Does Forensic DNA Help to Solve Crime? The Benefit of Sophisticated Answers to Naive Questions

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Abstract
Forensic science has played an increasingly important role in the investigation of crimes. We argue in this paper that, in addition to bench science, field experimentation involving forensic methods is critical to properly assess the relative utility of various methods of solving crimes. We illustrate this point by summarizing the findings from a recent Campbell Collaboration systematic review of field studies of the effectiveness of DNA testing. Our search identified five studies, including one randomized-controlled-trial of the value of DNA testing in burglary cases. The findings generally support the value of DNA testing for police investigations, particularly for high volume crimes such as burglary, although most of the empirical evidence is methodologically weak. Additional work is clearly needed, not only with respect to DNA testing but other forensic methods as well.

Keywords
evaluation, DNA, forensic, investigation, systematic review

Forensic science has played an increasingly important role in police investigations of crimes. A recent report on the state of forensic science by the National Research Council (NRC) stressed the need for more research into many aspects of forensic science, while criticizing the strength of scientific evidence supporting the practices and interpretations of most forensic methods, with the exception of DNA testing. The

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NRC committee concluded that DNA was the only “forensic method [that] has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual source” (Committee on Identifying the Needs of the Forensic Sciences Community, 2009, p. 7). The report focused heavily on the scientific validity of the methods, as well as the organizational and structural issues related to the practice of forensic science. Included among the report’s many recommendations for improving forensics was increasing the research on the accuracy, reliability, and validity of forensic methods, and the sources of human-observer bias. To address the organizational issues, the NRC recommended removing control of the labs from law enforcement agencies and prosecutors’ offices and creating a National Institute of Forensic Science.

Missing from the report was a focus on the relative utility of using new forensic methods over traditional investigative methods. We argue in this paper that an important complement to the bench science called for in the NRC report is experimentation in field settings to assess the relative utility or effectiveness of the various methods of solving crime as part of routine police practice. We will illustrate the value of this form of research by summarizing the findings from a recent Campbell Collaboration systematic review conducted by the authors on the utility of DNA testing as part of police investigations.

Discovering the Obvious

The value of DNA evidence in a criminal investigation may seem as obvious as the value of a parachute when jumping out of an airplane. Smith and Pell (2003) published a satirical systematic review of the effectiveness of parachutes for preventing major trauma related to gravitational challenge. The authors were criticizing the belief of many in the medical research community that only the “gold-standard” randomized controlled-trial can be relied upon for drawing strong causal inferences about the effectiveness of a particular intervention or practice. The authors’ tongue-in-cheek conclusion was that because they could find no such methodologically rigorous studies on the effectiveness of parachutes, we cannot rely on the observational assessment that they work. They further suggested that those who most ardently support randomized controlled trials over other forms of research commit themselves to participation in such future studies by jumping out of planes themselves (with blinding and random assignment to a parachute and a nonparachute condition, of course).

Just as parachutes have demonstrated a long history of improving the outcome of falling from great heights, DNA has clearly established itself as critical in helping to solve individual criminal cases, particularly murder and rape cases. A search for recent newspaper stories of criminal cases involving DNA testing turns up numerous relevant stories in which it seems unlikely that the case would have been solved without the use of DNA. For example, a September 23, 2006, article in the Washington Post (Jackman, 2006) reported on a 40-year old cold case that was solved with DNA. When a cold-case detective submitted preserved DNA evidence the Virginia state DNA database discovered a new suspect. When presented with the DNA evidence and additional
evidence gathered after DNA had identified him as suspect, Leslie E. Carver confessed to the murder. Having remained unsolved for 40 years (with few investigative leads, according to the newspaper article), it seems obvious that under the counterfactual condition of no DNA testing the case would not have been solved. Ultimately, we cannot know whether the investigators would have identified Mr. Carver in some other manner, but a strong logical case can be made for the utility of DNA in this and many other similar cases.

This raises the question of what is to be learned from experimental field studies that compare the effectiveness of a given forensic method against an existing investigative practice. The science of DNA testing has established that forensic DNA is able to provide a high degree of certainty when connecting a sample of DNA with a specific individual (Committee on Identifying the Needs of the Forensic Sciences Community, 2007). However, this does not answer the broader question of whether the routine use of DNA testing produces more arrests and convictions than other investigative practices. Engaging in one set of investigative practices often limits other investigative options. For example, a latent fingerprint could be used for fingerprint analysis or DNA analysis, but often not both. Which method is most likely to lead to a suspect? Given limited resources and substantial backlog in crime labs, not all forensic options will be pursued in every investigation. Thus, field experimentation, ideally in the form of a true experiment that randomizes cases to two or more different investigative conditions (see Shadish, Cook, & Campbell, 2001), can address a range of practical questions, including the real-world utility of DNA testing relative to other forensic methods, such as fingerprint analysis, or the value of providing investigative teams with immediate DNA results. Studies examining issues related to the outcomes of forensic technology use in real-world contexts. As such, the results of these studies can help inform police investigative practices.

Below we summarize the findings from a systematic review of applied field studies examining the usefulness of DNA testing in solving a range of criminal cases. The completed review is currently under peer review and as such has not yet been accepted as a final Campbell Collaboration review (www.campbellcollaboration.org).

Summary of Systematic Review Methods

This review used the systematic review methods of the Campbell Collaboration and was based on a peer-reviewed protocol (a detailed a priori methodology for the review). A systematic review is intended to summarize all the applicable research on a topic and uses transparent and replicable methods to extract and synthesize findings across studies. Campbell reviews also carefully evaluate the methodological rigor of the included studies. The methods used in our review are briefly summarized below.

Eligibility Criteria

The focus of this review was experimental (randomized) and quasi-experimental studies of DNA testing by police as part of their investigations of crime. We did not consider
the use of DNA testing by criminal defendants or by prosecutors. Of particular interest was the routine or expanded application of DNA testing in cases that often do not make use of available DNA methods. Eligible studies must have compared routine or expanded DNA testing to some alternative, that is, there must have been some variation in the use of DNA testing that was a focus of the study.

We were inclusive with respect to research designs. The ideal design type would randomly assign cases to either a DNA testing condition or a traditional investigative practice condition, and then assess the case outcomes by condition. We also considered quasi-experimental designs in which a control group was either matched to a DNA testing group or was identified as comparable. Finally, we also included interrupted time-series designs that estimate the impact of DNA testing on a relevant outcome over time.

We included studies irrespective of the crime type examined. We were particularly interested in whether there was evidence of differential effectiveness of DNA testing for different types of crimes.

Eligible studies for this review may have examined one or more outcomes at several stages of the investigative process. As such, eligible outcomes included the rate at which suspects were identified, or arrested; the conviction rate; length and speed of an investigation; the cost of the investigation; and the case clearance rate.

Search Strategy

The search strategy was designed to identify all studies, published or unpublished, that met the above eligibility criteria. Preliminary electronic database searches were conducted with the terms “DNA” and “Police” or “Policing” or “Investigation.” Additional terms were developed from the results of these preliminary searches. In addition to searching numerous electronic databases, we also searched the UK Home Office Website for relevant publications. Google Scholar was used to identify publications not already captured through the formal databases. Key individuals working in the field of forensics were solicited for assistance in identifying relevant studies. We also made efforts to identify studies in languages other than English. The specific keywords used and databases search can be found in the published protocol for this review (Wilson, Weisburd, & McClure, 2009). This search strategy identified over 10,000 potential documents. Documents that appeared relevant based on the title and abstract (if available) were retrieved for closer inspection. Careful review of these studies identified five empirical evaluations that met our explicit eligibility criteria.

Coding and Data Extraction

A critical aspect of a systematic review is the coding and data extraction. The goal of a good systematic review is to implement a transparent and reliability method of coding the essential features of the studies and extracting the relevant statistical results (Lipsey & Wilson, 2001; Wilson, 2010), preferably in a form that allows for meaningful
comparison across studies. The latter is typically achieved through the use of an effect size index, such as a standardized mean difference, odds-ratio, or correlation.

This systematic review used coding forms that captured information on the research design, including: (1) the nature of assignment to conditions; (2) the use of matching of cases or the use of statistical controls, such as regression analysis, to adjust for potential selection bias in the case of nonrandom assignment to conditions; (3) the representativeness of the sample of cases (e.g., census, random sample, convenience sample); (4) attrition of cases from the study; and, (5) replication of findings in multiple jurisdictions. Items in the coding protocol also captured the essential features of the independent variable, that is, the aspect of the design that reflected variation in the use of DNA in an investigation. Although we did not anticipate the possibility of synthesizing effects across studies using meta-analytic methods (e.g., Cooper, Hedges, & Valentine, 2009; Lipsey & Wilson, 2001), where possible we computed odds-ratios representing the magnitude of the DNA testing effect on relevant outcomes. For more detail, see Wilson, Weisburd, and McClure (2009).

**Summary of DNA Systematic Review Findings**

We identified five relevant studies that met our eligibility criteria (Briody, 2004; Dunsmuir, Tran, & Weatherburn, 2008; Roman et al., 2008; Schroeder, 2007; Tully, 1998). These studies focused on different aspects of the use of DNA in police investigative work. The first, and most methodologically rigorous, of these was the Roman et al. (2008) randomized controlled trial of DNA testing in burglary cases. Three other quasi-experimental comparison group studies (Briody, 2004; Schroeder, 2007; Tully, 1998) examined the value of DNA testing for various crime types, and a quasi-experimental time-series analysis (Dunsmuir et al., 2008) examined the value of an expanding DNA database for improving clearance rates. These studies provide clear examples of the potential for applied field evaluations of forensic technology.

**The Effect of DNA Testing in Burglary Cases (Roman et al., 2008)**

The clearest example of the type of research we are advocating is the Roman et al. (2008) evaluation of DNA use in burglary investigations. This study used a true experimental design (i.e., random assignment to conditions). The study was implemented in five police departments in different cities or counties in the United States. Funding from the National Institute of Justice provided each site with additional resources for conducting DNA analysis on evidence from residential and commercial burglary cases. Only cases with biological evidence suitable for DNA analysis were included in the study. These cases were randomly assigned to one of two conditions. The experimental condition required evidence to be submitted for DNA analysis as soon as possible. Cases in the control condition could be submitted for DNA analysis after 60 days. Random assignment occurred following the determination that a case was eligible. The target sample size per site was 500 cases, or 250 per condition. Though
two sites fell short of this target, there were a total of 2,160 cases in both conditions across the five sites. The outcomes measured in this study included suspect identification, suspect arrest, and referral of the case for prosecution. This study also collected cost data, reporting both the marginal cost of the DNA testing (average cost for each case) and the cost-effectiveness or cost of an additional conviction.

As a well-implemented true experiment, this study provides a strong basis for drawing a causal inference between the use of DNA and improved police effectiveness in solving volume crimes. This study maintained the integrity of the random assignment and the analyses are based on intent-to-treat (i.e., original assignment to conditions). The authors note that some treatment cases did not receive DNA testing in less than 60 days. As such, these cases were no different from control cases. This treatment integrity issue would downwardly bias any improvement in outcomes under the DNA testing condition, yielding a more conservative estimate of effectiveness. Furthermore, the external validity of this study is enhanced by the multisite design. The five distinct police jurisdictions differed in important ways, providing a range of contexts in which the effectiveness of DNA use was assessed.

It is important to recognize precisely what is being tested in this design: the effect of rapid DNA results in helping to solve residential and commercial burglary cases. This study is not assessing the accuracy of DNA testing or other questions related to the physical science related to its use. The experimental manipulation in this study is providing police investigators with DNA results on a timelier basis than is current practice in the United States. Thus, it is getting at the utility for police of quick DNA results.

The results from this study were dramatic. Burglary cases typically have a low clearance rate. In the control groups across the five cities, the percentage of suspects identified ranged from a low of 4 percent to a high of 21%. With rapid DNA results, the percentage identified increased for all jurisdictions. The smallest increase was observed in Orange County, California, where 19% of suspects were identified with DNA compared to 11% in control cases. In Denver, rapid DNA use more than tripled the percentage of suspects identified (58% vs. 18%) and in Los Angeles identification nearly doubled (41% vs. 21%). The percentage of suspects arrested also increased with rapid DNA testing in all sites, more than doubling in three jurisdictions. Finally, both Denver and Los Angeles saw large increases in the percentage of cases accepted for prosecution in the rapid DNA condition relative to the control condition (46% vs. 17%, and 22% vs. 10%, respectively). Orange County saw no change in the percentage of cases accepted for prosecution (9% in both the DNA and control conditions) and Phoenix, Arizona, and Topeka, Kansas, saw modest increases in absolute terms. Taken as a whole, these results suggest a robust effect of the use of DNA in high volume burglary cases that range from modest to large. Thus, this single high quality study provides compelling evidence of the value of DNA testing for solving property crimes in real world field settings.

Roman et al. (2008) also examined the issue of cost-effectiveness. We recognize that cost in this area is a moving target as the technology advances and the costs per DNA test decreases. However, the cost data from the Roman et al. studies showed that
the additional costs to the system to achieve an additional conviction ranged from just under US$2,000 to just under $13,000. The latter number is largely a function of the high costs of DNA testing at one of the sites. The authors note that there were unique circumstances at this site that contributed to these high costs.

**The Effect of an Expanding DNA Database at Solving Crimes (Dunsmuir et al., 2008)**

Dunsmuir et al. (2008) examined the effect of an expanding DNA database in New South Wales (NSW) Australia, on clearance rates for eight different crime types. In January of 2001, NSW began testing the DNA of all prison inmates and recording the results in an existing DNA database. As such, the size of the NSW DNA database began to grow substantially. Dunsmuir et al. examined whether the expansion in the DNA database improved police effectiveness through a times-series analysis of monthly clearance rates, charge rates, and the ratio of charge to clearance rates from 1995 through 2007, inclusively.

The manner in which DNA testing is used in investigations has expanded from comparing the DNA results to a small set of suspects identified through traditional investigative practices to running DNA results through local and national DNA databases to identify potential suspects. This study examines the utility of this approach at the macro-level. The study is testing whether the growth of the DNA database increases the overall efficiency of the police at solving crimes. If comparing DNA evidence from a crime against a DNA database is effective, then the proportion of cases solved should increase as the size of the DNA database increases.

The study estimated the percentage change over 12 months in the cases cleared, charge rate, and charge to clearance rate ratio as a function of the increase in the size of the local DNA database. These estimates ranged from a negative effect of -.9 to a high of 8.1%. Nineteen of the 24 models tested showed an improvement in the clearance rates over time. These difference models examined eight different crime types for three different outcomes (cases cleared, charge rate, and the ratio of the charge to clearance rate). The results varied substantially across crime types, with no clear explanation for this pattern. The largest effects were seen for sexual assault, robbery with firearm, and robbery without firearm.

The primary methodological concern with this time-series analysis, as discussed in detail by the authors, is the threat of history—that some other historical event or events account for the observed improvement in clearance rates, such as changes in police practice unrelated to DNA testing. Attempts were made to address this through the use of covariates in the analysis to control for these other factors, but the potential threat cannot be completely ruled out. However, this study adds positive evidence to the real-world value of DNA testing, providing a set of estimates for the macro-level impact of the use of a DNA database on the clearance rates for various crimes. Additional similar studies in different jurisdictions would help establish the generality and robustness of the findings of this study.
Quasi-Experimental Assessments of the Effect of DNA on Case Outcomes (Briody, 2004; Schroeder, 2007; Tully, 1998)

We identified three studies, Briody (2004), Schroeder (2007), and Tully (1998) that all used a quasi-experimental design that compared criminal justice outcomes in cases with DNA testing relative to cases without DNA testing. A potential bias in these studies is selection. Cases with DNA testing are likely to differ in important ways from cases without DNA testing that cannot be fully explained by case seriousness and other easily observable case characteristics. However, the results taken together with other studies, such as the Roman et al. (2008) experimental study, contribute to the body of knowledge on DNA testing.

The study reported in Briody (2004) was conducted in Australia and examined whether the presence of DNA evidence affected the acceptance of cases for prosecution, the rate at which defendants plead guilty, and the conviction rate. The research design matched DNA cases with non-DNA cases based on the seriousness of the crime. Additionally, only cases that had reached a final disposition and cases with complete records were included. Separate analyses were performed for sexual offenses, homicides, serious assaults, and property crimes. Logistic regression models were used to assess the influence of DNA on case outcomes, along with numerous other case characteristics, including the existence of fingerprint evidence. Unfortunately, the presence of DNA-evidence was dropped from models if it was not significantly correlated with the outcome of interest.

For both sexual offenses and homicides, the presence of DNA evidence increased the probabilities of a prosecution and a conviction. In the case of convictions, the odds-ratio for the presence of DNA evidence was 33.1 for sexual offenses and 23.1 for homicides. Thus, the presence of DNA evidence greatly increased the odds of a conviction for otherwise comparable cases. For serious assault, the presence of DNA evidence also increased the odds of a conviction by slightly less than a factor of five. For property crimes, the presence of DNA evidence increased the odds of a prosecution and a guilty plea. The general pattern of evidence is supportive of the benefit of using DNA evidence in obtaining convictions and guilty pleas.

Using a similar design, Schroeder (2007) examined whether DNA evidence affected clearance rates of homicide cases in the Borough of Manhattan, New York, and facilitated case closure. Using 602 cases with available files, he categorized the cases into groups based on the role of DNA in the investigation. DNA evidence was available in 270 cases but was only used in the investigation of 40 cases. Case clearance rates were substantially higher in the cases that did not use the available DNA results (74%) versus the cases that did use the DNA results (28%). This likely reflects selection bias. The police were highly successful in solving these cases without the assistance of DNA testing. The very low clearance rate for homicide cases with DNA evidence and testing suggests that these cases were fundamentally different and more difficult to solve. Among the 40 cases that used DNA testing, the DNA results helped identify a suspect in 16 cases. Thus, DNA appears to have been of some utility in a small
percentage of homicide cases. Because of the clear selection bias issues, we judge the evidence from this study regarding the utility of DNA testing in homicide cases as questionable.

Finally, Tully (1998) used historical data from the state of Maryland and compared cases with DNA testing to two comparison groups: (1) historical (pre-DNA) cases from 1979 through 1986 in which biological evidence was collected, and (2) current cases with biological evidence but no DNA testing. The outcomes of interest were the rates of plea bargaining, convictions, and the sentence length. Unfortunately, the two comparison groups were combined in the report and as such we could not examine them separately. Only 107 DNA cases and 92 non-DNA cases were available across the three counties. The study provides limited information on how these cases were selected, making a careful assessment of methodological quality difficult.

At the aggregate level, the results from Tully (1998) are all positive. We computed odds-ratios from the available data and although only 3 of the 9 aggregated odds-ratios were statistically significant, all were positive, favoring the cases that used DNA testing. The smallest effect, an odds-ratio near 1, was for the effect of DNA testing on convictions in rape cases. The author notes that a major complication with the rape cases was an understandable unwillingness of victims to testify, even with the existence of strong forensic evidence.

Overall, the three quasi-experimental studies provide evidence that is consistent with the single randomized controlled trial and suggest that the benefits seen under those rigorous research conditions for burglaries may generalize to other crime types. Selection bias remains a complication in interpreting these studies. This is most evident in the Schroeder (2007) analysis of homicide cases. Cases with untested DNA evidence are highly likely to be different in meaningful ways from cases with tested DNA evidence. The latter are more likely to be more difficult to solve, thus justifying the additional expense and effort of DNA testing.

**Discussion**

The evidence from this review generally supports the utility of DNA analysis. The strongest evidence for the effectiveness of DNA for volume crimes, such as burglaries, comes from the randomized controlled trial in five jurisdictions conducted by Roman et al. (2008). The improvements in the number of suspects identified, arrested, and prosecuted were impressive and represent a two- to threefold increase in the percentage of cases solved. This is particularly valuable given the small percentage of volume crimes that are typically solved. Furthermore, DNA has most typically been used for violent crimes, such as murder and sexual assault. This study established the applicability of DNA testing to crime types outside of its typical domain. It also can be argued that as the size of the DNA databases expand, the effectiveness of the use of DNA testing on a broad scale will increase, as established by Dunsmuir et al. (2008).

It is important to recognize that the use of DNA testing for volume crimes represents an important shift in the way DNA is used in the investigative process. It was
initially used solely to compare the DNA of suspects identified through traditional investigative practices against DNA samples obtained at a crime scene or from a victim’s body. The development of large-scale DNA databases allows the direct identification of suspects by testing crime scene DNA samples against a database. Three of the five studies examined (Briody, 2005; Dunsmuir et al., 2008; Roman et al., 2008) provide evidence that this approach has value in solving property crimes.

As pointed out in a recent report by the Committee on Science, Technology, and Law of the National Academies (2009), DNA is the only forensic technology based on strong science. In the case of serious crimes, such as homicide and sexual assault, it can be argued that solving one additional crime is worth the cost. The research reviewed in this article suggests that DNA analysis may have an even greater utility at a macro-level, that is, in affecting the overall clearance rate, for high volume crimes often committed by repeat offenders, such as burglaries, than in low volume violent crimes, such as homicide. The Schroeder (2007) study suggests that DNA analysis was helpful (identified new leads) in a surprisingly small percentage of cases (16 of 270). Findings of this type illustrate the value of evaluation research on the utility of forensic technologies.

While our conclusions support the intuitive conclusion that forensic DNA analysis does make a positive contribution to the effectiveness of police investigations, our review also led us to another discovery about the state of research on a topic that has several important distinctions from the field of gravity/parachute research. While the general benefits of forensic DNA can be recognized as clearly as the benefits of parachutes, the specific benefits are much more complicated than the advantages of a parachute when exiting a plane at high altitude. The cost-effectiveness of DNA analysis for burglaries is not a question that lends itself to bench science. The use of different forensic methods involve opportunity costs, which can be quite expensive when considering that the choice between options may be the difference between identifying a suspect or not. Understanding the conditions under which a particular investigative approach is more or less likely to lead to success in closing cases is valuable and, as the studies reviewed here illustrate, can be examined through rigorous empirical methods.

We were only able to identify five studies that evaluated the real-world utility of DNA analysis. Based on a preliminary search of the literature, we are confident that there are even fewer studies examining other forensic methods. More experimental studies, such as the one conducted by Roman et al. (2008), need to be conducted. The best time to implement randomized controlled studies is before a technology becomes routine practice. Experimentation fits naturally in an environment that is adopting and trying new technologies or approaches to using existing technologies, such as rapid DNA results. The random assignment of cases to existing practice or an experimental approach is both ethical and a wise use of resources when there is reason to believe that the experimental approach may improve on practice, providing real-world evidence of the benefits or absence thereof of the change in police practice.
DNA analysis is just one of many forensic technologies. The studies reviewed here illustrate the value of this type of field research for assessing the value-added benefit of new approaches to criminal investigations relative to existing practices. In an environment of limited resources, knowing which technologies provide the biggest benefit for solving crimes provides policy-makers with knowledge to support the expansion of certain practices or the reduction or elimination of others, as well as providing a base of information for criminal investigators weighing the opportunity costs of one choice over another. Field experimentation complements the bench science that is needed to establish the technical accuracy and limits of forensic technologies by examining a different set of pragmatic questions. Although the questions may seem naive, the findings are anything but obvious and require sophisticated research designs, such as the randomized controlled trial, to provide credible answers.

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