies, institutions, governments, Interpol, or the journal.

Declaration of Competing Interests

Max Houck is the Editor-in-Chief of *Forensic Science International: Synergy*. There are no other competing interests to declare.

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