# The influence of Forensic Advisors on the use of forensic science in the Belgian criminal justice system

## 1. Introduction

Forensic Advisors (FAs), a service of the National Institute for Criminalistics and Criminology (NICC) in Belgium at the free disposal of the magistrates, can help broaden the scope of the possibilities of the forensic expertise or guide the decision to privilege one trace over another for analysis [1]. In addition, within the NICC in Brussels and with external laboratories, they occupy the role as case-, exhibit- and analysis-coordinator. In many cases, they review the complete case file, taking into account all available information (police reports, crime scene investigation, laboratory reports, witness reports, suspect statements) to formulate advice on the analytical strategy to pursue. Considering thus the context of the case, they advise for or against analyses of certain samples or objects [2], with occasionally specifying the sampling strategy on the exhibits for the laboratory experts.

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In the scope of this article, the influence of the advice given by an FA in a case is studied. To do so, the decision to analyse a trace is scrutinised in detail. In cases with FA involvement, the types of traces recommended for analysis and then analysed are investigated. This decision to analyse a trace is then studied through decision tree modelling to determine the significant factors involved in the decision-making process. A closer look is taken on the decision to analyse biological traces, which are also followed up through the process by considering their output and contribution to the case. Finally, the decision-making process of the FAs themselves is studied by determining the factors leading to the recommendation of a trace for analysis.

## 2. Decision-making process regarding trace processing in the Belgian Criminal Justice System

The decision-making process regarding trace processing has been described and the triaging steps have been elaborated in several studies [3,4]. Generally, it can be divided into several steps [3,4]: (1) the decision to attend the crime scene, (2) the decision to search for traces, (3) the decision to collect traces, (4) the decision to analyse traces, (5) the decision to use traces in the inquiry, (6) the decision to collate trace-related information in a structured database and (7) the decision to use traces in court. It has been observed that these decisions were highly intertwined: the former influence the latter (simply by chronological sequence), but the latter also influence the former by anticipation of its use at that decision step.

In comparison with the suggested process based on the observation in the Swiss system, or more precisely the canton Vaud [4], in the Belgian structure, the main actors involved in trace processing are more separated and their roles increasingly compartmentalised, which can partly be explained by the separation of the police being part of the Ministry of the Interior and the magistrates and the NICC being part of the Ministry of Justice. In Belgium, crime scene investigation and collection of objects/exhibits and traces from the crime scene are performed by the crime scene unit (i.e. *evidence collectors* [5]), which is responsible for its processing after a requisition issued by the magistrate to attend the crime scene. After the search for finger marks, shoe marks (and other typical police traces), all collected traces and objects are handed over to the magistrate, who decides which objects and traces are submitted for further analysis. The traces and objects will then be transferred to a criminalistics laboratory for sampling and further analysis. Thus, the magistrate, responsible for the complete judicial process, has to specify in an official request the type of analysis which needs to be performed on the object or the traces. This assessment is often made without previous consultation with the forensic experts. Thus, the sampling process (i.e. techniques used and location of sampling) lies in the hands of the forensic experts, without detailed knowledge of the case or the state of the object on the crime scene due to lack of time and/or access to the relevant information in the case file. The triaging of traces for analysis is thus performed at the moment of submitting objects to the laboratory. Whether, one or 10 specimens are then collected from the objects is at the discretion of the expert (but authorisation needs to be given by the magistrate in its requisition) and often no further triaging is performed before proceeding to analysis. However, when a large number of specimens is to be analysed, the analyses are performed in different phases.

The triaging decision is made at different moments for traces collected at the crime scene and traces collected on objects recovered from the crime scene. Traces collected at the crime scene undergo a triaging step after their collection. However, objects will be submitted for analysis to

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an external laboratory on request of the magistrate, where specimens will be collected and, in the clear majority of cases, analysed. Traces are collected from objects for the purpose of being analysed. The triaging step is thus shifted to the collection stage. In comparison, in the canton Vaud in Switzerland (location of the previous study), the sampling of traces on transportable objects is performed by the crime scene unit at their laboratories. Triaging of the traces amongst all collected traces (from the crime scene and the objects) then occurs, and the chosen traces are submitted to an external laboratory for analysis. In many cases, traces are submitted in batches, waiting for the results of the first batch before sending the next one.

Triaging of traces is paramount when considering financial aspects as well as personnel resources. Laboratory backlog can be avoided or at least not increased by selecting and filtering out the potentially most useful traces, at best chosen based on their perceived utility in the context of the case [6]. The Forensic Advisors' role is aligned with this decision step, guiding the magistrates in matters of scientific analyses: outlining analytical possibilities, preferred sequence of multidisciplinary analyses and prioritisation of analyses. While the first two mainly involve knowledge about technical aspects, their work largely encompasses the consideration of the context of the case, the history of the objects (sampling conditions, previous analyses, etc.), and the available results in order to make informed decisions regarding the triaging of traces. It is thus of importance to understand whether their expertise is taken into account when deciding which traces to analyse and which traces they consider relevant for recommendation for analysis.

# 3. Data and methods

## 3.1. Study data and methodology

Cases with involvement of the FAs between January 2014 and June 2016 were studied in detail. Homicide, robbery and burglary cases were studied as they presented the majority of the workload of the FAs [1]. All types of traces as well as their flow through the case were inventoried in a purpose-built Filemaker® database. The data could then be extracted to a Microsoft® Excel datasheet for pre-treatment. Visualisation of the data was performed with Tableau® Software and R® was used for statistical analysis and modelling.

## 3.2. Variables

Two dichotomous dependent variable are considered in this study: the *analysis of a trace* (whether the trace is analysed or not; 1 = trace was analysed, 0 = trace was not analysed) and the

*advice for the analysis* of a trace (whether a trace is recommended for analysis by the FA; 1 = trace was recommended, 0 = trace was not recommended)[1].

In the Swiss system, the decision to analyse a trace was determined to be highly case-specific, context-dependent and influenced by a large number of variables (Bitzer et al. 2016). Factors from several knowledge dimensions (strategic, situational, physical, criminal and utility) contributed to the decision to analyse a trace. In this study, these same dimensions will thus be considered. The independent variables were separated into the four environments defined by [7] with the addition of a utility knowledge dimension [6], including previously available information (see Table 1). Some variables are case-specific, and thus the same for all the traces in the case, whereas others are trace-specific. The involvement of an FA and the advice for analysis are considered strategic factors.

*Table 1: Description of independent variables used to model the decisions under scrutiny. For the sake of simplicity, the term "identification" of the suspect will be used here. However, this should not be understood in an evaluative/interpretative manner. The variable marked with (*) (i.e. the type of trace) is not available for the first model (analyse a trace). Variables marked with (#) are not available for the second model (recommended for analysis).*

| Variable | Type | Case- or trace-specific | Description |
|---|---|---|---|
| Strategic | | | |
| Prosecutor or Investigating Judge | Binary | Case | Depending on the judicial phase, a King's prosecutor or an Investigating judge is responsible for the case (Prosecutor = 1) |
| Forensic advisor | Categorical | Case | Five forensic advisors |
| Recommended for analysis # | Binary | Trace | Trace was recommended for analysis = 1 |
| Type of cases | Categorical | Case | Three types: Simple, complex or review (for details, see [1]) |
| District | Categorical | Case | Three districts: Antwerp, Brussels, Liege |
| Immediate | | | |
| Use of a weapon | Binary | Case | A weapon (gun, knife, . . .) was used |
| Type of target | | | Three categories: business, public and private (i.e. shop, street, apartment) |
| Surveillance camera | Binary | Case | Surveillance camera images available, no information about the quality of these images |
| Witness report | Binary | Case | Witness report available, no information about the quality of this report |
| Violence against victim | Binary | Case | Victim was hurt by the offender(s) |
| Number of offenders | Ordinal | Case | Number of offenders described in the summary of the case |

[1] A trace is considered non-recommended either due to advice against the analysis of this trace or not considered for recommendation because other traces have been privileged for analysis.



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| Age of the victim | Ordinal | Case | Age of victim in categories (10, 20, 30, …) |
| Gender of victim | Binary | Case | Gender of the victim (Male = 1) |
| Gloves | Binary | Case | Offenders were described as wearing gloves |
| Mask | Binary | Case | Offenders were described as being masked |
| Physical | | | |
| Type of trace # | Categorical | Trace | Biological trace, gun shot residues, ballistics, etc. |
| Matrix of the trace* | Continuous | Trace | Probability of obtaining a positive result (which can be used for comparison) on a specific matrix in the year before the decision about analysis of this trace |
| Criminal | | | |
| Link | Binary | Case | Crime link is known, as registered in the database, the link is known before the analysis of the trace |
| Utility | | | |
| Positive result | Binary | Trace | Positive result (a profile suitable for comparison) available within the specific case before analysis of the trace |
| Suspect known | Binary | Case | Police inquiry led to the identification of a suspect before analysis of the trace |
| Identification available | Binary | Trace | Identification by DNA or other types of traces before analysis of the trace |
| Suspect identification | Binary | Trace | Suspect identification through DNA analysis available before analysis of the trace |

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## 3.3. Analytical strategy

Algorithms from classification modelling were applied to determine the factors influencing the decisions under scrutiny in this study. Decision-tree modelling, from simple CART and single decision tree C5.0 to complex bagged trees, was preferred as it allows for the integration of different types of variables. Decision tree modelling constitutes a simple feature selection technique allowing to identify the few most important variables which help predicting the outcome (i.e. the decision under scrutiny). The statistical procedure is based on Kuhn and Johnson [8]. The dataset was partitioned in a training set and a test set, with a split ratio of 0.8, and 100 times recursively resampled. Highly correlated variables (threshold ≥ 0.75) as well as near zero variance variables were removed. To compare the different algorithms, their performance was assessed through ROC (receiver operating characteristics) curves and the corresponding area under curve (AUC), sensitivity and specificity. The final models were then constructed by applying the chosen algorithm on the complete dataset according to the decision under scrutiny.

# 4. Results and discussion

First an overall description of the results is presented, then the attrition flow of biological traces recommended for analysis by an FA and the ones not recommended for analysis is shown. This is followed by a statistical analysis of the decision to analyse a trace; the decision to analyse a trace considering all types of traces in homicide cases and the decision to analyse a biological trace in homicide, robbery and burglary cases. Finally, if the recommendation for analysis influences the decision to analyse a trace, it is interesting to study the influence of the variables on the decision to advise a trace for analysis.

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## 4.1. Descriptive analysis of dataset

Burglary, robbery and homicide cases with the intervention of FAs were studied in detail. An inventory of objects and traces collected, advised for analysis or not, analysed or not and the results obtained for the performed analyses was established. 83 cases with traces were encoded, with a total of 1927 collected traces (all types of traces) including biological traces (nuclear, Y-STR and mitochondrial), gunshot residues, ballistics, microtraces, and others (see Table 2). Although the search for and the analysis of historically police types of traces, such as fingermarks and shoemarks, are generally performed by the crime scene unit and thus, before the intervention of the FA, a few of these traces were advised for analysis by the FA (Table 2), after reviewing the complete case file. The same applies to toxicological analyses, which are performed following the autopsy. In all types of offence, the recommendation and analysis of biological traces is by far the most important type of trace considered, in terms of number of traces recommended and analysed. When the trace is recommended for analysis, the analysis rate is generally higher than when the trace is not recommended for analysis.

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*Table 2: Summary of the number of recommended and non-recommended collected and analysed traces per type of trace and type of offence. (*) includes: traces analysed before the intervention of an FA, not recommended for analysis in a first phase of analysis and the traces advised against analysis.*

| | Robbery | | | | Burglary | | | | Homicide | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recommended for analysis | | Non-recommended for analysis* | | Recommended for analysis | | Non-recommended for analysis* | | Recommended for analysis | | Non-recommended for analysis* | |
| | N collected | N analysed (%) | N collected | N analysed (%) | N collected | N analysed (%) | N collected | N analysed (%) | N collected | N analysed (%) | N collected | N analysed (%) |
| **TOTAL** | **63** | **60 (95)** | **241** | **159 (66)** | **12** | **7 (58)** | **67** | **49 (73)** | **374** | **303 (81)** | **1170** | **608 (52)** |
| **Biological traces** | 57 | 54 (95) | 121 | 54 (45) | 12 | 7 (58) | 35 | 18 (51) | 233 | 179 (77) | 734 | 247 (34) |
| **Fingermarks** | 2 | 2 (100) | 90 | 90 (100) | - | - | 26 | 26 (100) | 3 | 3 (100) | 277 | 257 (93) |
| **Ballistics** | - | - | - | - | - | - | - | - | 49 | 49 (100) | 42 | 42 (100) |
| **Microtraces** | 1 | 1 (100) | 9 | 0 (0) | - | - | 1 | 0 (0) | 39 | 36 (92) | 30 | 19 (63) |
| **Gunshot residues** | - | - | 1 | 1 (0) | - | - | - | - | 12 | 11 (92) | 36 | 24 (67) |
| **Shoe marks** | 3 | 3 (100) | 16 | 13 (81) | - | - | 5 | 5 (100) | - | - | 17 | 6 (35) |
| **Textile** | - | - | - | - | - | - | - | - | 12 | 6 (50) | 11 | 2 (18) |
| **Toxicology** | - | - | - | - | - | - | - | - | 5 | 3 (60) | 11 | 2 (18) |
| **Other** | - | - | 4 | 1 (25) | - | - | - | - | 21 | 16 (76) | 12 | 9 (75) |

For biological traces in homicide cases, the flow of traces through the complete process can be seen in Figure 1. A first difference between the traces recommended for analysis and those not recommended for analysis can be seen in the analysis rates. Indeed, 77% of recommended traces were analysed, whereas only 34% of non-recommended biological traces were analysed. In addition, the recommended analysed traces appear to deliver better results: 78% of recommended analysed biological traces yield a useable result (i.e. profile that can be used for comparison) compared to 55% of non-recommended analysed biological traces. The comparison (within the case and with the database) and individualisation rates appear to be similar for both groups. However, the rate of pertinent individualisations (i.e. individualisation linking the suspect and the crime scene/ the victim or the victim and a potentially crime-related object seized from/on a suspect) appears to be higher for recommended (56%) traces than for non-recommended traces (27%).

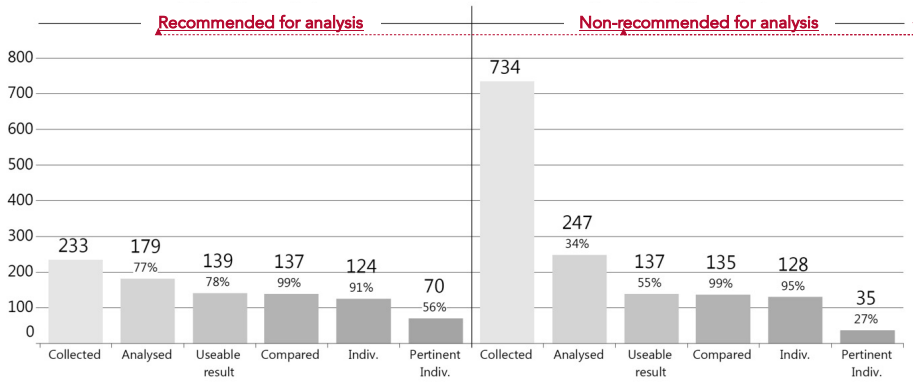


*Figure 1: Attrition rates for biological traces in homicide cases, from collection, analysis, useable results, comparison, individualisation to pertinent individualisation recommended for analysis compared to biological traces not recommended for analysis, with the percentage referring to the ratio with the previous column.*

The individualisation rate appears to be very high, compared to the values found in the literature (e.g. mean identification rates (identification compared to analysed ) around 30% were found for Australia and the United Kingdom [9–11]). In this case, these identification values lie at 69% for recommended traces (124 individualisations for 179 analysed traces), and at 52 % for non-recommended traces (128 individualisations for 247 analysed traces). When taking a closer look at the numbers of individualisations and pertinent individualisations (see Table 3), it can be noted that most individualisations that have been yielded are with the victim's profile. For non-recommended traces, a large proportion of the individualisations can also be attributed to a person known to the victim (*Other* in Table 3). For the recommended traces, many individualisations with the victim are yielded, however a larger proportion can be considered pertinent than for the non-recommended traces.

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*Table 3: Detail of the individualisations and pertinent individualisations reached for traces recommended for analysis and those not recommended for analysis.*

| | N | | | |
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| ***Individualisation detail*** | **Recommended for analysis** | | **Non-recommended for analysis** | |
| | **Individualisation** | **Pertinent individualisation** | **Individualisation** | **Pertinent individualisation** |
| ***Suspect only*** | 19 | 19 | 14 | 14 |
| ***Victim only*** | 84 | 23 | 58 | 3 |
| ***Suspect + Victim*** | 14 | 14 | 10 | 7 |
| ***Victim + Other*** | 4 | 0 | - | - |
| ***Other*** | 3 | 0 | 46 | 0 |

## 4.2. Comparison and selection of classification model

Different classification models were applied to the resampled training and the corresponding test sets in order to determine the best classification model for the given dataset. More specifically, the application of different classification models aimed at assessing whether the simpler models, which allow for easier interpretation, could compare in terms of performance and accuracy with more complex ones. The obtained boxplots for the resampled performance values (AUROC; Area under ROC measured through a combination of specificity and sensitivity) indicate that the overall performance values were very good (1 being the highest number) for all the models tested (see Figure 2).

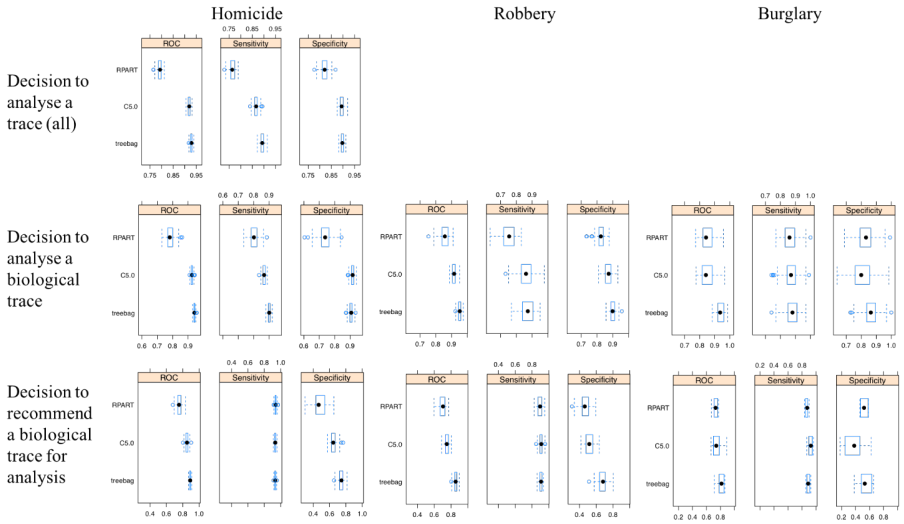


*Figure 2: Comparison of performance values (AUROC, sensitivity and specificity values) for all tested models using resampled training and test sets (n = 100) for the decision to analyse a trace (all types of traces), the decision to analyse a biological trace and the decision to recommend a biological trace for analysis in homicide, robbery and burglary cases.*



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*The C5.0 models were chosen for classification modelling, as a compromise between good performance results and simplicity of interpretation. As the number of traces other than biological traces was very low for robbery and burglary cases, no classification model for the decision to analyse all traces for these types of cases was compiled.*

As the aim of this study is to identify the variables affecting a given decision and to understand their relationship, the C5.0 decision tree algorithm has been chosen for all considered datasets. For most decisions, these models created with the C5.0 algorithm compare well to the more complex bagged tree models in terms of AUROC values.

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## 4.3. Decision to analyse traces

As discussed in the previous section, the recommendation of a trace for analysis by an FA leads to a higher ratio of the number of analysed biological traces per number of collected traces. This recommendation and the further decision by the magistrate whether to analyse a trace taking into account all types of traces were thus studied in more detail, applying decision tree modelling. Only non-police types of traces however were included in the dataset, as FAs do not have a significant influence on the analysis of fingermarks, shoe marks, tool marks, etc. In addition, only homicide cases were considered as the numbers of traces, other than biological traces, are quite small for the remaining types of traces.

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### 4.3.1. Decision to analyse all types of traces

**Homicide**

Out of the 21 variables included in the model, 11 remained significant in constructing the decision tree (see Figure 3). Not surprisingly, the type of trace is the first factor considered when it comes to deciding whether to analyse a trace or not. Indeed, the expected contribution of forensic science in the case depends on the type of trace; the information potential of different types of traces is not identical in different scenarios. Another recurring important variable is the fact of already having a positive result in the case. Indeed, in node 11, when no positive result (i.e. useable result) has been previously obtained in the case, the analysis rate lies at 75%, whereas when a positive result is already available, the analysis rate drops to 33%. The next important variable is the recommendation of a trace for analysis. In node 27, for instance, the fact that a trace is recommended for analysis increases the analysis rate to 71% compared to 19% when the trace is not recommended for analysis. Other variables, such as the type of target (i.e. business, public, private), violence against the victim, the use of a weapon and knowledge about a suspect in the case also influence the decision to analyse a trace.

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Overall, it can be noted that the decision to analyse a trace is very complex. Many factors are involved in this decision, but in the model presented, the recommendation of a trace for analysis by an FA was one of the factors included in the decision to analyse a trace. It can thus be

concluded that their recommendations are taken into account, although many other factors are also considered.

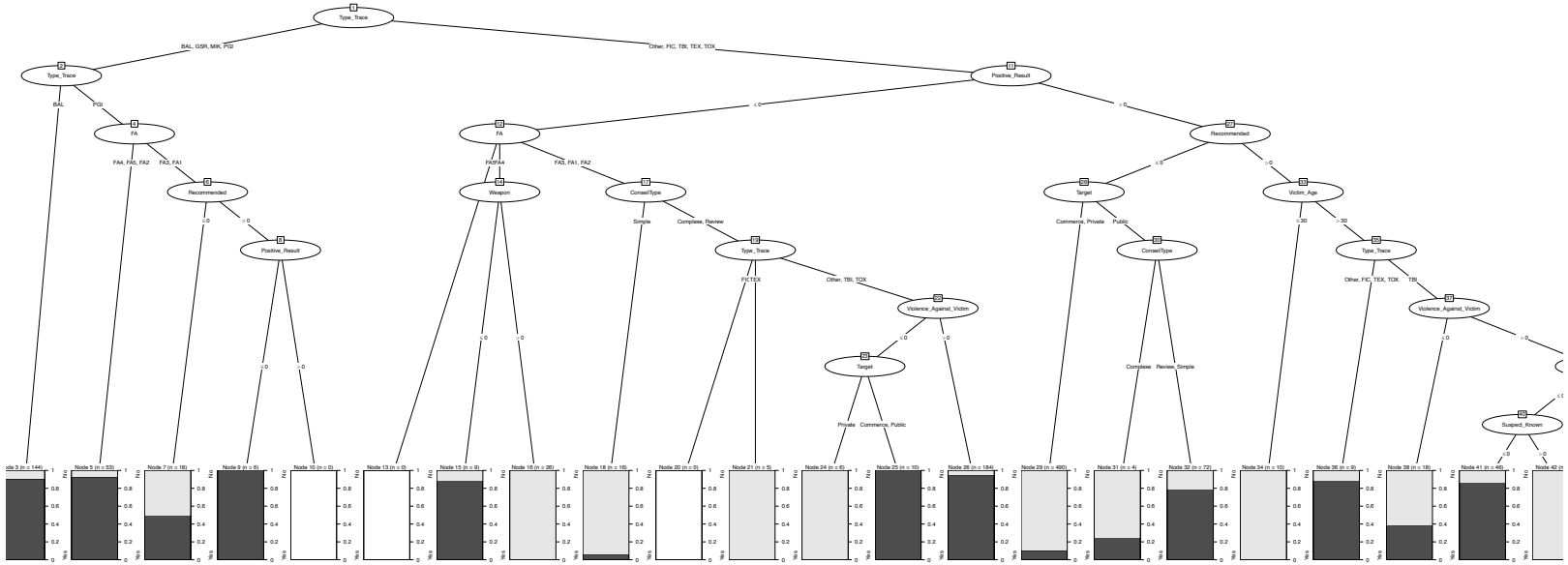


*Figure 3: C5.0 decision tree of the decision to analyse a trace, all types of traces included (at the exception of the typical 'police' traces).*

### 4.3.2. Decision to analyse biological traces

As biological traces represent by far the majority of traces collected and analysed in all three types of offence, it was decided to focus on the decision to analyse this particular trace.

**Homicide**

The decision to analyse biological traces in homicide cases depends on 12 of the 20 introduced variables (which remained after correlation analysis). Initially, the analysis rate lies at 44%. The first variable considered appears to be the age of the victim (see Figure 4 Node 1). When the victim is younger or equal to 50, the analysis rate drops to 37.6%, whereas when the victim is older than 50, the analysis rate is 53%. The ranking of this variable was indeed highly surprising to magistrates to whom the results were presented. In their opinion, this variable does not influence (at all) this stage of the decision-making. Indeed, there is a difference in number of cases between these two categories. In 21 cases, the victim was younger or equal to 50, whereas in 9 cases the age was above 50. In addition, when the victim's age is below 20, the analysis rate approaches 60%. In Node 18, the material the trace was recovered from is considered. Thus, when the material is not favourable to yielding a positive result or no information is available for the type of matrix, a mere 6% of biological traces are analysed. However, when the matrix is favourable, the analysis rate lies at 59.4% of biological traces. Although no statistics exist or are available to the magistrate making the decision to analyse a trace, the latter seem to have a good knowledge about which traces to choose in terms of their potential for yielding a positive result. This same result has also been found for the favourable matrices [12]. In Node 2, the fact that a positive result is already available in the case is considered. When no positive result is available, the analysis rate lies at 69%, whereas in the contrary case, a mere 27.5% of biological traces are analysed. Thus, previous results, whether they deliver information or not, are taken into account when deciding to proceed to subsequent analyses. The fact that the trace is recommended by the FA for analysis is included twice in the model (Nodes 13 and 26), in both cases the analysis increases when the trace has been recommended for analysis. In Node 13, when the trace is not recommended for analysis, a mere 4.3% of biological traces are analysed. However, when the trace is recommended for analysis by the forensic advisor, 66.7% of biological traces are analysed.

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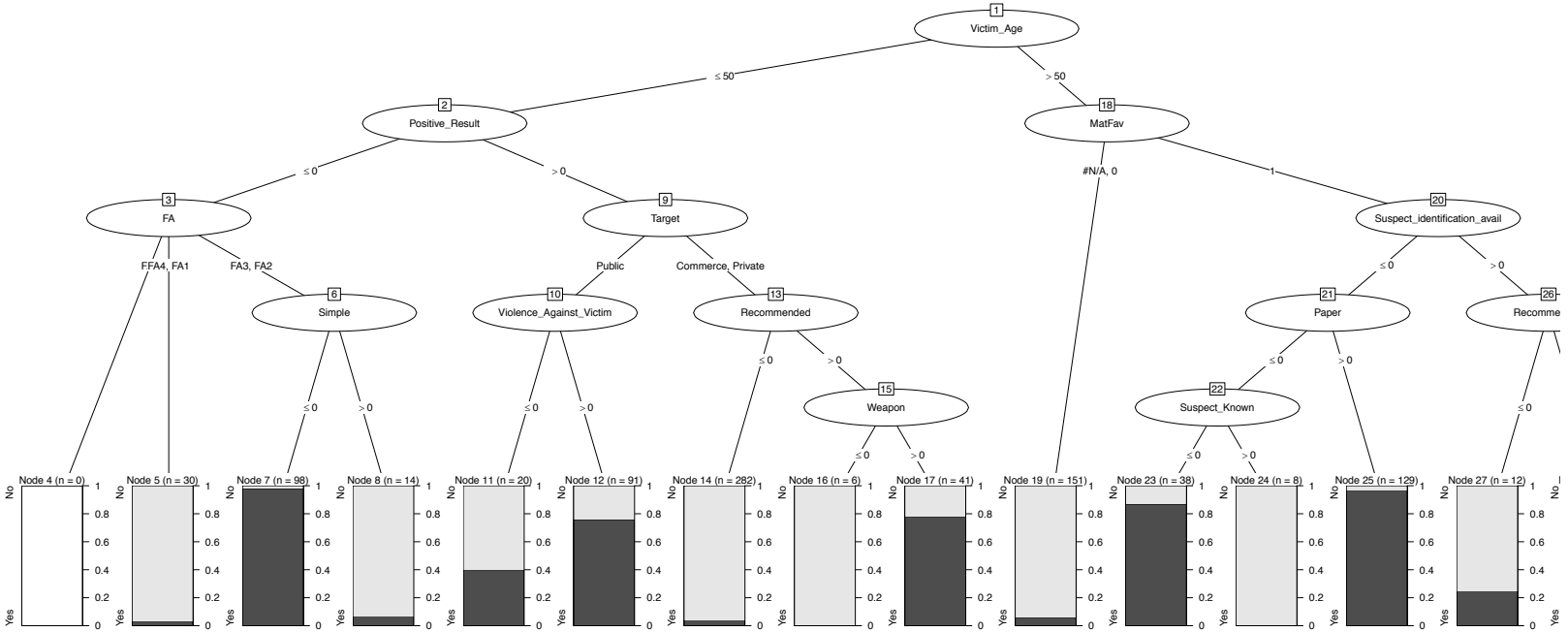


*Figure 4: C5.0 decision tree model for the decision to analyse a biological trace in homicide cases.*

## Robbery

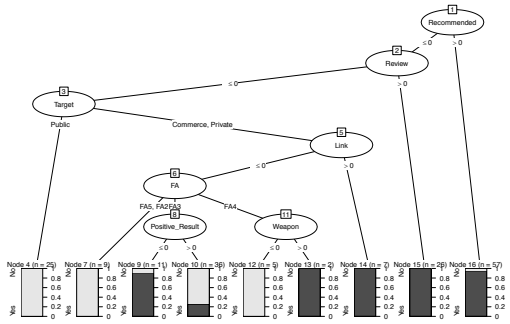


*Figure 5: C5.0 decision tree model for the decision to analyse a biological trace in robbery cases.*

The decision to analyse a biological trace in robbery cases is influenced by 7 out of 19 considered in the modelling variables. Originally, the analysis rate lies at 60.7%. The first variable considered in the model is the fact that a trace is recommended for analysis. When the trace is recommended for analysis, then 94.7% of biological traces are analysed. When the trace is not recommended for analysis, then the analysis rate drops to 44.6%. When the trace is not recommended for analysis, then the type of case handled by the forensic advisor is of importance. When the traces are within a *review* case, then 100% of traces are analysed. Whereas, when it can be considered a *simple* case, then the analysis rate lies at 29.5%.

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## Burglary

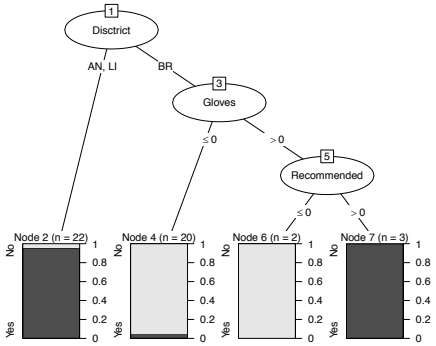


*Figure 6: C5.0 decision tree model for the decision to analyse a biological trace in burglary cases.*

The decision to analyse a biological trace in burglary cases is influenced by 3 of the 18 introduced variables. Again, the fact that a trace was recommended for analysis is considered and positively influences the decision under scrutiny. When a trace is recommended by the forensic advisor, it is always analysed (see Figure 6 Node 7), whereas when a trace is not recommended, it is not analysed (see Figure 6 Node 6).

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## 4.4. Decision to recommend biological traces for analysis

Since the decision to analyse a trace is influenced by the recommendation of a trace for analysis by an FA, the factors leading to the recommendation of a specific trace rather than another is scrutinised.

The decision to recommend a biological trace for analysis in homicide and robbery cases is complex as it depends on many factors (see Figure 7 and Figure 8). In **homicide** cases, factors from all five dimensions are included in the decision in question. The first factor is the age of the victim (type of victim targeted). When the victim is younger or equal to 50, 17% of biological traces are recommended for analysis, whereas when the victim is 50 years old or older, 34% of biological traces are recommended for analysis. Similar to the decision to analyse a biological trace in homicide cases, less traces are recommended when the victim is younger or equal to 50 years old. The influence of some factors is however not always very clear. In both nodes 9 and 23, the matrix of the trace is considered to be important for the decision to recommend a trace for analysis. However, in node 9, when a trace is on a favourable matrix, 7.5 % of these are recommended for analysis, whereas, when the matrix is considered non favourable, 38% of traces are recommended. In node 23, the rate of recommendation increases considerably when the matrix is considered favourable (1% for non-favourable matrices to 57% for favourable matrices). The influence of this variable is thus not completely clear and depends on the other factors or circumstances of the case. Indeed, the variability of the variable relating to the matrix of the trace has been shown in [13], and thus it cannot be relied on.

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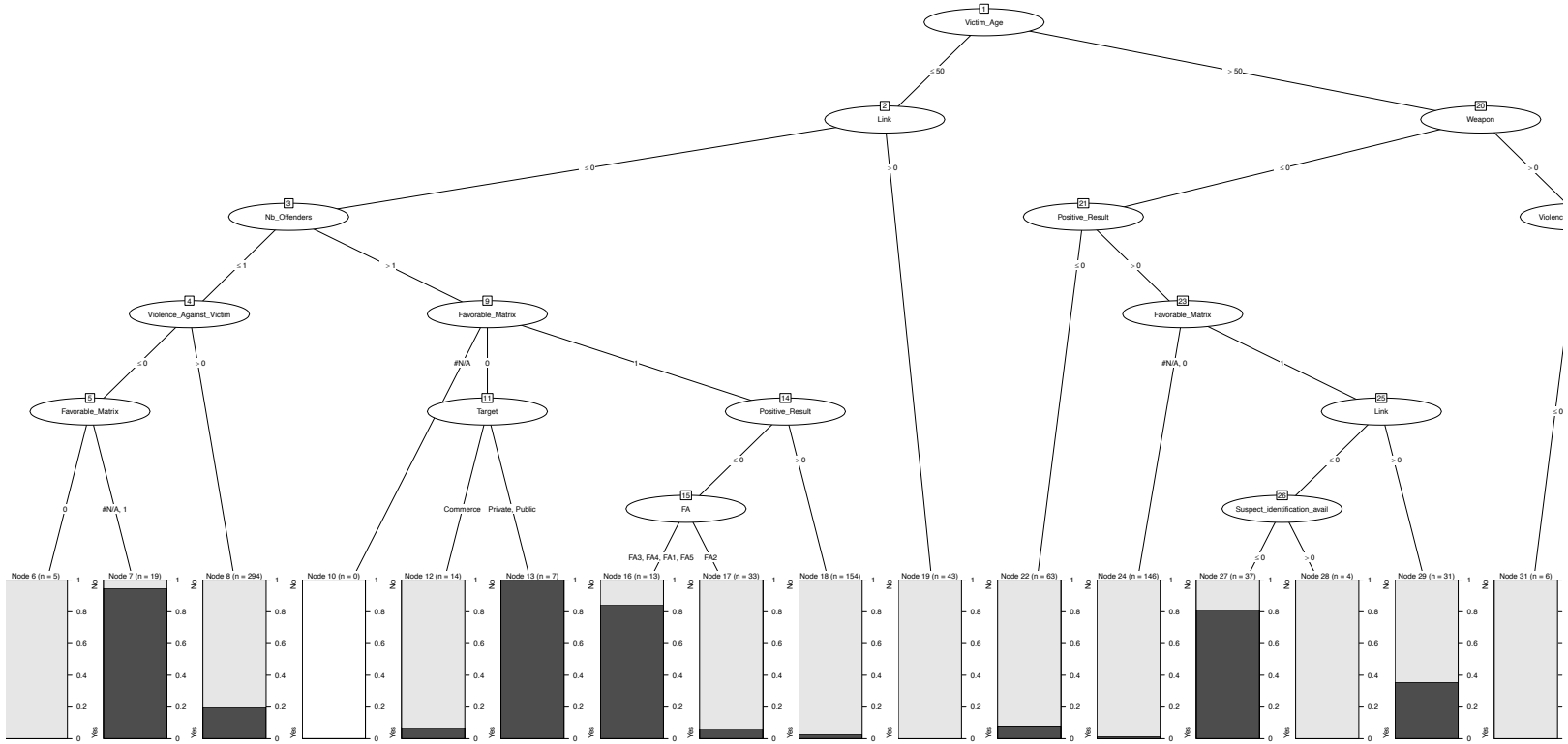


*Figure 7: C5.0 decision tree model for the decision to recommend a biological trace for analysis in homicide cases.*

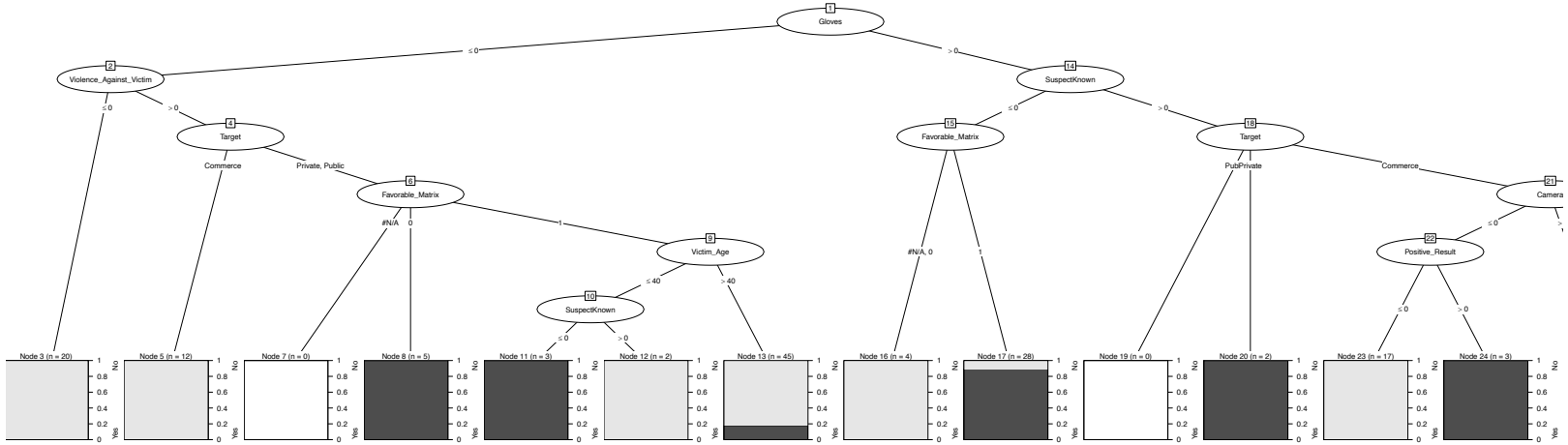


*Figure 8: C5.0 decision tree model for the decision to recommend a biological trace for analysis in robbery cases.*

In **robbery** cases, the first factor to influence the decision to recommend a biological trace for analysis, is whether the offenders wore gloves. When no gloves were worn (or no information was given whether the offender(s) wore gloves), then 18% of traces are recommended for analysis. However, when the offender(s) wore gloves, 45% of biological traces were advised for analysis. This could be explained by the fact that when gloves were worn, it is more difficult to find fingermarks, another type of trace that can lead to the identification of a suspect through a search in a database.

The decision to recommend a biological trace for analysis appears to be quite straightforward in **burglary** cases. Indeed, only 2 variables remain in the final model (see Figure 9). The first factor involved in this decision is the fact that a suspect is known through police inquiry before deciding whether to analyse a trace or not. When a suspect is known, no biological traces are recommended for analysis. When no suspect has been identified thus far, the decision depends on the district; in Antwerp all biological traces are recommended for analysis, whereas in Brussels and Liege a third of biological traces are recommended for analysis. It has to be noted however, that the number of traces is fairly small (e.g. Figure 9 Node 3).

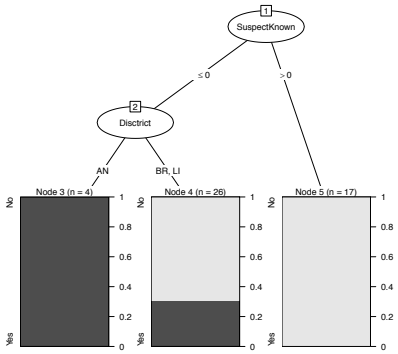


*Figure 9: C5.0 decision tree model for the decision to recommend a biological trace for analysis in burglary cases.*

# 5. Conclusion

The demand for the intervention of the forensic advisor has been increasing over recent years, demonstrating an increasing need for assistance regarding the scientific aspects of a judicial case from a generalist's perspective. Forensic advisors occupy multiple roles, but one of the reasons for their intervention is to provide assistance in the decision to analyse traces [14]. Due to the fact

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that according to the legal procedures magistrates have authority regarding this decision, the influence of FAs on this decision remains unclear. Indeed, when asked about the influence of the forensic advisor on the decision to analyse a trace, magistrates stress the fact that the role of forensic advisors is advisory and that the final decision authority lies with them. And so do the FAs themselves.

Due to this ambiguity, it is particularly interesting to study the influence of the recommendation of forensic advisors on the decision to analyse a trace. According to the results of the decision tree analysis, the fact that a biological trace is recommended for analysis is amongst the significant factors for the decision to analyse a trace in all three offence types studied (homicide, robbery, burglary). In all instances where it influences the decision, the fact that a trace is recommended for analysis by the FA increases the analysis rate for biological traces. Thus, it appears that the magistrate's decision regarding which traces to analyse is guided by the recommendation of the forensic advisor.

The recommendations given by the forensic advisors themselves appear to be quite complex. Similar to previous results [4], the advice is case-specific and shaped by the context of the case. Indeed, when studying their working procedures, forensic advisors take the time to review the complete case file, if available. They consider information from police reports, mainly the crime scene investigation report(s), but witness and suspect interview reports might also influence their recommendations. Indeed, this information can influence the utility of the clue in the case. A suspect confessing to have touched a certain surface previously, might lead to disregarding traces on this surface for analysis.

Not only are the recommendations by the forensic advisors considered in the magistrate's decision to analyse a (biological) trace, but most importantly, it influences the flow of traces through improving the success rates, individualisation rates and pertinent hit rates. Thus, potentially, an increase in utility is generated through the intervention of a forensic advisor.

Overall, the influence and impact of forensic advisors' recommendation could be demonstrated. Through their ability and the opportunity to consider the maximum amount of information from a forensic generalist point of view as well as a continuous contact and exchange of information with forensic experts, they can generate case-specific and context-dependent advice. It is thus of utmost importance for their advice to be relevant, to have access to this information early in the investigation. Indeed, their centralising position in this decentralised system [15], as well as their forensic generalist view allows them to impact on the case flow in a substantial manner, when they are requested and their advice considered.

Further research is ongoing studying the difference in decision-making in cases with intervention of an FA and in cases without their intervention.

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# References


[1] S. Bitzer, L. Heudt, A. Barret, L. George, K. Van Dijk, F. Gason, B. Renard, The introduction of forensic advisors in Belgium and their role in the criminal justice system, Sci. Justice. 58 (2018) 177–184.

[2] A. Barret, Conseiller forensique. Une nouvelle fonction à l'INCC, Just News. (2011).

[3] O. Delémont, S. Bitzer, M. Jendly, O. Ribaux, The Practice of Crime Scene Examination in an Intelligence-Based Perspective, in: Q. Rossy, D. Décary-Hétu, O. Delémont, M. Mulone (Eds.), Routledge Int. Handb. Forensic Intell. Criminol., Taylor & Francis, 2018.

[4] S. Bitzer, O. Ribaux, N. Albertini, O. Delémont, To analyse a trace or not? Evaluating the decision-making process in the criminal investigation, Forensic Sci. Int. 262 (2016) 1–10. doi:10.1016/j.forsciint.2016.02.022.

[5] A. Ludwig, J. Fraser, R. Williams, Crime Scene Examiners and Volume Crime Investigations: An Empirical Study of Perception and Practice, Forensic Sci. Policy Manag. Int. J. 3 (2012) 53–61. doi:10.1080/19409044.2012.728680.

[6] S. Bitzer, N. Albertini, E. Lock, O. Ribaux, O. Delémont, Utility of the clue – From assessing the investigative contribution of forensic science to supporting the decision to use traces, Sci. Justice. 55 (2015) 509--513. doi:10.1016/j.scijus.2015.05.005.

[7] O. Ribaux, A. Baylon, E. Lock, O. Delémont, C. Roux, C. Zingg, P. Margot, Intelligence-led crime scene processing. Part II: Intelligence and crime scene examination, Forensic Sci. Int. 199 (2010) 63–71.

[8] M. Kuhn, K. Johnson, Applied Predictive Modeling, Springer, 2013.

[9] ANZPAA NIFS, End-To-End Forensic Identification Process Project, 2012.

[10] ANZPAA NIFS, End-To-End Forensic Identification Process Project - Phase 2, 2016.

[11] Home Office, Summary Report of the Scientific Work Improvement (SWIM) Package, Home Office, 2007.

[12] A.A. Mapes, R.D. Stoel, C.J. de Poot, P. Vergeer, M. Huyck, Decision support for using mobile rapid DNA analysis at the crime scene, Sci. Justice. (2018). doi:10.1016/j.scijus.2018.05.003.

[13] S. Bitzer, Utility of the Clue. Formalisation of the decision to analyse a trace and insights into the evaluation of the investigative contribution of forensic science, Université de Lausanne, 2016.

[14] S. Bitzer, Factors leading to the implication of Forensic Advisors in the Belgian criminal justice system, Forensic Sci. Int. 285 (2018) 181–188.

[15] E. Casey, O. Ribaux, C. Roux, The Kodak Syndrome: Risks and Opportunities Created by Decentralization of Forensic Capabilities, J. Forensic Sci. 0 (2018). doi:10.1111/1556-4029.13849.


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# Acknowledgments

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