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Value of DNA Evidence in Detecting Crime

ABSTRACT: DNA material is now collected routinely from crime scenes for a wide range of offences and the timely processing of the DNA is seen as key to its success in investigating and detecting crime. An analysis of DNA material recovered from the volume crime offences of residential burglary, commercial burglary, and theft of motor vehicle in Northamptonshire, U.K., in 2004 has enabled the DNA to be categorized into seven sources. Further analysis using a logistical regression has revealed a number of predictors, other than timeliness, that greatly influence whether the DNA material recovered from a crime scene enables the crime to be detected. The results indicate that a number of these predictors are of statistical significance and may be just as relevant in determining whether DNA successfully detects the crime as the timeliness of the processing of the DNA material. The most significant predictor was found to be investigating officer accreditation with location, quantity, and type of DNA material at the crime scene also being relevant. Accreditation of the Crime Scene Examiner recovering the DNA material was found not to be significant. Consideration is given to where further emphasis is needed by the U.K. police service to maximize the opportunities to detect volume crime with DNA.

KEYWORDS: forensic science, DNA, identification

DNA evidence is now widely accepted as a standard forensic technique for the investigation and detection of a wide spectrum of crime types from volume crime (burglary and autocrime) to serious and major crime such as rape and murder. The U.K. DNA Good Practice Manual (1) states that (p. 5) "DNA helps police link offenders to crime scenes by matching DNA profiles that have been stored in the National DNA database (NDNADB) to DNA samples taken from crime scenes or suspects. It can also be used to eliminate suspects from enquiries."

DNA material collected at a crime scene is processed to produce a DNA profile, which is loaded onto the NDNADB. If the loaded profile matches that of a named individual already on the NDNADB (known as a DNA "match"), then that information is passed back to the police force who submitted the crime scene DNA material. This usually leads to the arrest of the individual (who would be considered a suspect for the crime) and a police interview follows in which the suspect is expected to account for how their DNA came to be at the crime scene. If the police do not accept the explanation offered or if the suspect confesses to the crime, then the suspect will be charged with the offence and that DNA "match" counted as a detection.

To date, discussions on maximizing the opportunities to link offenders to crime scenes by means of DNA analysis have focused on the timeliness of processing the DNA material recovered from crime scenes. This issue was first raised in 1996 (2) when it was recommended that police forces and forensic service providers (who process the DNA material) should, collectively, strive to reduce the time taken from DNA collection through to arresting suspects identified by the DNA process. The review *Under the Microscope* (3) and *Under the Microscope, Refocused* (4) supported this view. Most recently, Webb et al. (5) examined the impact of an initiative between a U.K. police force and forensic service provider to speed up the investigation of domestic burglary where DNA material had been recovered from the crime scene (known as fast-tracking). They found that the fast-tracking initiative reduced the time between reporting a burglary and charging a suspect (where a DNA identification had been produced) from an average of 89 to 45 days.

In this paper, we consider the different types of DNA material that might be recovered from a crime scene and their evidential value in detecting the crime. A number of predictors that might influence whether a successful outcome (i.e., crime detection) can be accomplished with timely DNA intelligence are considered.

An overview of the types of DNA material frequently encountered at crime scenes is followed by an analysis of the success (or otherwise) of these different DNA types in detecting crime against a number of predictors.

DNA Types

The U.K. DNA Good Practice Manual (1) considers a number of DNA types that are routinely encountered at crime scenes. These types can be aggregated into seven DNA sources as follows:

Blood	Blood may be encountered in the form of pools, drops, splashes, or smears and is usually deposited following a bleeding injury such as might occur in a violent affray or by an offender cutting themselves
Cigarette ends	Discarded by offenders, saliva on cigarette ends can provide sufficient material for a DNA analysis to be performed
Saliva	This includes items screened for saliva but excluding cigarette ends. For example, drinking vessels, scarves, balaclavas, etc
Chewing gum	Like discarded cigarette ends, discarded chewing gum offers potential to extract saliva from the chewer
Hair	DNA material suitable for conventional DNA analysis is contained within the hair root and any scalp cells surrounding the root. Suitable hairs might typically be found on weapons used in acts of violence, on victim's clothing, etc
Semen	Semen may be encountered as a liquid or a dried stain and is most common in sexual offences
Cellular	This is a general term for DNA material that is not easily attributed to any of the above sources. Typically, cellular DNA would be recovered by swabbing a surface the offender is thought to have had skin contact with although no stain is visible

The Custodians of the NDNADB provide information on the relative amounts processed of each of the above seven sources and

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TABLE 1—*Relative recovery and profiling rates for DNA sources, July–September 2005.*

DNA Group	Percentage of Total Samples Processed	Percentage of Samples Processed Suitable for Loading on NDNADB
Blood	26.1	86.1
Cigarette ends	24.0	73.5
Saliva	27.1	37.2
Chewing gum	0.9	71.2
Hair	1.1	18.1
Semen	5.2	92.1
Cellular	15.6	12.4

the relative success of each source in providing profiles suitable for loading and searching on the NDNADB. Table 1 shows these data for the second quarter of 2005 (July–September 2005) for all police forces in England and Wales (personal communication, Forensic Science Service, 2005).

The rates shown in Table 1 above do not differ significantly from those for the previous 18 months (personal communication, Forensic Science Service, 2005). Therefore, the relative recovery and profiling rates for the seven sources would appear to be reasonably static. This is not surprising as the NDNADB has been in existence for over 10 years and the techniques for DNA recovery and profiling are well established.

Although much has been written concerning the timeliness of DNA processing, we have been unable to find any research that considers the evidential value of the different DNA sources against predictors that might influence the successful outcome of a DNA "match" to detect crime. We consider now what might influence this match other than timeliness.

DNA Source Data

For the following analysis, we have taken data from Northamptonshire Police for the period January–December 2004 and have considered the offences of residential burglary, commercial burglary (from a shop, office, etc.), and theft of a motor vehicle. These three offence types were chosen for a number of reasons as they:

- Offer the potential to examine a large number of crime scenes for DNA material.
- Are key offences for most police forces and also the U.K. Home Office (6).
- Are typically "recidivist" offences, which means that offenders are likely to have a DNA profile on the NDNADB.

In the above period, all offences in the above three categories that were notified to a Crime Scene Examiner (CSE) received a visit and scene examination for forensic evidence. In reality, this amounted to 95% of recorded residential burglaries, 93% of recorded commercial burglaries, and 72% of recovered stolen vehicles. The shortfall in all cases was due to crimes not being notified to a CSE rather than a conscious decision not to attend. This attendance policy was intended to prevent offences not being visited by a CSE and thus ensure that the data were not affected by offences being "screened out" without the opportunity for a CSE to recover DNA material. Also, all DNA material recovered from these crimes was sent to a forensic service provider for profiling rather than the "best sample for each crime" approach in Webb et al.'s study (5).

For the three crime types under consideration, DNA material was found at 1818 crime scenes and this produced 615 DNA "matches," with 383 of these "matches" being successfully converted to detections.

Where a DNA "match" was achieved, the mean time taken from the crime being reported to a suspect being arrested was 16 days. This compares favorably with Webb et al.'s observed "fast-track" time-scale of 45 days. The time distribution of DNA "matches" is shown in Fig. 1. In common with Webb et al. (5), Fig. 1 excludes "outliers" where a DNA profile of the suspect was

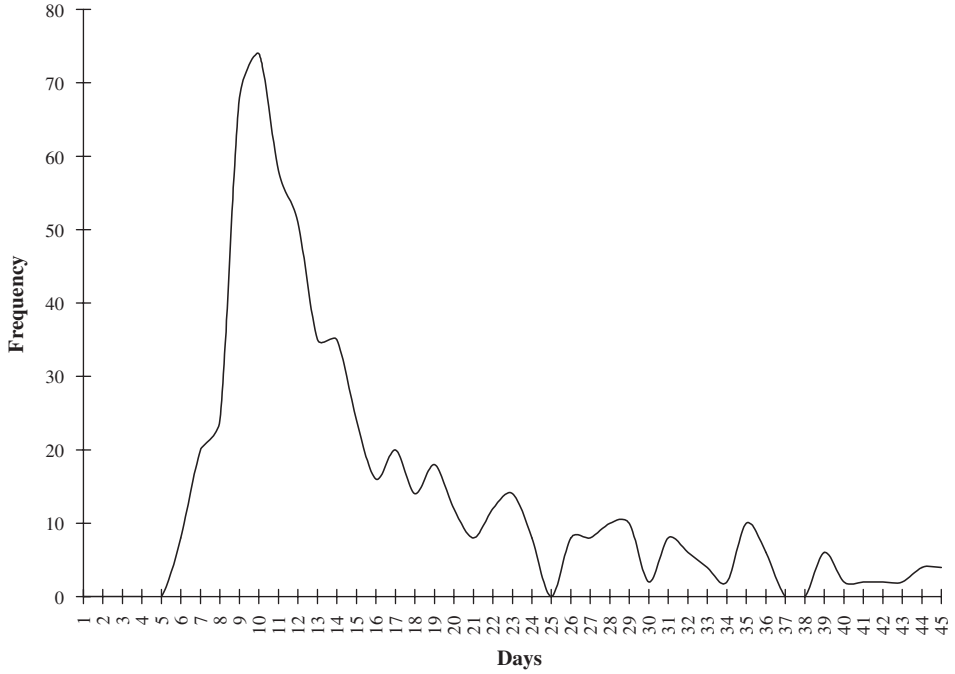

FIG. 1—*Frequency of DNA "matches" for days from crime reported to suspect arrested.*

not available on the NDNADB at the time the DNA material from the crime scene was loaded onto the NDNADB.

Results

The following analysis considers the conversion of DNA "matches" to detections for each DNA source against a number of predictors. Two of the seven DNA sources defined above (hair and semen) have been excluded from the analysis, as the amount of data available did not permit a meaningful analysis to be conducted.

Firstly, the percentage of "matches" converted to detections was compared against each of the five DNA sources (blood, cigarette ends, saliva, chewing gum, and cellular), Fig. 2. This figure also considers the conversion of "matches" to detections when more than one "match" of the same source was found at a crime scene and also where two or more sources were found at the same crime. For the blood source, there were no crimes where more than one blood "match" was obtained.

Using Pearson's χ^2 test (7), Fig. 2 shows a statistically significant increase in the conversion of "matches" to detections when more than one "match" of the same (or another) source is obtained for cigarette ends, saliva, chewing gum, and cellular. This is not surprising as finding more DNA evidence at a crime will invariably produce a stronger case for a suspect to explain than finding a single piece of evidence. The exception to this is blood where there was little increase in the conversion rate to detections when blood and another DNA source were found together. One reason for this is the excellent conversion rate when blood is found on its own compared with the other four sources (90% compared with 15%, 20.7%, 6.7%, and 3.1%). Finding blood on its own appears to provide much stronger evidence than finding DNA from the other four sources. The evidential value of blood will be explored again later.

The next predictor examined was whether the DNA material was recovered inside or outside the crime scene, Fig. 3. For a burglary, inside would mean within the building and for autocrime inside would mean within the vehicle itself. As DNA can be deposited easily on items brought to the crime scene by the offender (such as cigarette ends or chewing gum), it is not unusual to find significant amounts of DNA material outside of the crime scene.

As there were insufficient data to compare "matches" of each of the five sources on their own inside and outside a scene, Fig. 3 shows each source when more than one "match" of the same (or another) source is included. As discussed above, this other source is predominantly blood.

The only sources where detections were obtained for DNA material found outside a crime scene were blood and cellular. Although DNA "matches" were found outside for the other three sources, none produced a detection. In itself, this is of interest as it demonstrates that certain sources of DNA that are mobile (such as cigarette ends or chewing gum) appear to be "weaker" evidentially than others such as blood. In this context, mobility implies that the DNA material can be readily transported and deposited at the crime scene in a way that makes it difficult to show whether the deposit is innocent. For example, a cigarette end found outside a scene may have been dropped by a passer-by whereas blood found outside the scene needs the suspect to explain how they came to shed blood (less straightforward than smoking a cigarette). In this sense, the cellular source is an anomaly as it is just as mobile as cigarette ends (if not more so). However, location of the DNA material is just one of several predictors.

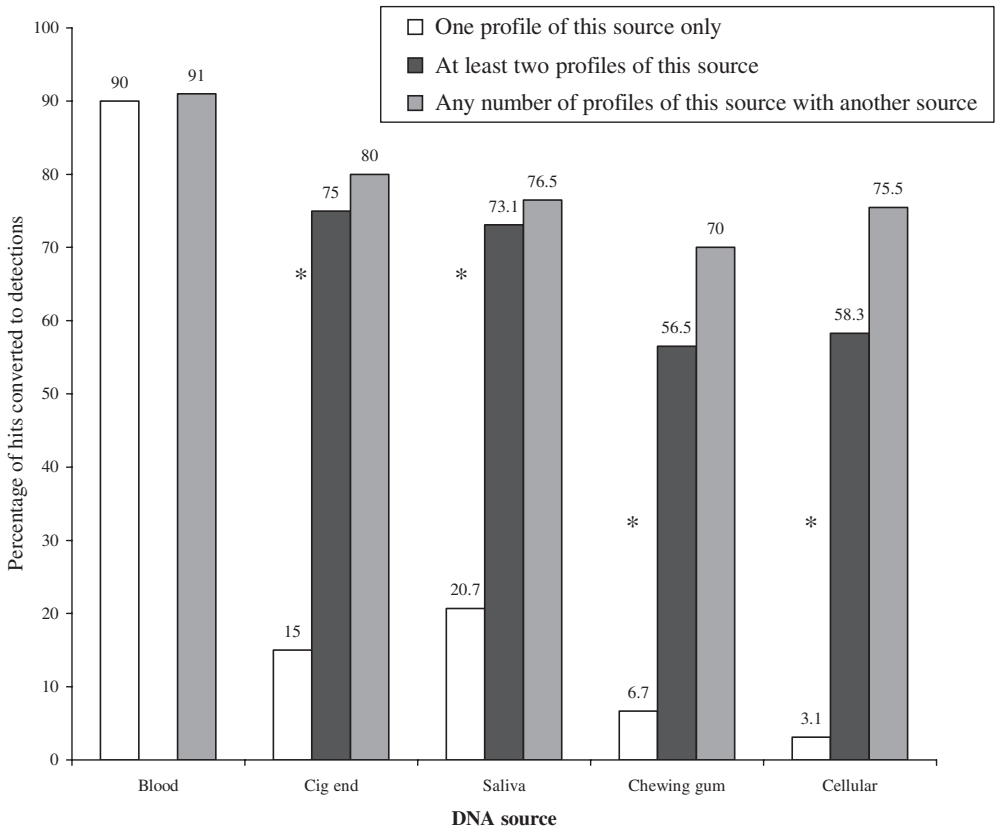

FIG. 2—*Conversion of DNA "matches" to detections for the five DNA sources. The asterisk (*) indicates a significant difference at the 99% confidence interval ($p < 0.01$).*

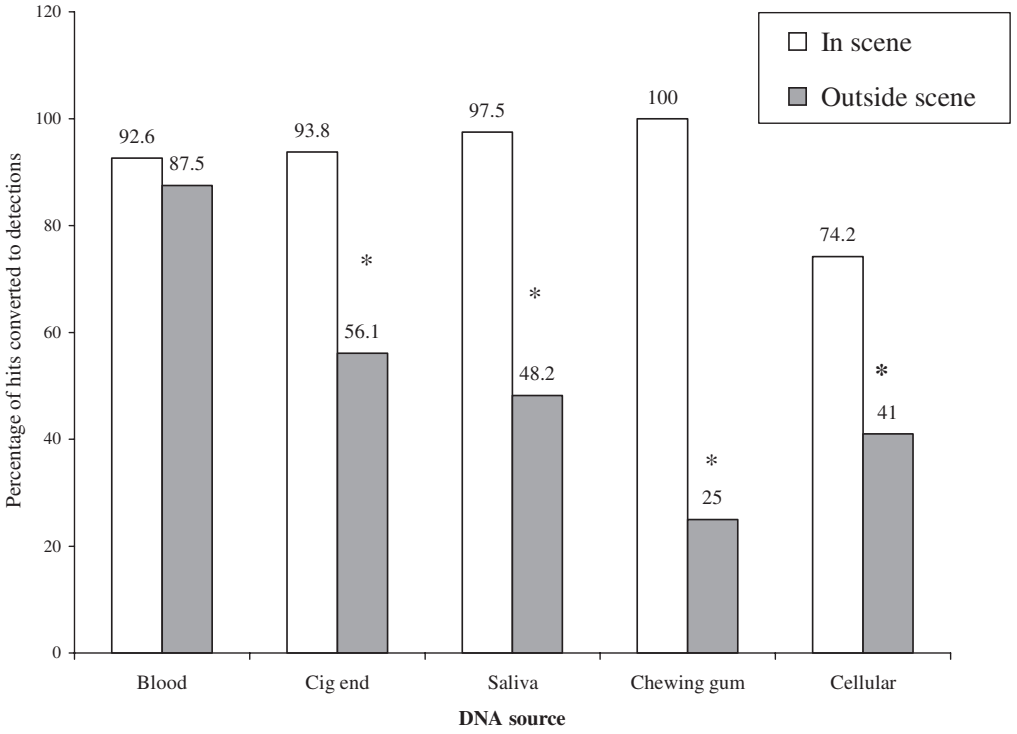

FIG. 3—*Conversion of DNA "matches" to detections for the five DNA sources as a function of the location of the DNA material. The asterisk (*) indicates a significant difference at the 99% confidence interval ($p < 0.01$).*

Finding blood either inside or outside a scene produces a statistically significant increase in the conversion of "matches" to detections for the other four sources and again demonstrates the evidential value of blood over the other four sources. Note that the only source where the difference between finding the DNA material inside or outside has no statistical significance on detections is blood. Again, this demonstrates the evidential value of blood, as its location has little effect on the conversion of the "match" to a detection.

The next predictor to be considered was the skill and experience of the police officer interviewing the suspect to establish that person's guilt or otherwise. This predictor was measured by looking at the interviewing officer's investigative accreditation as the investigation of property crime requires the skills of trained investigators with a good knowledge of the community and the criminals operating in it (8). Each crime where a DNA "match" was obtained was examined to see whether the interviewing officer had reached the required investigative standard to investigate property crime and was accredited. Such accreditation is not achieved with less than 4 years of service. The results are shown in Figs. 4–6 for each DNA source plotted against the percentage of DNA "matches" converted to detections. Figure 4 shows the results where only one "match" was obtained for each crime, Fig. 5 where two or more "matches" of the same source were obtained, and Fig. 6 where "matches" from more than one source were obtained.

Figures 4–6 show a statistically significant increase in the conversion of "matches" to detections when the investigator is accredited. The only exception to this is blood in Fig. 6 and, as stated above, blood appears to be evidentially superior to the other DNA sources and it may be easier for an inexperienced officer to convert a blood "match" to a detection. For saliva, chewing gum, and cellular sources in Fig. 4, no detections were obtained by nonaccredited investigating officers although, in total, "matches" for 42 crimes were obtained.

Having considered the experience and accreditation of the investigator, the final predictor considered here was the experience and accreditation of the CSE. Following appointment and initial training, CSEs undergo a 2-year training period culminating in accreditation as a CSE. In a manner similar to the analysis carried out above for investigators, each crime where a DNA "match" was obtained was examined to see whether the CSE who examined the crime scene had reached the required standard and was accredited.

Figures 7–9 show each DNA source plotted against the percentage of DNA "matches" converted to detections. Figure 7 shows the results where only one "match" was obtained for each crime, Fig. 8 where two or more "matches" of the same source were obtained, and Fig. 9 where "matches" from more than one source were obtained.

In Figs. 7–9, there was no statistical significance between the conversion of DNA "matches" to detections and whether the CSE who examined the crime scene was accredited or not. Thus, in sharp contrast to the accreditation of the investigating officer, there is no apparent correlation between the skills of the CSE and the conversion of "matches" to detections.

Logistical Regression

In order to consider the combined influence of these different factors on the conversion of DNA "matches" to detections, a logistical regression was performed using an equation of the form

$$P(y) = \frac{1}{1 + e^{-(b_0 + b_1 x_+ b_2 x_2 + \ldots + b_n x_n + \varepsilon)}}$$

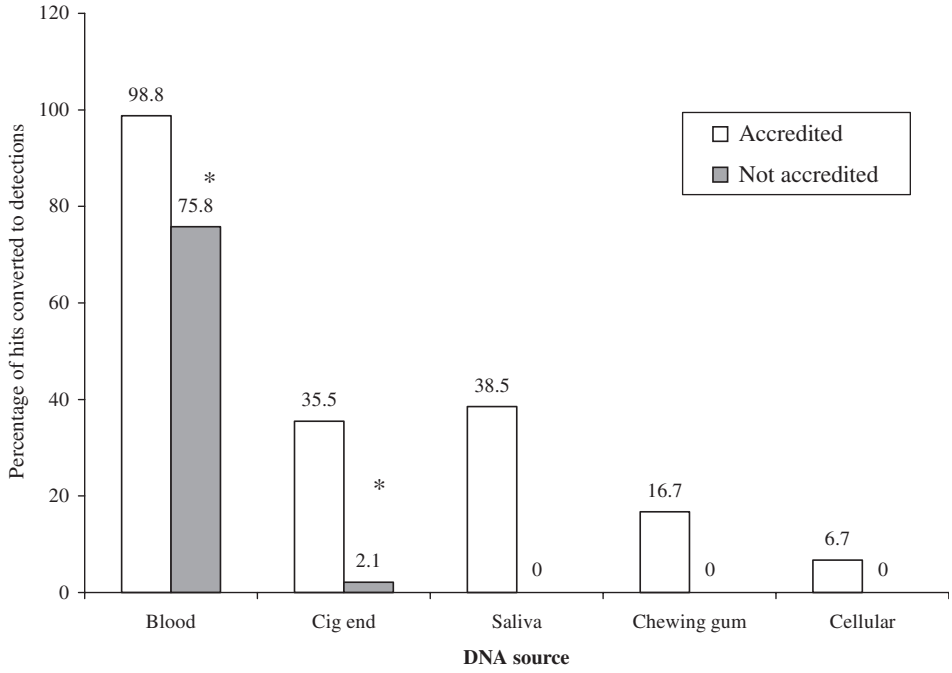

FIG. 4—*Conversion of DNA "matches" to detections for the five DNA sources where only one "match" was obtained for each crime as a function of whether the investigator was accredited. The asterisk (*) indicates a significant difference at the 99% confidence interval ($p < 0.01$).*

where $P(y)$ is the probability of y occurring given known values of x_i, b_0 is the y intercept, and b_i is the regression coefficient of the corresponding variable x_i. ε represents a residual term (7).

Such a regression is well suited to this analysis as the outcome variable is a categorical dichotomy (i.e., a "match" will or will not be converted to a detection) and the predictor variables are categorical.

Table 2 shows the results of the regression in terms of Exp(B), which is an indicator of the change in odds of the outcome variable from a unit change in each predictor (7). In this analysis, as each predictor is dichotomous, the unit change in the predictor is equivalent to the predictor changing from *false* to *true*. That is, the value of Exp(B) shows, for each predictor, the odds of the outcome variable changing when the predictor changes from *false* to *true*. As the outcome variable is also dichotomous, Exp(B) in Table 2 shows the change in odds of detecting a crime from a DNA "match" when the predictor changes from *false* to *true*. For example, blood found inside the crime scene is 3.3 times more likely to result in a detection than blood found outside the crime scene and an accredited investigator is 15.3 times more likely to obtain a detection from blood as a DNA source than a nonaccredited investigator.

The two most significant observations from Table 2 are that, for all five sources, the accreditation of the CSE was not significant in affecting the outcome, whereas the accreditation of the investigator was crucial. For all five sources, the accreditation of the investigator significantly affected the outcome of the DNA "match," with the accredited investigator having between 15.3 and 44.8 times more likelihood of converting a DNA "match" to a detection than a nonaccredited investigator. Interestingly, blood had the lowest improvement for an accredited investigator (15.3 times) whereas more mobile DNA (chewing gum) had the largest improvement (44.8 times). This confirms what we reported earlier, which is that blood has a superior evidential value and is less dependent on the accreditation of the investigator to convert the "match" to a detection.

Where data were available and the regression model found a significance in the predictor, finding DNA inside a crime scene, finding more than one DNA "match" at a scene, and finding more than one DNA source at a scene all increased the odds of converting the "match" to a detection.

Table 3 shows the coefficients calculated by the logistical regression, which may be used to construct the equation discussed above. For example, the probability of detecting a crime where blood was found as a DNA source may be calculated by setting the coefficients b_i equal to the values shown in Table 2 and then setting the predictor variables x_i equal to 1 or 0 depending on whether the calculation is being performed for that condition being true or false (i.e., DNA found inside = 1, DNA found outside = 0, accredited investigator = 1, nonaccredited investigator = 0).

Discussion

Procedures for processing DNA material recovered from crime scenes are now mature and previous studies cited in this study have contributed to producing timely DNA "matches" and their conversion to detections. This analysis has taken the processing of DNA intelligence (in the form of DNA "matches") to a new level by considering what predictors, other than timeliness, can contribute to the successful outcome of that intelligence.

We have shown that most of the predictors considered in this study do influence the outcome of a DNA "match" but the one that has been shown to have most bearing (and the one that can most easily be changed) is the investigative skill of the officer interviewing a suspect arrested as a result of a DNA "match." The DNA source producing the match has been shown to affect the outcome of a DNA interview with what we have termed mobile DNA (i.e., cigarette ends, chewing gum) requiring more skill on the part of the investigating officer to covert it to a detection. Conversely, converting nonmobile DNA (blood) "matches" to detections has been shown to be the least influenced by the

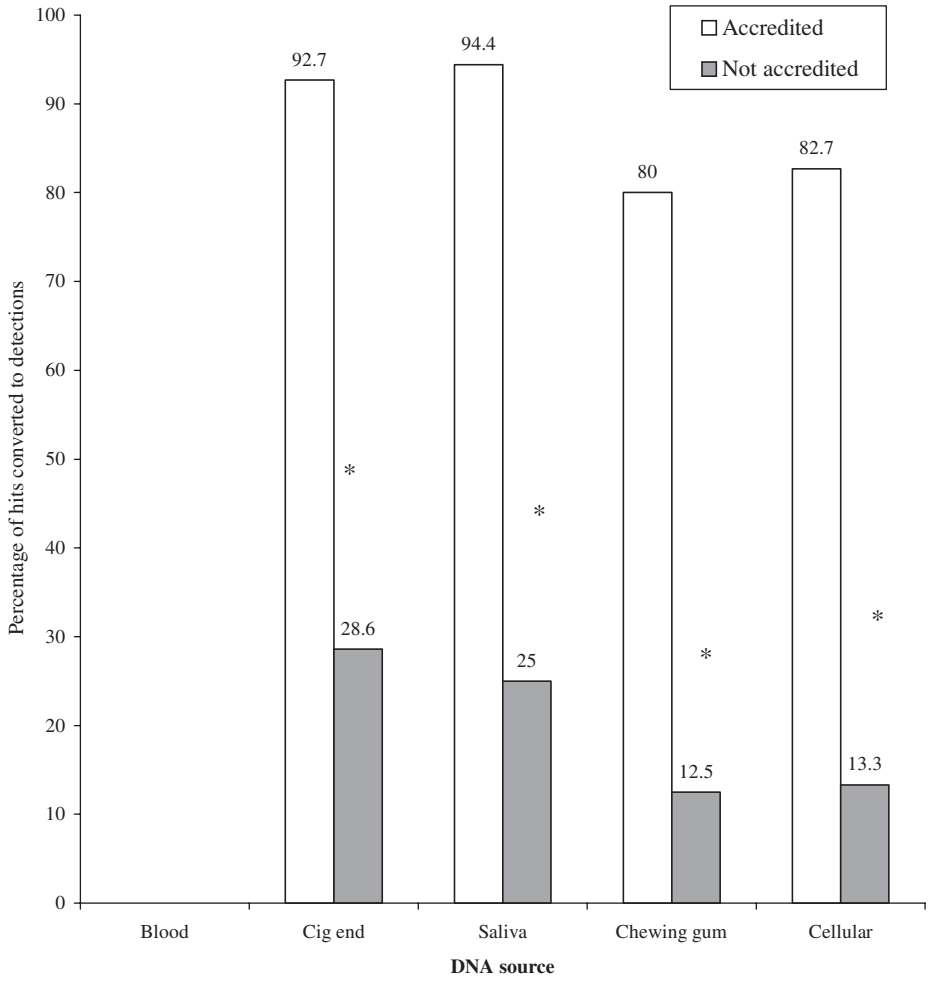

FIG. 5—*Conversion of DNA "matches" to detections for the five DNA sources where two or more "matches" of the same source were obtained for each crime as a function of whether the investigator was accredited. There were no crimes where more than one blood "match" was obtained. The asterisk (*) indicates a significant difference at the 99% confidence interval ($p < 0.01$).*

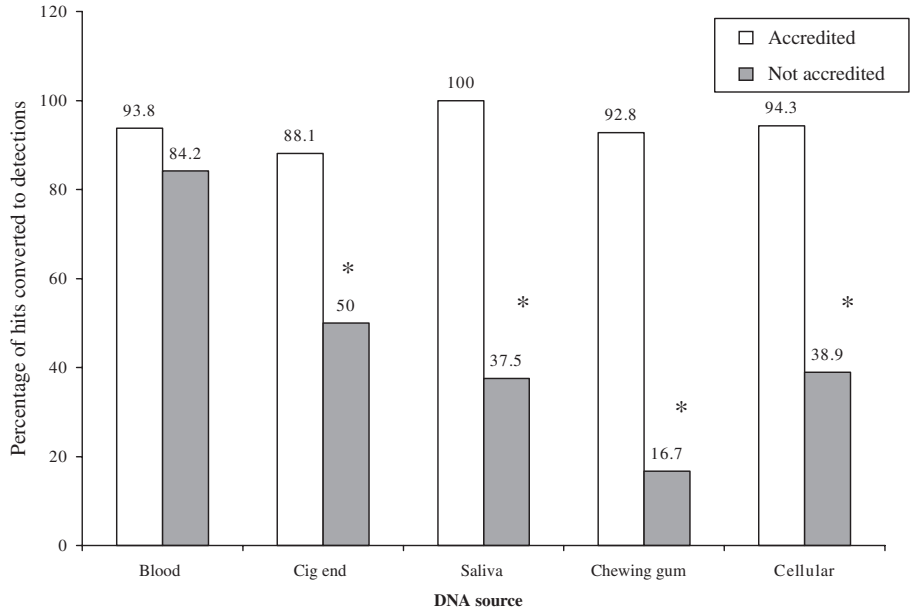

FIG. 6—*Conversion of DNA "matches" to detections for the five DNA sources where "matches" from more than one source obtained for each crime as a function of whether the investigator was accredited. The asterisk (*) indicates a significant difference at the 99% confidence interval ($p < 0.01$).*

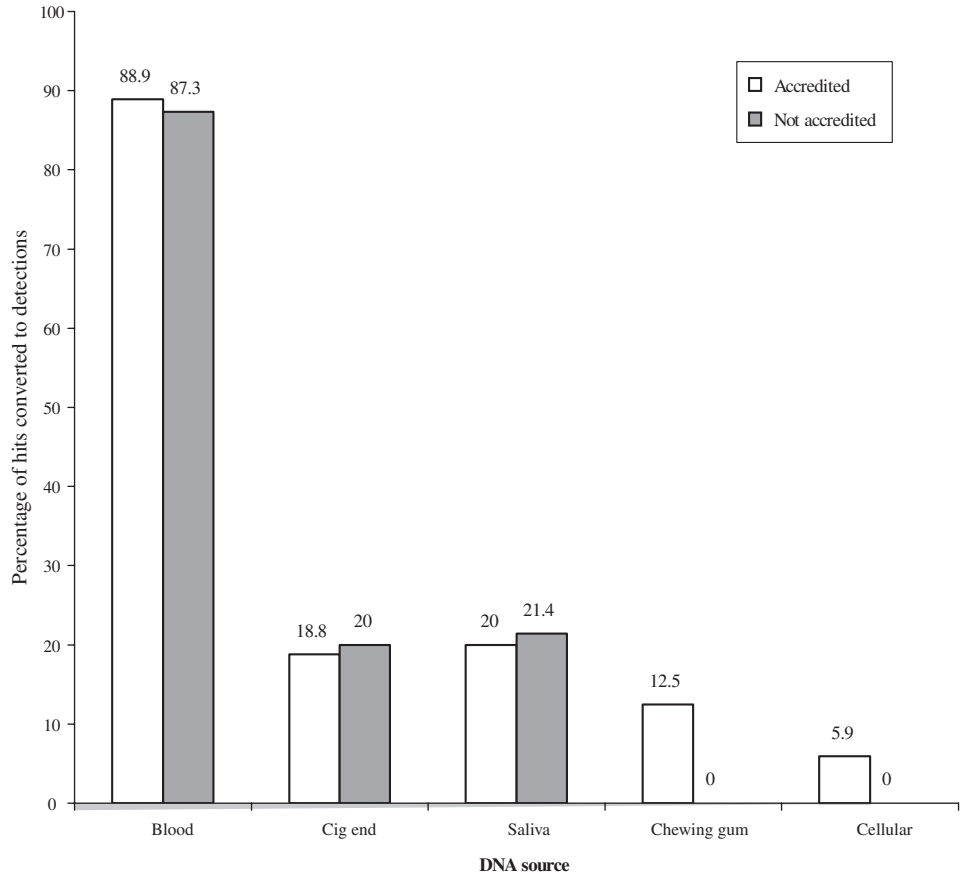

FIG. 7—*Conversion of DNA "matches" to detections for the five DNA sources where only one "match" was obtained for each crime as a function of whether the Crime Scene Examiner (CSE) was accredited.*

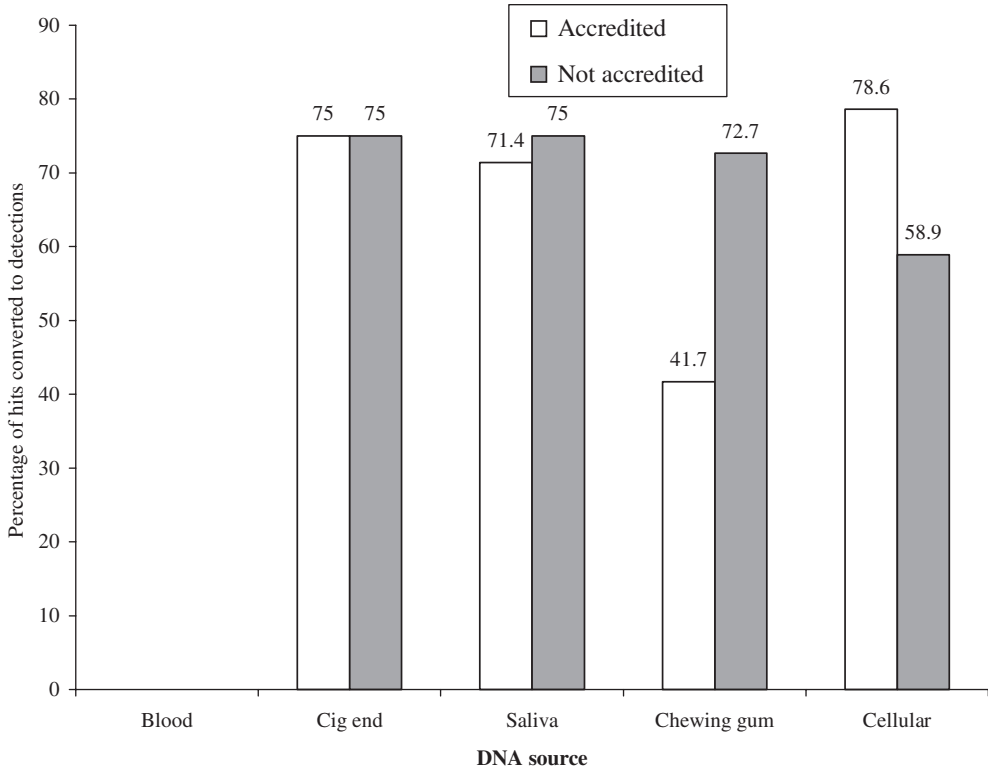

FIG. 8—*Conversion of DNA "matches" to detections for the five DNA sources where two or more "matches" of the same source were obtained for each crime as a function of whether the Crime Scene Examiner (CSE) was accredited. There were no crimes where more than one blood "match" was obtained.*

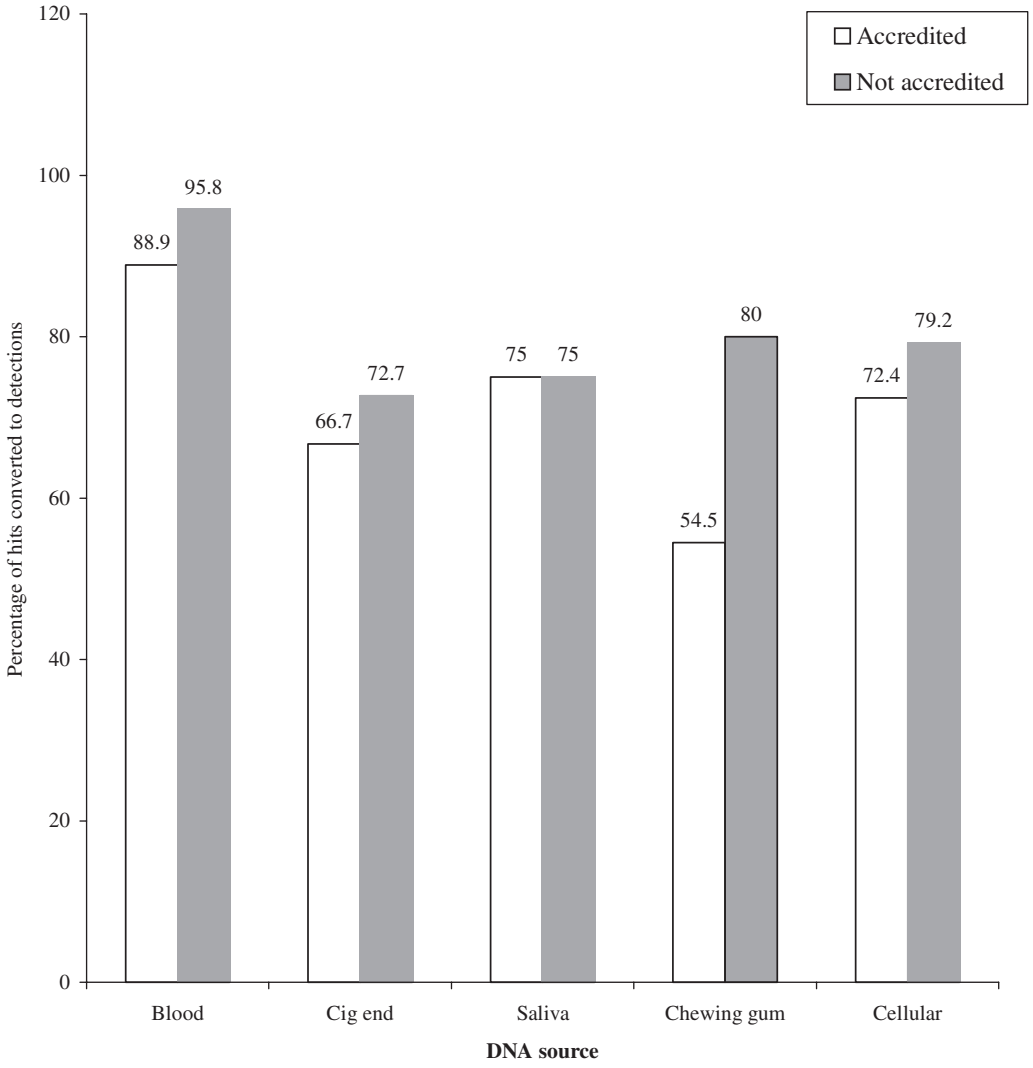

FIG. 9—*Conversion of DNA "matches" to detections for the five DNA sources where "matches" from more than one source obtained for each crime as a function of whether the Crime Scene Examiner (CSE) was accredited.*

TABLE 2—*Logistical regression model for each of the five DNA sources showing the values of Exp(B).*

	Predictor Exp(*B*)				
DNA Group	DNA Inside Scene	2+ Matches of this Group	More Than One Group	Accredited Interviewer	Accredited CSE
Blood	3.3*	No data	Not significant	15.3*	Not significant
Cigarette end	No data	11.1*	20.1*	20.6*	Not significant
Saliva	No data	5.6*	12.0*	26.6*	Not significant
Chewing gum	No data	Not significant	Not significant	44.8*	Not significant
Cellular	8.6*	14.5*	35.6*	23.0*	Not significant

*Significant difference at the 99% confidence interval ($p<0.01$) using the model χ^2 statistic.

TABLE 3—*Logistical regression model for each of the five DNA sources showing the values of the coefficients b_0 and b_i.*

		Coefficient b_i (SE)				
DNA Group	b_0 (SE)	DNA Inside Scene	2+ Matches of this Group	More Than One Group	Accredited Interviewer	Accredited CSE
Blood	0.37 (0.3)	1.2 (0.5)	No data	Not significant	2.7 (0.6)	Not significant
Cigarette end	− 3.4 (0.5)	No data	2.4 (0.4)	3.0 (0.5)	3.0 (0.4)	Not significant
Saliva	− 3.3 (0.7)	No data	1.7 (0.6)	2.5 (0.6)	3.3 (0.6)	Not significant
Chewing gum	− 0.34 (0.4)	No data	Not significant	Not significant	3.8 (1.1)	Not significant
Cellular	− 5.5 (0.9)	2.2 (0.6)	2.7 (0.7)	3.6 (0.8)	3.2 (0.7)	Not significant

predictors. We consider that nonmobile DNA provides more robust evidence than mobile DNA as it is less straightforward for a suspect to give an innocent explanation of its recovery from a crime scene. Further, we have shown that nonmobile DNA can increase the evidential value of mobile DNA sources when they are found together.

Just as Webb et al. (5) reported an improvement in morale and job satisfaction by "fast-tracking" DNA, undoubtedly failure to convert DNA "matches" to detections through inexperience will have the reverse affect on investigating officers and, indeed, all those concerned with the collection and processing of DNA material from crime scenes.

Since April 2000, the U.K. government has invested £241M in the collection and processing of DNA from crime scenes such as those considered in this study (9); perhaps, there should now be more emphasis of the processing of the DNA intelligence to optimize opportunities to detect the crime.

A similar study on the predictors affecting the successful conversion of fingerprint identifications to detections is currently being undertaken by the author and will be reported in due course.

Acknowledgments

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