

Solving the Unsolvable: A Statistical Analysis of the Impact of Forensic Science on Criminal Investigations

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ABSTRACT: This study investigates the application and perceived effectiveness of forensic science within professional practice, drawing on survey data from 36 respondents. Analysis of frequency distributions revealed that a majority of participants consistently incorporate forensic methods into their work, with 50.0% (n = 18) reporting “Always” and 33.3% (n = 12) reporting “Often.” In contrast, less frequent use (“Sometimes,” “Rarely,” and “Never”) accounted for only 16.7% of responses, suggesting that limited engagement with forensic tools is uncommon. Case-level analysis further emphasized the significance of forensic science, as 33.3% (n = 12) of cases demonstrated a 50–80% reliance on forensic methods, while 16.7% (n = 6) reflected reliance exceeding 80%. These findings indicate that forensic science frequently functions as a pivotal factor in case resolution. Evaluations of specific forensic techniques reinforced this conclusion. DNA profiling was rated Very Effective or Effective by 77.7% of respondents, yielding a mean ordinal score of 3.19 on a four-point scale, while digital forensics was regarded as Very Effective or Effective by 88.9% of respondents. These results reflect strong professional confidence in both domains, though minor limitations—such as resource constraints, training gaps, and technological challenges—were noted as potential barriers to optimal practice. Overall, the findings underscore the extensive utilization and widespread trust in forensic science among practitioners. The evidence demonstrates its critical role not only as a supplementary tool but as an essential determinant in the investigative and judicial process.

KEYWORDS: Forensic Science, Evidence Analysis, Ballistics, Crime Scene Investigation, Law Enforcement, Investigative Techniques, Forensic Technology, Criminal Justice, DNA Profiling, Digital Forensics, Criminal Investigations, Wrongful Convictions, Evidentiary Reliability

Introduction

Forensic science has emerged as an indispensable component of contemporary criminal investigations, fundamentally reshaping the methodologies employed by law enforcement agencies in the resolution of complex criminal cases. Traditionally, forensic techniques were regarded as ancillary tools, utilized primarily in high-profile or exceptional cases. In the current investigative landscape, however, these techniques have become central to the investigative process, enabling the systematic collection and analysis of evidence, the reconstruction of criminal events, and the establishment of verifiable linkages between suspects, victims, and criminal activity.

The acceleration of technological advancements in forensic science has been instrumental in this paradigm shift. DNA profiling facilitates the precise identification of individuals from trace biological material, while fingerprint analysis continues to provide a reliable mechanism for associating suspects with specific crime scenes. Digital forensics allows for the recovery, preservation, and analysis of data from electronic devices, thereby illuminating criminal networks and activities that might otherwise remain undetected.

Similarly, ballistic examination, toxicology, and trace evidence analysis equip investigators with robust methodologies for the scrutiny of physical evidence with high degrees of accuracy and reliability. Collectively, these innovations have significantly enhanced the capacity of law enforcement to resolve cases previously deemed unsolvable, including long-standing cold cases and complex, high-stakes investigations.

Beyond its practical application in evidence collection and case resolution, forensic science exerts a critical influence on the judicial process. The provision of objective, scientifically validated evidence ensures that investigations are conducted in a thorough, methodical, and legally defensible manner, thereby reinforcing the integrity of legal proceedings and fostering public confidence in the criminal justice system. This study critically examines the impact of forensic science on criminal investigations, with particular emphasis on its contributions to case resolution, the refinement of investigative methodologies, and the overarching pursuit of justice. By elucidating these contributions, this research underscores the potential of forensic science to enhance investigative efficacy, mitigate errors, and uphold the principles of accountability and fairness within the criminal justice framework.

Literature Review

DNA Profiling as a Corrective Mechanism in Justice

DNA profiling stands as one of the most transformative innovations in the field of forensic science. Since its emergence in the 1980s, this technique has profoundly influenced criminal investigations by aiding in the resolution of cold cases as well as ongoing inquiries. Its impact extends beyond the successful prosecution of offenders; DNA analysis has also served as a corrective mechanism within the justice system by exonerating wrongfully convicted individuals. The Innocence Project (2020), for instance, reports that more than 375 exonerations in the United States have been achieved through post-conviction DNA testing, highlighting the ethical and legal significance of this technology. The establishment of the Combined DNA Index System (CODIS) further expanded the practical applications of DNA profiling by providing investigators with a centralized database for the rapid comparison of biological samples collected at crime scenes. This system has enabled law enforcement agencies to identify suspects, link crimes across jurisdictions, and expedite case resolutions with unprecedented accuracy and efficiency (Butler, 2019). Taken together, these developments underscore DNA profiling's dual role as both a critical evidentiary tool and a safeguard of judicial integrity, cementing its place as a cornerstone of modern forensic science.

Implications for Legal and Investigative Contexts

Nayerifard et al. (2023) conducted a systematic literature review analyzing studies published between 2010 and 2021 that investigated the application of machine learning (ML) techniques in digital forensics. The review identified image forensics as one of the most mature and extensively developed areas for ML integration, with convolutional neural networks (CNNs) emerging as a predominant methodology due to their robust capabilities in pattern detection and classification. Despite these technological advancements, several critical challenges persist within the field. Notably, issues of explainability remain a significant concern, as many ML models operate as "black boxes," limiting the transparency of decision-making processes and complicating their acceptance in legal proceedings. The authors also emphasized the need for rigorous validation of forensic tools to ensure their reliability and reproducibility, particularly under adversarial conditions where actors may deliberately attempt to manipulate or obfuscate digital evidence. Furthermore, the application of ML-based techniques to encrypted or obfuscated datasets

remains a persistent limitation, reducing the practical utility of these methods in real-world investigative scenarios. Collectively, these findings highlight the considerable potential of machine learning to advance digital forensic practices while underscoring the imperative to address challenges related to interpretability, validation, and operational resilience to enhance both the efficacy and legal admissibility of ML-driven forensic analyses.

Digital Forensics: Responding to Technological Crime

Advancements in forensic chemistry and toxicology have significantly shaped the evolution of forensic science. Toxicology—the study of poisons and chemical substances—enables investigators to determine causes of death in suspicious circumstances. For instance, forensic toxicologists can identify and quantify toxic agents within a victim's body in cases of suspected poisoning. Likewise, forensic chemists support criminal investigations by analyzing materials such as fibers, explosives, and narcotics recovered from crime scenes, helping to establish connections between victims, suspects, and criminal activities (Nelson et al. 2018). These specialized fields have proven essential in resolving cases where traditional investigative methods alone are insufficient.

At the same time, digital forensics has become an indispensable aspect of contemporary forensic science in response to rapid technological developments. This discipline involves the recovery and analysis of data from electronic devices, including computers, smartphones, and cloud storage systems. As cybercrime continues to rise, digital forensics has grown increasingly critical, enabling specialists to recover deleted files, track online activity, and uncover evidence of criminal intent that might otherwise go undetected. High-profile investigations frequently rely on the examination of emails, phone records, and digital footprints to provide key evidence in solving criminal cases (Casey, 2011).

Operational Challenges in Forensic Investigations

Inman and Rudin (2001) stress that forensic science's effectiveness in volume crimes, such as burglary and vehicle offenses, depends less on adopting new technology and more on addressing recurring operational and strategic challenges. Critical factors include effective communication between investigators and forensic experts, proper resource allocation, adequate police training, and timely evidence processing. Evidence characteristics, such as mobility and multiple types (e.g., DNA and fingerprints), significantly affect usefulness, while insufficient training and operational inefficiencies often hinder investigations. Saferstein, (2015) further emphasizes that forensic professionals must combine scientific expertise with sound investigative practices to ensure evidence is collected, preserved, and analyzed effectively. Similarly, Wüllenweber and Giles (2021) argue that focusing on the proactive, strategic, and timely application of forensic science, rather than technology alone, is essential for improving case resolution and detection rates.

Empirical Questions

The study was guided by the following research questions:

1. What potential roles might emerging forensic technologies, including the application of artificial intelligence in crime scene analysis, play in shaping future investigative practices?
2. How has forensic science contributed to the conviction of offenders and improved the accuracy and reliability of criminal investigations?
3. What are the current limitations of forensic science, and how do these challenges impact the overall functioning of the criminal justice system?
4. Which forensic methodologies, including DNA profiling and digital forensics, have demonstrated the greatest effectiveness in resolving previously unsolved cases?

5. In what ways have forensic databases and systems, such as CODIS, enhanced the speed and precision of investigative processes?

These questions highlight essential aspects of forensic science and its application in criminal investigations that warrant further empirical study to clarify their impact on investigative accuracy, case resolution, the efficiency of criminal justice processes, and the development of evidence-based forensic policies.

Data Analysis

Participants/Demographic

The participants in the study comprised 36 professionals from various criminal justice roles, providing a representative perspective on the application of forensic science across the system. The sample comprised forensic scientists (33%), law enforcement officers and detectives (39%), and legal professionals, including prosecutors and defense attorneys (28%). Participants' professional experience varied considerably. Forensic scientists reported between two and twenty-five years of experience and were surveyed regarding their involvement in criminal investigations and their use of techniques such as DNA analysis, fingerprinting, digital forensics, and toxicology, with approximately 60% employed in laboratory settings analyzing evidence and supporting investigative processes.

Law enforcement officers, including police officers and detectives with five to thirty years of experience, contributed insights on how forensic science assists investigations, the challenges associated with forensic tools, and the role of forensic evidence in securing convictions. Legal professionals, including defense attorneys and prosecutors with three to twenty-five years of experience, provided perspectives on the influence of forensic evidence in legal proceedings, its contribution to exoneration efforts, and its role in preventing wrongful convictions. Participants were recruited from a diverse range of jurisdictions, including local, state, and federal law enforcement agencies, forensic laboratories, and legal offices. This geographic diversity enabled a comprehensive understanding of forensic science application across different levels of the criminal justice system, though access to advanced forensic technologies may have been greater in metropolitan areas compared to rural or underfunded regions, potentially influencing participants' responses.

Methodology

This study aimed to investigate the impact of forensic science on crime-solving using a mixed-methods research design. The primary objective was to evaluate the contribution of forensic science to crime resolution, its influence on the criminal justice system, and the challenges encountered by forensic professionals. By integrating quantitative and qualitative data, the study sought to assess the effectiveness of forensic tools and techniques in enhancing investigative outcomes, supporting legal processes, and informing law enforcement practices. A cross-sectional survey design was utilized to gather data from professionals representing various sectors of the criminal justice system, including forensic scientists, law enforcement officers, and legal practitioners. Structured surveys were administered to capture participants' perceptions, experiences, and insights regarding the application and impact of forensic science in criminal investigations. This approach facilitated a comprehensive understanding of the role, effectiveness, and practical implications of forensic science in contemporary crime-solving contexts.

Data Collection/Procedures

This study employed a systematic, multi-phase approach to investigate the impact of forensic science on criminal investigations. The research commenced with a comprehensive

literature review aimed at identifying the most significant advancements in forensic science and their practical applications in criminal case resolution. This review established the theoretical framework and contextual basis for subsequent research activities. Following the literature review, a structured survey was designed to elicit the perspectives of forensic scientists, law enforcement officers, and legal professionals regarding the efficacy and practical utilization of forensic techniques. The survey addressed participants' experiences with methodologies such as DNA analysis, fingerprinting, digital forensics, and toxicology, as well as their perceived influence on investigative outcomes and case resolution. In parallel, secondary data analysis was conducted using forensic databases, legal records, and relevant case studies to examine historical trends in crime resolution and the role of forensic science in facilitating successful investigations. This approach allowed for the triangulation of empirical evidence with professional insights, providing a comprehensive evaluation of forensic science impact.

Given that the data for this study are primarily derived from survey responses with ordinal and categorical scales, several descriptive statistical measures are appropriate. Frequency distributions and percentages have been effectively utilized to illustrate how often participants employ forensic methods and their corresponding ratings of effectiveness. Measures of central tendency, including the mean or median, are suitable for summarizing ordinal data such as Likert-scale ratings, while the mode can identify the most frequently selected responses. Additionally, measures of variability, such as the standard deviation or interquartile range, provide insight into the dispersion of responses and the degree of consensus among participants regarding the effectiveness of forensic techniques.

Results

The dataset comprises a total of 36 observations. Analysis of the frequency distribution reveals that half of the applications (50.0%, $n = 18$) fall within the "Always" category, followed by "Often" at 33.3% ($n = 12$). The remaining categories—"Sometimes," "Rarely," and "Never"—constitute considerably smaller proportions, accounting for 13.9% ($n = 5$), 2.8% ($n = 1$), and 0.0% ($n = 0$), respectively. Given the categorical nature of the data, the mode serves as the most appropriate measure of central tendency, with "Always" emerging as the most frequently observed application rate. Overall, the distribution is markedly skewed toward higher-frequency categories, as "Always" and "Often" collectively represent 83.3% of all responses. In contrast, the lower-frequency categories account for only 16.7% of the dataset, underscoring the relative infrequency of less commonly reported application rates.

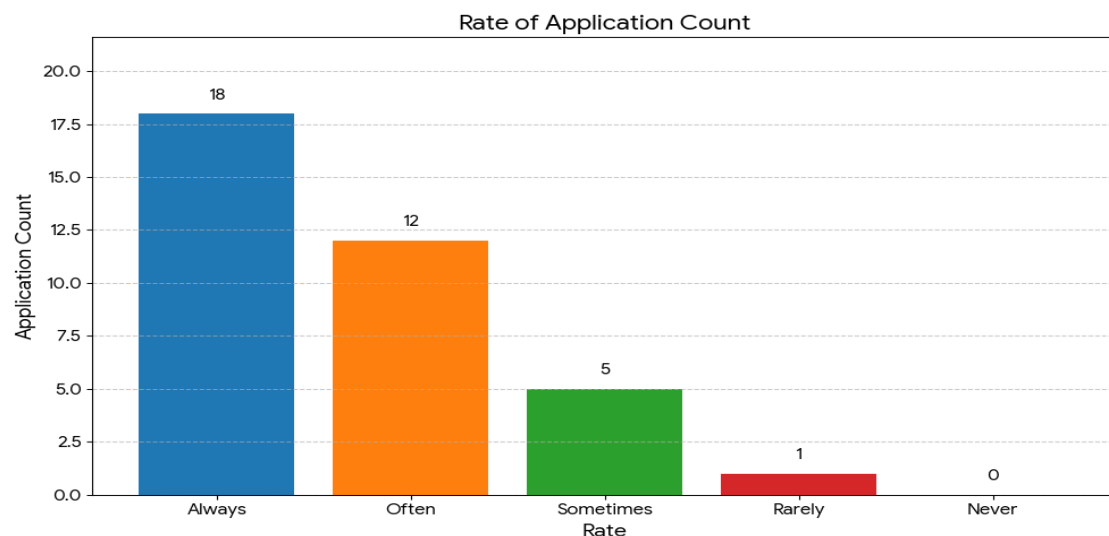


Figure 1. Frequency of Forensic Science Use (N=36)

The data indicate that the majority of respondents report frequent utilization of forensic science, with 25 out of 36 responses classified as “Always” or “Often.” A smaller, yet noteworthy, subset of respondents ($n = 9$) employ forensic methods occasionally, corresponding to the “Sometimes” category. Very few respondents fall into the “Rarely” ($n = 2$) or “Never” ($n = 0$) categories, suggesting that nearly all individuals surveyed incorporate forensic science to some degree in their practice. These findings underscore the pervasive and integral role of forensic science in the respondents’ professional activities.

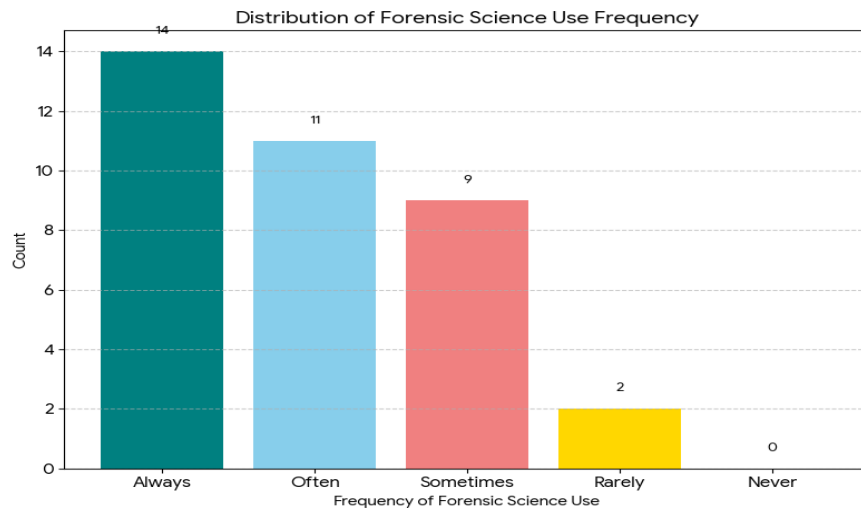


Figure 2. Frequency of Forensic Science Use (N=36)

A total of 36 cases were examined to assess the extent to which forensic science contributed to their resolution. The frequency distribution reveals that a minimal proportion of cases (5.6%, $n = 2$) were solved with less than 5% reliance on forensic methods, indicating limited utilization in these instances. Cases exhibiting 5–25% forensic involvement comprised 19.4% of the sample ($n = 7$), whereas 25–49% contribution was observed in 25.0% of cases ($n = 9$), reflecting a moderate dependence on forensic evidence. The largest subset, representing 33.3% of cases ($n = 12$), fell within the 50–80% range, highlighting substantial reliance on forensic methodologies. Finally, 16.7% of cases ($n = 6$) were resolved with more than 80% contribution from forensic science, underscoring its potentially decisive influence in certain investigations. Collectively, these findings indicate that forensic science functions not merely as a supplementary tool but as a critical determinant in the resolution of criminal cases.

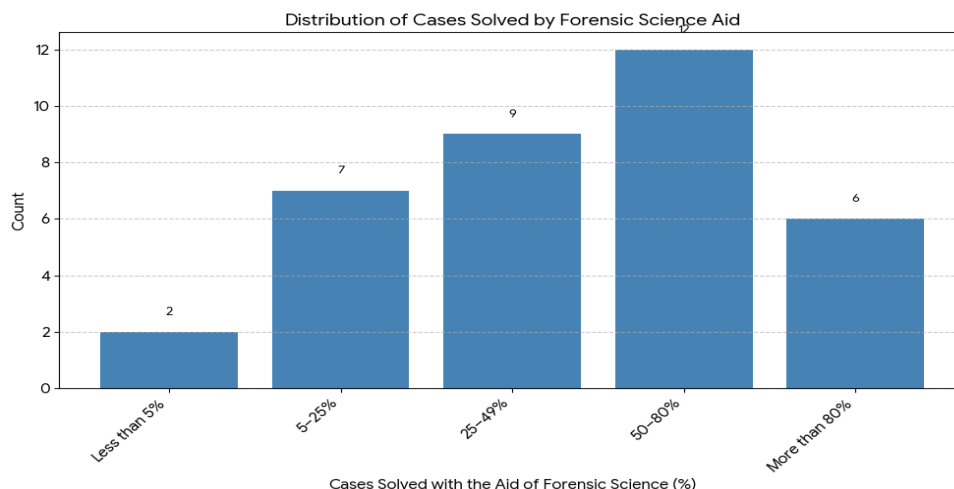


Figure 3. Cases Solved with the Aid of Forensic Science (%) (N=36)

The empirical evidence derived from the survey responses provides compelling support for the efficacy of DNA profiling in forensic science. Of the 36 respondents, 16 (44.4%) evaluated DNA profiling as *Very Effective*, 12 (33.3%) as *Effective*, 7 (19.4%) as *Somewhat Effective*, and only 1 (2.8%) as *Rarely Effective*. These proportions indicate that more than three-quarters (77.7%) of participants regard DNA profiling as either *Very Effective* or *Effective*, thereby affirming its perceived centrality in forensic practice. When operationalized on a four-point ordinal scale (*Very Effective* = 4, *Effective* = 3, *Somewhat Effective* = 2, *Rarely Effective* = 1), the mean score of 3.19 further substantiates the conclusion that perceptions of DNA profiling are concentrated at the higher end of the effectiveness spectrum. Taken together, these findings underscore DNA profiling's status as a scientifically validated and broadly trusted investigative tool, with negligible levels of skepticism expressed by respondents concerning its reliability or forensic utility.

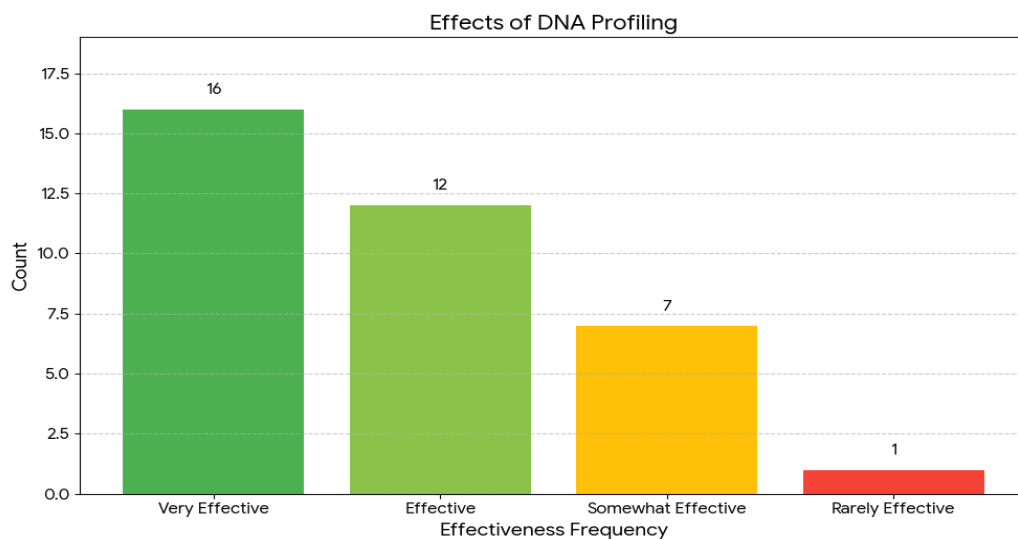


Figure 4. Effects of DNA Profiling (N=36)

A survey was conducted to assess perceptions of the effectiveness of digital forensics in modern investigations. Respondents evaluated it across four categories: *Very Effective*, *Effective*, *Somewhat Effective*, and *Rarely Effective*. Results showed that 50% rated digital forensics as *Very Effective*, 38.9% as *Effective*, and 11.1% as *Somewhat Effective*, with no responses in the *Rarely Effective* category. Out of 36 participants, nearly 89% expressed confidence in digital forensics, confirming its value as a critical tool in contemporary investigations. The small percentage who rated it as only *Somewhat Effective* may reflect challenges such as limited resources, training gaps, or the complexities of new technologies like encryption and cloud storage. Overall, the findings suggest that digital forensics is widely regarded as highly effective in supporting criminal investigations and judicial proceedings, while continued investment in resources and training could further enhance its impact.

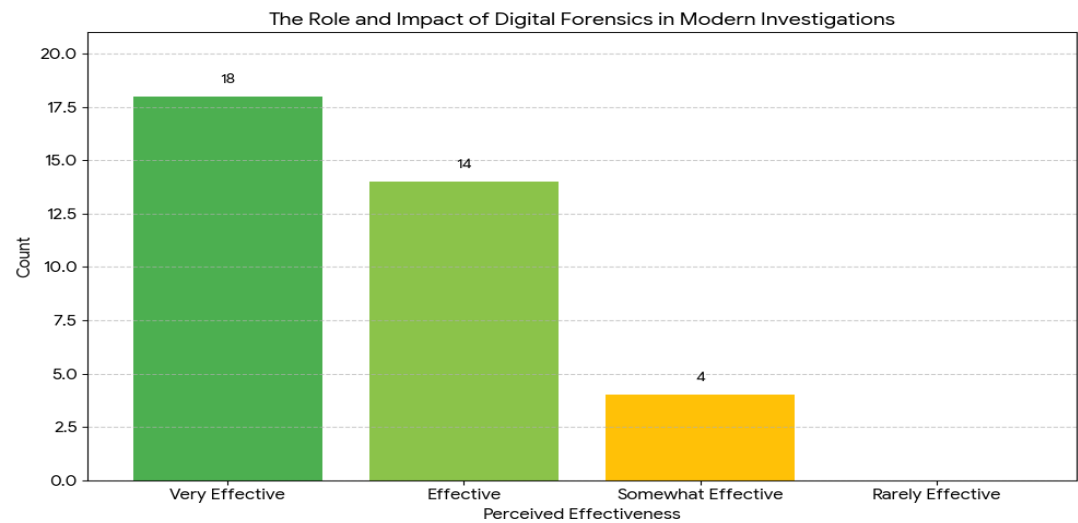


Figure 5. The Role and Impact of Digital Forensics in Modern Investigations (N=36)

Limitations

A primary limitation of this study is the relatively small sample size of 36 participants, which may restrict the generalizability of the findings to the wider population of criminal justice professionals. The distribution of responses was heavily skewed toward higher-frequency categories (“Always” and “Often”), limiting variability and potentially reducing the ability to detect differences in perceptions or utilization of forensic methods across subgroups. Moreover, the study relied on self-reported survey data, which may be influenced by response biases, including social desirability or overestimation of forensic tool usage. The analysis also encompassed a limited number of cases, potentially excluding complex or atypical investigations where forensic methods are applied less frequently. Finally, although perceptions of DNA profiling and digital forensics were assessed, the study did not include objective measures of case outcomes or error rates, which would provide a more robust evaluation of forensic efficacy. These limitations indicate that the findings should be interpreted cautiously and highlight the need for future research incorporating larger, more diverse samples and complementary empirical data to strengthen the generalizability and validity of conclusions.

Implications of Findings

The findings of this study underscore the integral role of forensic science in criminal investigations. With 83.3% of respondents reporting frequent use of forensic methods, the data indicate that these tools are essential to investigative workflows and case outcomes. Case-level analysis further highlights the reliance on forensic methodologies, with half of the cases showing 50–80% or greater contribution, demonstrating their critical influence in resolving complex investigations. Specific techniques, including DNA profiling and digital forensics, were widely regarded as highly effective, reflecting strong professional confidence, though minor limitations related to resources, training, and technology were noted. Collectively, these results emphasize the need for continued investment in forensic infrastructure, training, and integration across investigative and judicial processes, reinforcing the centrality of validated forensic methods in ensuring accurate, reliable, and equitable criminal justice outcomes.

Discussion and Conclusion

The analysis of survey data highlights the pervasive and consistent role of forensic science in contemporary investigative practice. Across multiple measures—including frequency of use, contribution to case resolution, and perceived effectiveness of specific methodologies such as DNA profiling and digital forensics—the findings indicate that forensic science is both widely utilized and highly valued within the criminal justice system.

The frequency distribution of forensic science utilization demonstrates that the vast majority of respondents regularly apply forensic methods, with 83.3% reporting “Always” or “Often.” The comparatively small proportion of responses in the “Sometimes” and “Rarely” categories (16.7% combined) suggests that forensic applications have become institutionalized within professional routines. This pattern reflects broader shifts in law enforcement practices, where forensic methodologies increasingly serve as central tools for both investigative leads and evidentiary support in judicial proceedings.

Examination of forensic science’s contribution to case resolution further underscores its critical role. While a small subset of cases (5.6%) relied minimally on forensic input, the majority demonstrated moderate to substantial dependence, with 33.3% of cases exhibiting 50–80% reliance and 16.7% exceeding 80%. These results indicate that forensic evidence is often decisive rather than merely supportive, with varying levels of involvement corresponding to the complexity and demands of specific investigations.

Specific forensic techniques were also highly endorsed. DNA profiling was rated “Very Effective” or “Effective” by over three-quarters of respondents (77.7%), with a mean score of 3.19 on a four-point scale, reflecting strong consensus regarding its reliability and centrality in investigative contexts. Similarly, digital forensics was regarded as highly effective by nearly 89% of participants, emphasizing its critical role in addressing technologically facilitated crimes such as cybercrime, financial fraud, and digital communications in traditional criminal activities. Minor limitations reported—such as resource constraints, training gaps, and technological challenges—point to areas where further investment could enhance the effectiveness of digital forensic practices.

Taken together, these findings provide compelling evidence that forensic science is an indispensable component of modern criminal investigations. Its frequent use, decisive contribution to case resolution, and widespread professional endorsement underscore its scientific credibility and practical efficacy. At the same time, the study highlights the necessity of sustained investment in training, infrastructure, and emerging technologies to address areas where forensic methods are less impactful. Strengthening these domains will expand the reach and reliability of forensic methodologies, reinforcing their role as critical determinants of justice in the digital era.

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