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The Effectiveness of Forensic Evidence in the Investigation of Volume Crime Scenes

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Abstract

This study investigates the effectiveness of forensic evidence in UK volume crime investigations. The main aim was to identify characteristics of forensic evidence that influence its effectiveness in converting detections into criminal charges, as well as to critically consider the effectiveness of a recent service level agreement (SLA) implemented by Wiltshire Police, which aimed at reducing CSI attendance. The sample consisted of 445 police recorded cases received from Wiltshire Police. Presence or absence and location-related features of fingerprint, DNA, and footwear evidence were evaluated on the effectiveness of forensic evidence and examined within the contexts of different volume crimes. Results showed a high level of correlation in converting detections into criminal charges where the presence of DNA, footwear, and multiple evidence types was recorded; and a positive correlation between forensic evidence ineffectiveness and presence of fingerprints, particularly in residential burglaries. Differences between individual offence types were expressed. The most prominent feature influencing the effectiveness of forensic evidence was found to be related to the movability of the exhibit associated with the recovered evidence, with DNA recovered from non-movable items exhibiting the strongest effectiveness. Cases processed after the implementation of the SLA did not show significant differences in forensic evidence effectiveness as compared to cases processed prior to the SLA, however, they demonstrated a lack in effectiveness of DNA evidence. The findings of the current research provide a better understanding of the contextual influences on the potential of forensic evidence and can support improvement of crime scene screening and CSI resource deployment.

Keywords: Forensic Evidence, Volume Crimes, Fingerprints, DNA, Footwear, CSI

Introduction

Forensic science is widely used in the investigation of crimes, and is recognised as a valuable tool in administering justice[1]. The procedure which forensic evidence must undergo from its identification at the crime scene until the testing of its probative value in the court room, however, is a complex one[1,2]. It usually starts with the reporting of a crime and its investigation by the attending police officer. They are responsible for assessing the scene and evaluating the need for the attendance of a Crime Scene Investigator (CSI). CSIs then identify potential forensic evidence at the scene and recover it for analysis by an expert forensic examiner in the forensic laboratory or equivalent police bureau. After conducting the appropriate tests (e.g. DNA analysis, fingerprint comparison), results are sent back to the police in a report, and if necessary, an expert witness report is produced for presentation of the evidence in court. This is where the jury includes the information provided by the forensic evidence into their decision about the final verdict.

Since the integration of forensic science into the criminal justice process in the 18th century[3], there have been continuous attempts to unravel the true contribution of this new discipline to criminal investigations[4–7]. This interest has been growing recently, especially due to a large financial investment in forensic services during the past years[1].The latest research in this matter is mainly focused on the use of forensic science in volume crimes[4,5,7], which is regarded as a fairly recent adoption, as opposed to harder-to-solve crimes, for which forensic science has already been proven useful because forensic evidence is often the only clue available in those cases[7–9]. The main reasons for this new focus are the pressing need to counter volume crimes efficiently, and the fact that these make up the majority of the CSI's work[10]. The concept of volume

crime is usually used to denote “any crime which, through its sheer volume, has a significant impact on the community and the ability of the local police to tackle it”[11, p.8]. This commonly includes the crimes of burglary, robbery, and other types of theft, various types of vehicle crimes, and sometimes criminal damage and assault, whereby the classification of a crime as a volume crime can change based on its prevalence[12].

Historically, the impact of forensic practices on the conviction of volume crimes has been very low[7–9]. Most of these studies, however, were undertaken prior to the introduction of new techniques and might present an outdated picture of forensic science. Since then, more advanced techniques have increased the effectiveness of forensic science and more recent studies suggest that forensic evidence is the main source of securing the detection in around a quarter of volume crimes cases[7]. The strive for a successful estimation of the contribution of forensic science, has led to the identification of various research obstacles[7]. For instance, the complex nature of the criminal justice process from crime scene to court, brought along by the procedural aspects involving various stages along the way, renders an estimate of the overall effect of forensics difficult to attain. Most studies have only focused on the effect of forensics at one stage of the process, thereby disregarding the effect of previous stages on the one under investigation (e.g. looking at recovery rates of forensic evidence at crime scenes, without acknowledging selectivity of CSI attendance). Another issue that has been raised repeatedly in the assessment of forensic impact, is the inconsistency between police forces in counting rules, recording conventions, or less visible factors, that influence how successful detection of crime is measured[13]. This decreases the generalisability of interpretations of force results to a nationwide context.

Just as forensic science is used at different stages in the criminal justice process, it is employed in different roles supporting an investigation[7,13]. It can be both, a

corroborative tool (confirming or eliminating suspects from the investigation) and an inceptive tool (identifying unknown offenders), but also be used as intelligence. Not all of these applications may be recognised when the value of forensic science is tied to quantitative figures. Even with sole consideration of the number of detections achieved through forensic evidence, what is often overlooked, is the possibility of linking offenders to additional offences through database searches against the evidence[7]. These indirect detections, or ‘Taken into Considerations’ (TICs), however, are common in volume crime[14,15]. One piece of forensic evidence thus has the potential of unravelling multiple crimes. Conversely, when investigating incidents in which several identifications have been found via multiple types of evidence, it is often not possible to discern the effects of each piece of evidence alone[5]. A similar problem arises, when the impact of forensic evidence is compared to other aspects of the investigation, such as interviews conducted with witnesses or victims[7]. Even if the outcomes of these comparisons might suggest that physical evidence does not weigh as much as other factors in reaching a conviction, this does not mean it is redundant to the investigation. In fact, due to the multifaceted use of forensic evidence, it might be just as important and necessary to corroborate other lines of investigation, such as CCTV or witness statements.

To have a proper understanding of the uses and drawbacks of forensic science, one must be able to understand the process of attrition (i.e. the discrepancy between the number of crimes committed, and the number of crimes subsequently prosecuted) in criminal investigations[15]. Due to the length of the investigation process and the many factors influencing outcomes at various stages, there are numerous factors that can lead to attrition in a case. One pivotal study mapped the process of attrition in burglary and vehicle offences from the point of forensic identifications to the final verdict, finding two major areas of attrition [15]. 27% of cases remained undetected, due to suspect’s being

eliminated from the scene for legitimate reasons. In those cases, where a crime was detected and charged, 11% of cases resulted in no suspect conviction. This was partially due to the CPS deciding there was no case to answer, or that it was not in the public interest to pursue the case. Other studies also agree that elimination of a suspect (mostly due to legitimate access) is the major reason for an identification not leading to a detection, and point to generally high numbers of attrition due to a perceived lack of public interest to proceed[5]. This clearly demonstrates that the failure of a case to reach a conviction can be due to many causes other than forensic evidence being insufficient. Such factors also include an inability to trace the suspect, exceeding of the time limit to charge, or the victim declining support for the case[7]. This again, reinforces the difficulty in deciphering the effectiveness of forensic evidence in an investigation.

Studies investigating the underlying issues if this ineffectiveness of forensic evidence, have identified a recurring set of themes[4]. The current existing consensus is that forensic science is inefficiently used on an international scale. A likely cause of this is the improper implementation of forensic science into the investigation process. The most salient cause identified is the frequent lack of knowledge within police forces regarding the potential of forensic science, as well as its limitations[4,7]. The influence of the location of the evidence on its meaning within the context of a crime, is often misunderstood[10]. Consequently, this can lead to incompetency regarding evidence preservation or to a focus on specific evidence sources and disregard of others[4,7]. Low forensic awareness also regularly results in no, or only poorly, conducted screening of crime scenes, which in turn leads to mismanagement of forensic resources[4,7]. While unnecessary visits of CSIs can lead to a negative perception of the police service by the public[8], too high workloads can negatively affect the quality of examinations and hinder quick responses to crime scenes, therefore decreasing the chance of recovery of property

or securing of necessary evidence before it is contaminated or lost. This deficiency in forensic awareness stems from insufficient training of investigators, and their perceptions that forensic knowledge is not a core part of their required skill set. Despite recommendations in the 90's, urging the enhanced training of police officers in forensic matters, an Her Majesty's Inspectorate of Constabulary (HMIC) inspection a decade later showed that nothing had been changed[4]. This and the continuous urgency to fortify the implementation of forensic science into investigations shows that improvement is long overdue.

Most police officers, therefore, have expressed the need for more information on the evaluation of forensic potential at crime scenes, not least due to their responsibility for cost-effective deployment of resources[13]. More specifically, they have asked for a way to identify those types of scenes and evidence that show the highest forensic potential. A better understanding of the contextual meaning of forensic evidence in police officers would further facilitate the work of the CSIs, as they are responsible for making contact with the first attending officer at the scene to obtain information on the forensic potential and extent of CSI attendance.

The main rationale of the current study was to assess the effectiveness of forensic evidence in volume crime scene investigations. In doing so, it assisted in expanding knowledge of forensic potential in evidence frequently recovered at such scenes. Therefore, the study focused on the perceived main issue in the deployment of forensic science to criminal investigations, namely the lack of contextual awareness of the value of forensic evidence and the ensuing inefficient screening of the crime scene.

The methodology deployed in this study aimed to strengthen the reliability of the results through identifying the circumstances in which case outcomes are attributable or

unrelated to forensic evidence and by looking at the value of forensic evidence in serving a specific role only. This research has therefore chosen a focus on the contribution of forensic evidence to the acquisition of criminal charges of volume crimes, while trying to avoid the limitations identified in many previous studies[7,13].

In addition to this, many police forces regularly change CSI attendance in line with force policies for ‘priority crime’ (i.e. the crime type which is set as priority in the particular police force). This frequently requires CSIs to attend crime scenes based on the crime type, regardless of the forensic potential present. Due to the issues surrounding the uncertainty about the true contribution of forensic science to police investigations and in the attempt to counter unnecessary financial expenses. Oneforce has recently implemented a new service level agreement (SLA) to cut down on CSI attendance rates at priority 3 crime scenes (i.e. non-forensic crimes, which are only subjected to CSI examination in exceptional circumstances), unless significant forensic potential exists that cannot realistically be recovered by attending officers for subsequent examination by CSIs. As the effects of this SLA have not yet been investigated, this study will be undertaken in collaboration with a contributing police force and use their data to research the potential effects.

In summary, this research aims at assessing the effectiveness of forensic evidence in volume crime scene investigations, by identifying aspects of forensic evidence which enhance its effectiveness that can be identified and evaluated by police officers. The comparison of pre and post SLA effectiveness of forensic evidence should further highlight any potential issues in forensic resource management (e.g. if crime scene screening in this force is sufficient, effectiveness of the forensic evidence recovered should be the same before and after decrease of CSI attendance, when measured in proportion to the number of scenes attended).

Research Questions and Hypotheses

The main research questions to be answered in this study are as follows:

i) How does the nature and location of forensic evidence influence its effectiveness in converting a detection into a criminal charge?

ii) Does the SLA have an influence on these outcomes or on the rates of criminal charge acquisition in general?

Related to the research questions above, the following hypotheses have been established:

i) Multiple types of forensic evidence enhance the chance for acquisition of a criminal charge, as they strengthen the link between the suspect and the offence and can provide different evidential details.
ii) Forensic evidence is more likely to be effective when inside, at the point of entry, or on a fixed object, as evidence found outside the crime scene or at the point of entry is believed to have less potential of being related to the offence, while moveable evidence is easily transportable.
iii) Reducing CSI attendance will not enhance forensic evidence effectiveness / increase the rates of charge acquisition, as evidence effectiveness is tied to factors other than attendance rates (e.g. scene screening).

Methodology

Sample

To provide information that would enhance the currently improper screening of crime scenes, the researchers have adapted a quantitative approach to evaluate the value of forensic evidence based on its different features. As such, the study will differentiate between those features that, if present, enhance the effectiveness of forensic evidence in supporting the case towards reaching a criminal charge, and those that are linked to its ineffectiveness. Police data was considered the most useful for this methodology, as it provides information about the context of the forensic evidence as recovered at the crime scene. By using police data, direct as well as indirect detections will be considered and reasons for obtaining no criminal charge other than ineffectiveness of forensic evidence are taken into account, thus providing an opportunity to consider other sources of attrition.

The obtained data set comprised anonymised records for 706 offences with CSI attendance, committed in the Wiltshire Police force area, in the time period between April 2015 and March 2019. This data was provided to the researcher by Wiltshire Police in collaboration with South West Forensics, after extraction from two interconnected databases. To narrow down the research focus even further and examine the value of forensic evidence in reaching a criminal charge for a case with an identified suspect only, the cases included were those in which the evidence quality had been rated ‘sufficient to identify’ and resulted in a suspect identification on ‘Niche’, the Crime Recording System for Wiltshire Police. This decision was made based on the multifaceted use of forensic evidence as explained above and imitates research methodologies of previous studies[7].

The case records provided, contained information regarding the presence of fingerprint, DNA, and footwear evidence recovered by the CSIs, as extracted from ‘Socket’, the

Forensic Database Case Management System. As the array of forensic evidence is vast, only these three types of evidence were included, as they are the most commonly found at volume crime scenes [17–20], thus making the findings more valuable for CSI and police officers. Of the different offences contained in the data set, only volume crime cases were included into the sample, based on the focus of the project. All offences not considered as being volume crimes, were excluded from the data set. After exclusion of irrelevant cases and after further cleaning of the data was undertaken (both is described in detail below), the final sample consisted of 445 cases.

In 414 of the 445 cases (93%) there was only 1 evidence type present, in 30 cases (6.7%) there were 2 different evidence types present, and in 1 case (0.2%) there were 3 different evidence types present, resulting in a total of 477 pieces of evidence. Of these 477, 262 (54.9%) were fingerprint, 181 (37.9%) DNA, and 34 (7.1%) footwear evidence. The most frequent combination of two evidence types (63.3%) was fingerprint and DNA (*n*=19), with DNA and footwear mark being less present (*n*=6, 20%), and the least frequent combination being fingerprint and footwear mark (*n*=5, 16.7%). 335 (75.3%) of the cases were processed prior to the implementation of the SLA, whereas 110 (24.7%) of the cases were processed afterwards. 39.8% (*n* = 177) of cases accounted for ‘Burglary Residential’, 17.1% (*n* = 76) for ‘Other Burglary’ offences, 12.4% (*n* = 55) for ‘Burglary Business’, 8.3% (*n* = 37) for ‘Theft of Motor Vehicle’, and 22.5% (*n* = 100) for multiple other offence types (see figure 1). 204 cases (45.8%) resulted in the suspect being charged or summonsed, 132 cases (29.7%) showed evidential difficulties in the case upon closure despite a named suspect being identified and the victim supporting the actions, 88 cases (19.8%) resulted in completion of the investigation without a suspect identification, with the remaining 21 cases (4.7%) resulting in other outcomes (see table 1 below).

The research was undertaken with approval of the university ethics committee (CURES)[21,22] and with written permission of Wiltshire Police and South West Forensics. The researcher received the data in an anonymised form in a Microsoft Excel spreadsheet and stored it on an encrypted memory stick with password protection. The raw data as received from Wiltshire Police, contained the following information: Offence Type (see table 6 in the Appendix for raw data categories); Pre- or Post-SLA (whether the offence was processed prior or past the introduction of the SLA); Evidence Type (fingerprint, DNA, footwear); Hit Exhibit Description (a description produced by the CSIs about where the evidence was recovered); and Case Outcome (see table 7 in the Appendix for raw data categories).

As stated above, all offences that did not match the volume crime criteria were excluded from the data set, reducing it from 706 to 693 cases. In 57 cases, the outcome of the case was recorded as ‘New’, which meant that the process is still ongoing. As the effect of forensic evidence could not be determined in those cases, these were also excluded from the data set, leaving it with 636 cases. In 122 cases, the Case Outcome and/or Hit Evidence Description was unavailable, which made it impossible to work with those cases, leading to their exclusion. After the exclusion of all irrelevant cases, the data set contained 514 cases.

Before the data could be coded for analysis, a final cleaning had to be undertaken. This was based on the fact that in some instances, multiple evidence types were recovered. The way the data is presented in the police recording form, however, shows only one evidence type per row. This means, if an offence including three different evidence types was recorded, this would result in three different cases with one evidence type each being recorded. Offences with multiple evidence types are thus recorded as multiple cases in separate rows. To make sure all cases were only considered in the analysis once, in order

to not bias the outcome, and to be able to examine evidence type combinations, these different rows were merged into one. To verify that the cases indeed belonged to the same offence, cases were checked for identical crime numbers. Through this merging of rows, the data set was reduced by 32 cases (without loss of information). At last, 11 duplicate cases (where the same case was recorded twice, or where a case recorded multiple of the same evidence type) were identified and deleted from the data set, resulting in a data set of 471 cases.

To facilitate evaluation of the effectiveness of the forensic evidence, the different case outcomes recorded in the data set had to be joined into broader categories. For this purpose, three categories were established. The first category ‘Forensic Evidence: Effective’ (*n* = 225) comprised all outcomes showing that the forensic evidence has proven effective to the investigation outcome, whether the suspect has been charged, cautioned, or given a community resolution. The outcome is consequential for the suspect in some way and has been reached due to the forensic evidence. This also included indirect detections (TICs, in which an offender admits an additional crime in hope of reduced sentencing) because the detection of these crimes is linked to the forensic evidence found in relation to the original crime. The second category ‘Forensic Evidence: Ineffective’ (*n* = 220) contains all outcomes for which the forensic evidence has proven ineffective to the investigation outcome. This could be either due to evidential difficulties (e.g. the evidential value is too low to provide sufficient proof for the offence) or due to eliminations (e.g. the person identified had legitimate access). The remaining cases included those outcomes whereby the effectiveness of the forensic evidence was left undetermined due to factors external to forensics and were thus classified under the category ‘Forensic Evidence: Effectiveness Undetermined’ (*n* = 26). This relates to factors that are controlled by the wider investigation (e.g. investigation stopped because

the prosecution is not in the public interest; victim withdraws support for the investigation). In these cases, the forensic evidence is neither effective, nor ineffective; the stop in the investigation just makes it non-determinable. Those cases were therefore disregarded in the analysis, which was carried out using the remaining 445 cases. Detailed information on the allocation of outcomes to the different categories is presented in table 1 below.

Table 1:Categories established to group outcomes

Outcome categories	**Frequency *n***
Forensic Evidence: Effective:	
Charged	25
Summonsed/postal requisition	6
Alternative offence charged	2
Alternative offence summonsed/postal requisition	2
Youth caution	1
TIC (Suspect admits the offence in hope to get reduced sentence)	4
Community resolution (suspect not charged with offence, but crime resolved by community means e.g. paying low level fine to victim on mutual basis)	4
(Hist)Charged/summonsed	173
(Hist)Suspect charged with an alternative offence	1
(Hist)Caution youths	3
(Hist)Caution adults	4
Forensic Evidence: Ineffective:	
Investigation complete, no suspect identified	88
CPS – named suspect, victim supports, but evidential difficulties	3
Police – named suspect, victim supports, but evidential difficulties	14
(Hist)Named suspect ID-victim supports but ED	115
Forensic Evidence: Effectiveness Undetermined:	
Police – formal action not in public interest	1
Victim declines/unable to support action to identify offender	4
Victim declines/withdraws support – named suspect identified	20
Suspect identified but prosecution time limit expired	1
Grand Total	471

The data, as received from Wiltshire Police, further identified a detailed variety of offence categories, which had to be re-grouped into broader categories for simplicity and ease. As some crimes were re-named after 2017 (e.g. ‘Burglary Commercial’ into ‘Burglary Business and Community’, and ‘Burglary Dwelling’ into ‘Burglary Residential’), these were combined as representing one crime category, as were same crimes with varying level of intensity (e.g. ‘Burglary Commercial’ and ‘Aggravated Burglary Commercial’). Further

were all crimes labelled as ‘Attempt’ combined into one category. The reasoning behind not combining, for example, commercial burglaries with attempted commercial burglaries, is that although these crimes show the same initial intent, and therefore possibly the same modus operandi, by the offender, from a policing view, they are different. The police records and processes completed and attempted offences in a different way, in the sense that attempted cases may not receive as much attention as completed offences in the first place. For the sake of this study, these were thus kept separate, to enable accurate evaluation of the contribution of forensic evidence in both cases. The final offence categories used for analyses are ‘Burglary Business’ (*n* =55), ‘Burglary Residential’(*n* = 177), ‘Other Burglary’ (*n* = 76), ‘Attempted Burglaries’(*n* = 12), ‘Robbery’(*n* = 14), ‘Theft’(*n* = 18), ‘Taking of Motor Vehicle’(*n* = 37), ‘Motor Vehicle Offences’(*n* = 21), and ‘Criminal Damage’(*n* = 35). Detailed information on which offences were combined into these categories is presented in figure 1.

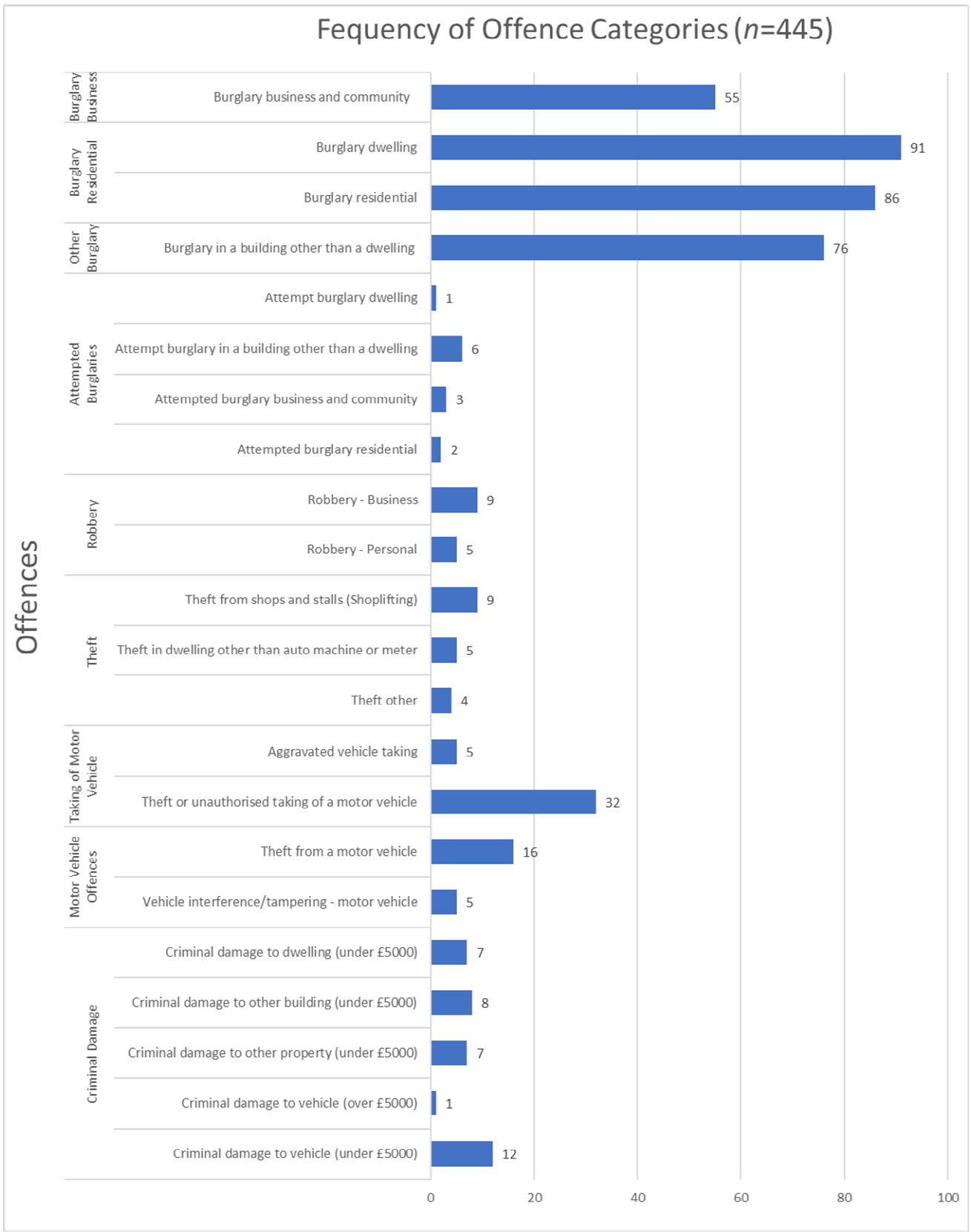

Figure 1: Offence categories

Data coding

For each incident recorded, the data file contained CSI descriptions on the recovered evidence, called 'Hit Evidence Descriptions'. These were used to code the forensic evidence on different features. A brief content analysis of these descriptions was undertaken to identify possible variables for coding. As police records make it difficult to use complex coding methods in a reliable way, it was decided on using a binary coding system, using 0 and 1 as opposed features (e.g. absent vs. present). Each case was coded for the following: Fingerprint: absent vs. present; DNA: absent vs. present; Footwear: absent vs. present; Multiple evidence types: absent vs. present; as well as per each of the three evidence types whether the evidence was found: outside vs. inside; not at the point of entry (POE) vs. at the POE; on a moveable object vs. on a fixed object. In those cases, where an evidence type was coded as absent (*n*=858), the subsequent features relating to the location of this evidence were coded as missing values (denoted as '2'). This led to 2574 features coded as missing values. Furthermore, in 14 cases, one or more evidence features relating to its location could not definitively be coded as falling into either of the opposing conditions, due to ambiguous or insufficiently detailed evidence descriptions. These features were also coded as missing values, resulting in an additional 19 missing values. As features of the same evidence type were hypothesized to influence each other's effectiveness and it was not possible to examine their interactions using a Regression method[1], additional variables were established based on the different paired and triplet combinations of features present (e.g. outside + at the point of entry; inside + at the point of entry + fixed). This resulted in further 60 variables, which were coded using the binary system presented before (i.e. combination absent vs. present).

[1] A Regression method could not be used, due to multicollinearity between different location-related variables.

The final variables used for analyses therefore included 13 forensic evidence features, 60 feature combinations, 2 levels of forensic evidence effectiveness (effective/ineffective), 9 offence categories, and 2 levels of SLA (pre/post).

Analytical strategy

Chi Square Tests are used to examine the relationship between categorical variables[23] and were therefore used to establish how the features of different evidence types are related to the effectiveness of the forensic evidence (i.e. effective/ineffective). This was examined for the whole sample, as well as per individual offence type. Furthermore, possible combinations of location-related features of the same evidence type were examined on forensic evidence effectiveness. Chi Square analyses were then conducted to establish the difference in forensic evidence effectiveness between pre- and post-SLA cases. The relationship between forensic evidence features and forensic evidence effectiveness was then re-examined for pre- and post-SLA cases separately. Due to the number and complexity of the feature-combination variables coded for this research, those were not examined in this step (the groups were too small to run statistically powerful analyses). As one assumption of the Chi Square Test requires not to have expected frequencies below 5, a Fisher's Exact Test was used in those instances where the assumption was violated[23]. This method is adopted to compute the probability of a Chi Square statistic in smaller samples, where the sampling distribution of the test statistic is too deviant from a Chi Square distribution. Additionally, effect sizes for all Chi Square analyses were calculated using Cramer's V, which is used to measure the strength of the association between categorical variables[23]. These were interpreted according to

Akoglu[24], with $V > 0.25$ denoting a very strong effect, $0.15 > V > 0.10$ denoting a moderate effect, and $0.05 > V > 0$ denoting a very weak or no effect.

Results

Descriptive Statistics

Descriptive statistics were run for forensic evidence features and their combinations. Table 2 shows the frequencies of forensic evidence features in the sample, relating to fingerprint, DNA and footwear evidence, respectively. The row 'Missing due to Absence' refers to location-related features that were coded as missing due to absence of the evidence type. The row 'Missing due to Insufficient Detail' refers to those location-related features that were coded as missing based on ambiguity or insufficiency of the evidence descriptions. Tables 3 and 4 show the frequencies of paired and triplet feature combinations.

Table 2: Frequencies of forensic evidence features related to fingerprint evidence

	Absent	Present	Outside	Inside	Not POE	POE	Moveable	Fixed
Frequency (*n*) **Fingerprint**	41%	59%	27%	70%	63%	35%	52%	47%
Frequency (*n*) **DNA**	59%	41%	30%	70%	69%	30%	59%	40%
Frequency (*n*) **Footwear**	92%	34	26%	74%	56%	41%	18%	82%

Note: The above percentage for forensic evidence features (e.g. outside; POE; etc.) are based on cases where the particular evidence was coded as 'present' only. Where the percentages for opposing features (e.g. outside / inside) do not add up to 100%, this is due to insufficient detail in the evidence description and therefore this feature was recorded as a 'missing' variable.

*Table 3: Frequencies of paired feature combinations (*POE = Point of Entry)*

	Outside + Not POE*		Outside + POE		Inside + Not POE		Inside + POE		Outside + Moveable		Outside + Fixed	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Frequency (*n*) Fingerprints	221	31	213	39	120	132	202	50	231	23	205	49
Frequency (*n*) DNA	155	24	150	29	79	100	153	26	156	24	151	29
Frequency (*n*) Footwear	31	2	26	7	16	17	26	7	32	2	27	7

Table 3: (Cont.)

	Inside + Moveable		Inside + Fixed		Not POE + Moveable		Not POE + Fixed		POE + Moveable		POE + Fixed	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Frequency (*n*) Fingerprints	145	109	181	73	136	119	210	45	241	14	178	77
Frequency (*n*) DNA	97	83	136	44	90	88	143	35	159	19	142	36
Frequency (*n*) Footwear	30	4	13	21	29	4	18	15	32	1	20	13

Table 4: Frequencies of tripled feature combinations

	Outside + Not POE + Moveable		Outside + Not POE + Fixed		Outside + POE + Moveable		Outside + POE + Fixed		Inside + Not POE + Moveable		Inside + Not POE + Fixed		Inside + POE + Moveable		Inside + POE + Fixed	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
Frequency (*n*) Fingerprints	236	16	237	15	245	7	220	32	150	102	222	30	245	7	209	43
Frequency (*n*) DNA	163	15	170	8	169	9	158	20	105	73	151	27	168	10	162	16
Frequency (*n*) Footwear	32	1	32	1	32	1	27	6	30	3	19	14	33	0	26	7

Analyses

Pearson's Chi Square tests were conducted to compare cases with outcomes related to forensic evidence (FE) effectiveness and ineffectiveness on presence of forensic evidence types. Effects of forensic evidence presence were then re-examined per separate offence category. Afterwards, location-related features and combinations of those were examined on FE effectiveness. Finally, the difference of FE effectiveness in pre- and post-SLA cases was analysed, as was the effect of FE presence and features in each of those groups. To reiterate, the different levels of forensic evidence effectiveness examined are presented in table 5 below:

Table 5: Levels of Forensic Evidence Effectiveness used in the analyses

Forensic Evidence: Effective	**Forensic Evidence: Ineffective**
The forensic evidence has proven effective to the investigation outcome, whether this be the suspect has been charged or cautioned, or given a community offence, the outcome is consequential for the suspect and reached due to the forensic evidence	*The forensic evidence has proven ineffective to the investigation outcome, either because of evidential difficulties (e.g. evidential value is low in proving the offence) or due to eliminations.*

The analyses showed significant results for the presence of all evidence types including multiple evidence at $p < 0.05$ (see table 8 in the Appendix). Whereas presence of fingerprints was shown to be related to FE ineffectiveness (46.7% in cases related to effectiveness and 71.4% in those related to ineffectiveness), presence of DNA, footwear, and multiple evidence showed a positive correlation with FE effectiveness. These variables were more common in cases related to effectiveness than ineffectiveness of forensic evidence, with 50.2% vs. 30.9%, 14.2% vs. 0.9%, and

10.7% vs. 3.2%, for presence of DNA, footwear, and multiple evidence, respectively. The effect sizes for analyses of fingerprint and footwear evidence showed a very strong effect, with each $V = .251$, and the effect sizes for DNA and multiple evidence showed a moderate to strong effect, with $V = .197$ and $V = .147$, respectively.

When Chi Square tests were conducted per offence category separately, only a few analyses showed significant results. All the effect sizes related to these analyses demonstrated a very strong effect, ranging between $V = .280$ and $V = .392$. The presence of multiple evidence types was found to be positively related to the effectiveness of forensic evidence in 'Burglary Business' offences, with 18.8% vs. 0.0% in effective and ineffective cases, respectively. In 'Burglary Residential' offences, presence of fingerprints was shown to be positively related to FE ineffectiveness (47.7.% for effective vs. 75.3% for ineffective), whereas presence of footwear showed a positive correlation with FE effectiveness (22.7.% for effective vs. 1.1% for ineffective). The same was found for 'Other Burglary' offences, with 36.1% vs. 75.0% for presence of fingerprints and 13.9% vs. 0.0% for presence of footwear marks, for effective and ineffective groups, respectively. Additionally, those offences showed a positive correlation between presence of DNA and effectiveness of forensic evidence (66.7% for effective vs. 30.0% for ineffective). For the remaining offences, no significant results were found, partially due to groups being too small to run the analyses. Results of these analyses can be found in table 9 in the Appendix (note: due to number of variables, only significant results are presented).

Analyses conducted for the different location-related features and their combined effect, showed a few significant results (see table 10 in the Appendix for significant results). DNA evidence was shown to have a positive correlation with FE effectiveness when found on fixed objects (47.8% for effective vs. 28.4% for ineffective). This was

also illustrated through results showing that DNA evidence found inside on a moveable object is positively related to FE ineffectiveness (38.9% vs. 58.2%). Likewise, DNA evidence from locations other than the point of entry have a positive correlation with FE effectiveness when fixed (25.0% vs. 10.6%), but with FE ineffectiveness when moveable (41.1% vs. 63.6%). Even when found inside and not at the point of entry, moveable DNA evidence was related to FE ineffectiveness, (34.8% for effective vs. 51.5% for ineffective). Evidence found inside at the point of entry on a moveable object further had a positive relation to FE ineffectiveness in fingerprint evidence (0.0% for effective vs. 4.5% for ineffective). All of the analyses related to this set of variables showed strong effect sizes of $V > .160$, with the exception of the results for fingerprint evidence found inside at the point of entry on a moveable object, which showed a moderate to strong effect size of $V = .134$. Other location-related features or combinations of those did not produce significant results.

When pre- and post-SLA cases were analysed, there was no significant difference in FE effectiveness between the two groups, with 49.3% of pre-SLA cases related to FE effectiveness and 54.5% of post-SLA cases related to FE effectiveness. Similar to the results obtained from analysing the entire data set, pre-SLA cases show a positive correlation between FE effectiveness and the presence of DNA (47.3% vs. 27.1%), footwear (20.9% vs. 0.6%) and multiple evidence types (9.7% vs. 3.5%), as well as a positive correlation between FE ineffectiveness and the presence of fingerprints (52.1% vs. 75.9%). The relation between DNA evidence on fixed objects and FE effectiveness was also significant for this group (47.4% vs. 22.2%), as found before. While the results for multiple evidence types in this context showed a moderate to strong effect with $V = .124$, fingerprint, DNA, and footwear evidence demonstrated a strong effect with $V > .200$. The effect size for fixed DNA evidence in this context was $V = .250$, denoting a very strong effect. For post-SLA cases, only a positive relation for

presence of footwear (23.3.% vs. 2.0%) and multiple evidence types (13.3% vs. 2.0%) with FE effectiveness was found, as was a positive relation between presence of fingerprint evidence and FE ineffectiveness (31.7% vs. 56.0%). These results all demonstrated a strong to very strong effect of $V > .200$, with $V = .310$ for footwear evidence presenting a very strong effect. The relevant statistics are given in table 11 in the Appendix.

Discussion

The aim of this study was to unravel those aspects of forensic evidence that can be evaluated by police officers and CSIs at the scene, and which increase the effectiveness of the evidence in converting a detection into the acquisition of a criminal charge. This was done through analysis of the correlation of different features with forensic evidence effectiveness. Due to a recent service level agreement leading to reductions in CSI attendance rates within the contributing police force, the effect of this new policy was also examined.

The results of this study have shown that the presence of DNA, footwear, and multiple evidence types is positively related to the effectiveness of forensic evidence in volume crime investigations, with the last finding supporting the *first hypothesis*. These findings demonstrate that in general, such forensic evidence is valuable to the investigation. The lack of effectiveness of fingerprint evidence (as shown by its positive correlation with forensic evidence ineffectiveness) might be explained by the abundance of this evidence type[17,18], and more specifically, the high likelihood of a fingerprint to belong to a victim of a volume crime offence (especially in burglary cases). This argumentation is supported through results showing that, when examined per individual offence type, fingerprints are only associated with forensic evidence

ineffectiveness in residential and ‘other’ burglary offences. These findings could also be linked to a high forensic awareness in offenders, leading to increased claims of ‘legitimate access’ or preventive measures such as wearing gloves[5,15,25]. Nevertheless, these findings do not mean that recovery of fingerprints is meaningless to the investigation, as forensic evidence is shown to fulfil different roles (e.g. exclusion prints might be just as important to further the investigation)[7,13,14]. Additionally, results have pointed to the usefulness of footwear evidence in such offence types, as well as the use of DNA evidence in ‘other’ burglary cases. The reason for this might be that it is easier to identify footwear marks in unusual locations (e.g. on a door in cases where the offender gained access through kicking the door, or on a table in cases where the offender stepped through a window onto the furniture) and offenders are unlikely to take preventive measures to avoid leaving footwear marks. Unfortunately, due to the limited sample size of cases presenting footwear evidence, it was not possible to examine the effectiveness of this evidence type in the investigation of other volume crimes, such as motor vehicle-related offences, robbery, theft, or criminal damage. The value of DNA evidence in ‘other burglary’ offences, might be explained through the fact that those are related to locations, such as allotments or schools, which are areas easily accessible by the public, hence footwear marks and fingerprints are generally common, leading to an increased amount of forensic dissonance. Similarly, businesses are usually highly frequented by numerous different people, which could explain why multiple evidence types increase the chance of a charge acquisition in offences related to such locations. The especially high effect sizes related to analyses performed within the contexts of different offence types, highlights the strong connection between value of specific evidence types and certain crimes. Therefore, a future research focus on the contribution of forensic evidence in the

investigation of specific crime types, might lead to additional findings that could help tailor the acquisition of specific evidence types to the crime under investigation.

Regarding the different evidence features that were investigated, the *second hypothesis* was only partially supported. Summarising the findings related to different feature combinations, the most significant aspect of forensic evidence seemed to be the concept of movability of the evidence, whereas the location of the evidence with regard to the crime scene (inside/outside) or the point of entry did not seem to alter its effectiveness. This was especially true for DNA evidence. In this sense, even when located inside at a distance from the point of entry, moveable evidence seems to be linked to forensic evidence ineffectiveness. This can be explained through the disputability of the evidence in court[26]: When argued by the defence, the forensic evidence may fail the threshold test to prove the crime, because of the nature of the 'moveable object'. It can hence be concluded that forensic evidence is most valuable when found on a fixed object. Due to the strong impact related to these results, the concept of movability should not be ignored. The absence of this finding in relation to footwear marks can be explained through the fact that footwear marks are usually found on fixed objects anyways, which makes it hard to assess their value when found on moveable objects.

When interpreting the relationship between forensic evidence features and the effectiveness of the forensic evidence, it must be noted that this study grouped different case outcomes into categories that represented only two levels of forensic evidence effectiveness (i.e. effective vs. ineffective). There might, however, be differences in the contribution of forensic evidence to cases resulting in ~~different~~ varying 'strengths' of criminal charges (e.g. 'caution' as opposed to 'charged'). Closer investigation into the contribution of forensic evidence to more specific case outcomes might yield further

insight about how forensic evidence supports other aspects of the investigation in strengthening the verdict.

The *third hypothesis* was confirmed, as the implementation of the SLA was not shown to affect the effectiveness of forensic evidence. This finding provides support for the SLA in that it has not had a detrimental impact on forensic evidence effectiveness. However, when examining evidence features, findings further revealed that DNA evidence was not related to forensic evidence effectiveness anymore after the new policy was introduced. This could suggest a decreased focus or ineffective use of this evidence type and point to potential issues in the identification or recovery of DNA evidence after reduction of CSI attendance rates (e.g. if more police officers are now responsible for this task, this could imply a lack of forensic awareness or skills in this particular area)[4], thus pointing to an adverse effect of the SLA. This supports the argument that instead of merely decreasing CSI attendance, rather an efficient screening procedure should be implemented concurrently, to enhance forensic evidence effectiveness. A closer investigation into this issue would certainly prove beneficial, since non-moveable DNA evidence was shown to strongly contribute to reaching a criminal charge in volume crime investigations. The use of this type of evidence should therefore not be disregarded.

Conclusion

The elucidation of volume crimes is due to their high abundance considered as especially important and a major part of the application of forensic science is directed at their investigation. A review of the literature, however, has highlighted major problems in CSI deployment, which arise through a disregard of the actual extent to which crime scenes compel forensic examination, caused by a lack of knowledge in those responsible for resource management. Since the total contribution of forensic evidence is hard to determine in a single study, due to the complexity in the investigative process, this study was decided to focus on providing knowledge which can be supportive to the work of the CSI and those undertaking screening of the crime scene.

The current study has illustrated that nature and location of forensic evidence can influence its effectiveness in converting a detection into a criminal charge in volume crime cases. The main findings highlighted a positive effect of the presence of DNA, footwear, and multiple evidence types on the effectiveness of forensic evidence. The association between forensic evidence ineffectiveness and the presence of fingerprints was explained through the high abundance of fingerprints and their high likelihood to belong to the victims.

These findings support towards an increased understanding of the nature of forensic evidence and the factors influencing its forensic potential, which is crucial for proper integration of forensic science into the investigation process. This should increase police officers' forensic awareness at the crime scene and support them in their decision-making process. An estimate of the value of forensic evidence and awareness of what aspects influence detection-charge rates, might further lead to a more positive view of forensic science in police officers. An enhanced knowledge of the potential of

forensic evidence could be beneficial to the selection of evidence to be submitted to laboratories and provide a better evaluation of what to expect from the evidence submitted. Awareness of the limitations of forensic evidence, especially the factors reducing its effectiveness, could also enhance consciousness and execution of evidence preservation. Overall, through a greater knowledge of forensic evidence amongst police officers, forensic science would be a significant step closer to its proper implementation into the criminal justice system and could expand its use in volume crime investigations to its full potential. This would finally enable investigators to use their strongest weapon in the administration of justice efficiently.

The results of this study are further valuable for a profound understanding of how context shapes the meaningfulness of forensic evidence, as they highlighted that forensic evidence can have different effects in the contexts of different crimes and that combinations of different features of the forensic evidence can further influence its effectiveness. The most pertinent finding revealed a high effectiveness of DNA evidence when found on a fixed object, as opposed to a moveable object, which instead was related to low effectiveness of the evidence. Further research is needed to consolidate this understanding of how the contextual aspect of forensic evidence influences its effectiveness and could focus on a deeper examination of its effectiveness in the investigation of different crimes. With this contextual understanding of forensic evidence, police officers will be able to assess different crime scenes on their specific forensic potential, and therefore manage the deployment of CSIs more efficiently. Conversely, CSIs can focus on main areas of interest during their investigation. Assimilation of this knowledge into routine practices of police officers and CSIs, will add towards improved efficiency of investigations.

While this study used research data from one police force only, which may limit the generalisability of results, it provided an opportunity to compare pre and post SLA attendances of CSIs through the possibility to evaluate resource management. An examination of the recent service level agreement showed that caution must be exercised when reducing the attendance of forensic support staff, especially when replacing them with personnel less specialised in the forensic field. Although there was no effect of the reduction of CSI attendance rates on the effectiveness of forensic evidence per se, therefore supporting the implementation of the SLA, it was linked to a lack of high effectiveness for DNA evidence identified prior to its implementation. Such deficiencies, if neglected, could lead to a decrease in effective use of forensic evidence in the long run. To counter this issue, education of the staff responsible could be directed at identifying these deficiencies and improve understanding and handling of the affected evidence type. Additionally, the lack of a positive effect of the SLA suggests that training in forensic awareness could be beneficial and points to the need of improved screening methods for crime scenes to increase effectiveness of forensic evidence even further. Such optimisation of scene screening strategies is crucial for assuring that resources are spent on the identification and recovery of evidence useful to the particular investigation. Only then, can valuable evidence be produced.

In conclusion, these findings demonstrate the importance of context in assessing the forensic potential of crime scene evidence. With these features differentiating between effective and ineffective evidence identified, the improvement of forensic evidence efficiency comes down to the adaption of this knowledge into the practices of investigators. With improvement of forensic evidence handling at the crime scene, opportunities for improvement along the line are given.

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Appendix

Table 6: Offence categories as recorded by the police in raw data

Offence categories	Frequency *n*
Aggravated burglary - dwelling	1
Aggravated burglary business and community	3
Aggravated burglary in building other than a dwelling	1
Aggravated burglary residential	1
Aggravated vehicle taking	9
Arson not endangering life	1
Assault a constable in the execution of his / her duty	1
Assault occasioning actual bodily harm (Section 47)	2
Attempt Burglary dwelling	2
Attempt Burglary in a building other than a dwelling	6
Attempt murder	1
Attempted burglary business and community	4
Attempted burglary residential	3
Burglary business and community	89
Burglary dwelling	130
Burglary in a building other than a dwelling	110
Burglary residential	118
Criminal damage to dwelling (under £5000)	15
Criminal damage to other building (under £5000)	11
Criminal damage to other property (over £5000)	1
Criminal damage to other property (under £5000)	8
Criminal damage to vehicle (over £5000)	1
Criminal damage to vehicle (under £5000)	18
Fraud/forgery associated with vehicle or driver records	1
Going equipped	1
Handling stolen goods	1
Making off without payment	2
Permitting premises to be used for Class B drug offences	1
Possess class B controlled drug - cannabis	1
Robbery - Business	13
Robbery - Personal	6
Theft from a motor vehicle	26
Theft from shops and stalls (Shoplifting)	11
Theft in dwelling other than auto machine or meter	7
Theft or unauthorised taking of a motor vehicle	42
Theft other	9
Unknown*	41
Vehicle interference/tampering - motor vehicle	7
Wounding with intent to do GBH Section 18	1
Grand Total	**706**

Note: Offences marked in red were excluded from the data set based on the volume crime criteria.
*Crimes were excluded amongst those with missing Outcome/Hit Exhibit Descriptions.

Table 7: Outcome categories as recorded by the police in raw data

Outcomes categories	**Frequency *n***
1: Charged	32
1: Summonsed/postal requisition	7
10: Police - formal action not in public interest	1
14: Victim declines/unable to support action to identify offender	7
15: CPS - named suspect, victim supports but evidential difficulties	3
15: Police - named suspect, victim supports but evidential difficulties	16
16: Victim declines/withdraws support - named suspect identified	20
17: Suspect identified but prosecution time limit expired	1
18: Investigation complete no suspect identified	123
1A: Alternate offence charged	2
1A: Alternate offence summonsed/postal requisition	2
2: Youth caution	1
4: TIC (taken into consideration)	11
5: Offender has died	1
8: Community resolution	10
9: CPS - prosecution not in public interest	1
Hist - 1. Charged/summonsed	213
Hist - 15. Named suspect ID-victim supports but ED	142
Hist - 1A. Suspect charged with an alternative offence	1
Hist - 2. Caution-youths	4
Hist - 3. Caution-adults	7
New	60
Unknown	41
Grand Total	**706**

Note: Offences marked in red were excluded from the data set. ‘Unknown’ refers to those cases where the outcome description was unavailable.

Table 8: Percentages and Chi Square results for comparison of evidence presence and absence on effectiveness

Variable	**Forensic Evidence Effective (*n*=225)**	**Forensic Evidence Ineffective (*n*=220)**	***X²***
Fingerprint Present	46.7%	71.4%	$X^2(1)=28.02$, p = .000, *V* = .251
DNA Present	50.2%	30.9%	$X^2(1)=17.19$, p = .000, *V* = .197
Footwear Present	14.2%	0.9%	$X^2(1)=27.94$, p = .000, *V* = .251
Multiple Evidence Present	10.7%	3.2%	$X^2(1)=9.62$, p = .002, *V* = .147

Table 9: Percentages and Chi Square results for comparison of evidence presence and absence on effectiveness, per offence category. The table presents only significant results

Burglary Business	**Forensic Evidence Effective (*n*=32)**	**Forensic Evidence Ineffective (*n*=23)**	***X²***
Multiple Evidence Present	18.8%	0.0%	$X^2(1)=4.84$, Fisher's = .035, *V* = .297
Burglary Residential	**Forensic Evidence Effective (*n*=88)**	**Forensic Evidence Ineffective (*n*=89)**	***X²***
Fingerprint Present	47.7%	75.3%	$X^2(1)=14.20$, p = .000, *V* = .283
Footwear Present	22.7%	1.1%	$X^2(1)=19.75$, p = .000, *V* = .334
Other Burglary	**Forensic Evidence Effective (*n*=36)**	**Forensic Evidence Ineffective (*n*=40)**	***X²***
Fingerprint Present	36.1%	75.0%	$X^2(1)=11.66$, p = .001, *V* = .392
DNA Present	66.7%	30.0%	$X^2(1)=10.22$, p = .001, *V* = .367
Footwear Present	13.9%	0.0%	$X^2(1)=5.95$, Fisher's =.020, *V* = .280

Note: The 'Total *n*' for 'Forensic Evidence Effective' and 'Forensic Evidence Ineffective' change based on number of cases present within each offence category.

Table 10: Percentages and Chi Square results for comparison of evidence features and their combinations on effectiveness

Variable	**Forensic Evidence Effective**	**Forensic Evidence Ineffective**	***X²***
For 'DNA present'	Total *n*=113	Total *n*=67	
DNA Fixed	47.8%	28.4%	$X^2(1)=6.59$, p = .010, $V = .191$
DNA Inside + Moveable	38.9%	58.2%	$X^2(1)=6.29$, p = .012, $V = .187$
For 'DNA present'	Total *n*=112	Total *n*=66	
DNA Not POE + Moveable	41.1%	63.6%	$X^2(1)=8.46$, p = .004, $V = .218$
DNA Not POE + Fixed	25.0%	10.6%	$X^2(1)=5.45$, p = .020, $V = .175$
DNA Inside + Not POE + Moveable	34.8%	51.5%	$X^2(1)=4.78$, p = .029, $V = .164$
For 'Fingerprint present'	Total *n*=97	Total *n*=155	
Fingerprint Inside + POE + Moveable	0.0%	4.5%	$X^2(1)=4.51$, Fisher's =.046, $V = .134$

Note: The 'Total *n*' for 'Forensic Evidence Effective' and 'Forensic Evidence Ineffective' change based on number of missing values present within the analysed variables.

Table 11: Percentages and Chi Square results for comparison of pre- and post-SLA cases on effectiveness, and effectiveness of evidence features within each of these two groups. Only relevant results are presented

Variable	**Pre-SLA (*n*=335)**	**Post-SLA (*n*=110)**	***X²***
FE Effective	49.3%	54.5%	$X^2(1)=.93$, p = .335, $V = .046$
FE Ineffective	50.7%	45.5%	
Pre-SLA (*n*=335)	**Forensic Evidence Effective (*n*=165)**	**Forensic Evidence Ineffective (*n*=170)**	
Fingerprint Present	52.1%	75.9%	$X^2(1)=20.56$, p = .000, $V = .248$
DNA Present	47.3%	27.1%	$X^2(1)=14.68$, p = .000, $V = .209$
Footwear Present	20.9%	0.6%	$X^2(1)=16.67$, p = .000, $V = .223$
Multiple Evidence Present	9.7%	3.5%	$X^2(1)=5.19$, p = .023, $V = .124$
For 'DNA present'	Total *n*=78	Total *n*=45	
DNA Fixed	47.4%	22.2%	$X^2(1)=7.68$, p = .006, $V = .250$
Post-SLA (*n*=110)	**Forensic Evidence Effective (*n*=60)**	**Forensic Evidence Ineffective (*n*=50)**	
Fingerprint Present	31.7%	56.0%	$X^2(1)=6.60$, p = .010, $V = .245$
DNA Present	58.3%	44.0%	$X^2(1)=2.24$, p = .134, $V = .143$
Footwear Present	23.3%	2.0%	$X^2(1)=10.54$, p = .001, $V = .310$
Multiple Evidence Present	13.3%	2.0%	$X^2(1)=4.66$, Fisher's = .038, $V = .206$
For 'DNA present'	Total *n*=35	Total *n*=22	
DNA Fixed	48.6%	40.9%	$X^2(1)=.32$, p = .572, $V = .075$

Note: Cells shaded in grey present non-significant results.