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Quantifying forensic investigations involving bloodstain pattern analysis within the UK☆

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ABSTRACT

Research informed by practice is more likely to have a greater impact on society. However, forensic cases are confidential and thus, real-life data regarding the details of violent crime is usually withheld from the public and academia. Through a partnership between the authors institution and a UK police service, casefiles from 78 criminal investigations from 2012 to 2020 involving Bloodstain Pattern Analysis (BPA) were examined and quantified. The most common methods of assault and weapons used were identified as well as the frequency of different bloodstain pattern classifications. The results of this study will help inform researchers and supply forensic training providers with data derived from forensic practice. Despite a significant body of literature exploring impact patterns and software for calculating the Area of Origin (AO), impact pattern was classified at only 22% of scenes, with sharp-force trauma being the most prevalent form of assault. This paper recommends a review of the BPA terminology, to include additional commonly encountered patterns that are not defined by the current standard.

Bloodstain Pattern Analysis (BPA) is a forensic discipline that involves the observation and interpretation of bloodstaining to provide reconstructive information regarding the events of a crime. BPA reports may include reference to the Area of Origin (AO), sequence of movements, blood volume, age of stains and classification of patterns [3]. There are many different classifications of bloodstains and patterns, which are referred to in academic literature [17] and in terminology documents [1,18,23] . As with other forms of forensic evidence, BPA may aid investigators in determining lines of enquiry, and in court to support or refute prosecution and defence hypotheses. The publication of research literature concerning different deposition mechanisms of blood under various conditions and scenarios is essential information for the analyst to inform and validate practice. Recent BPA research has examined fundamental features of drip patterns [8], software-based AO reconstructions from impact patterns [24], dilute bloodstains [21], coagulation within blood pools [15] and differing surface coating and textile effects on bloodstaining [4,20].

According to Bettison and colleagues [7] further research into "*critical factors that drive practitioner experience*", is needed in order to improve the credibility of BPA as a reliable forensic discipline and field of expertise. Whilst there are literature examples of collaboration between research and criminal justice [5], Beresford and colleagues [6] recognised a disconnect between academia and forensic science practice and recommended that researchers should be proactive in studying areas relevant within the discipline. When research is informed and driven by practice it can have a greater relevance and impact on society. Some researchers may be informed by their own professional experiences of BPA, or with links between academic and forensic institutions. However, for researchers without direct access to case information regarding homicide scenes, it may be difficult to know where the science needs to be directed.

Whilst details of BPA scenes have been published [14], a large, multi-case BPA review has not been available to forensic researchers. This study aims to support academia in directly addressing the recommendation by Beresford and colleagues [6] regarding research relevance by producing a dataset from a large sample of BPA scenes that details factors including the frequency of classified patterns, number of defendants and Injured Parties (IPs) involved, and the location and method of assault. This data may be used to inform future research, including experimental parameters, and forensic training.

1. Method

Through a partnership between the author's institution and a UK police service, the primary researcher was granted access to a forensic archive containing BPA casefiles from 2012 to 2020. 2012 being

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the earliest due to prior forensic work being conducted by the Forensic Science Service [12], and 2021 and 2022 cases being active or not yet archived. The police had 3 BPA practicing scientists during this period. Each BPA casefile varied in size and content but generally included scene notes, diagrams, photographs, expert witness statements, contextual information from pathology reports and email correspondence with Crime Scene Investigators (CSIs) and Police Officers. Each physical casefile/report had been archived at a secure, storage facility. Each report was located by the primary researcher, and notes were collated on site regarding the characteristics of each scene, nature of the crime and bloodstain patterns identified, as the casefiles could not be removed from the facility. The details within these notes were then transferred into a database. The researcher was also granted access to the case tracking system to collect further information related to the initial charge/investigation type. A police staff member provided further information to the primary researcher related to court proceedings that were not detailed in the police archive or database. During the data analysis stage of this study, the primary author attended and passed a UK nationally recognised Level 3 Advanced BPA course which provided the author with a qualified insight into the discipline.

Numerous documents have detailed standardised BPA terminology, with ASB Technical Report 033 [1] being the most recent and recommended by the UK's Forensic Science Regulator [11]. Where terminology in the files deviated from the current standard, these terms were adapted in the results to fit with ASB 033 [1]. For example, where a file included reference to an "arterial" pattern, it was quantified in the data as a projected pattern, in fitting with the current terminology standards. However, ASB 033 [1] does not include all the patterns commonly identified within the casefiles, and these have been highlighted in inverted commas throughout the paper.

2. Results

Data from 79 physical files was collected with initial reporting dates ranging from July 2012 to October 2020. Two scene files were part of a single investigation/case, meaning that the dataset is comprised of 78 investigations and 79 scenes in total.

Fig. 1 details the crime/charge frequency, determined either by the investigation title detailed on the police database, crime scene file or by the court verdict. Where more than one type of crime/charge was known to be brought against the defendant(s), it has been included, thus the total number of charges (82) being higher

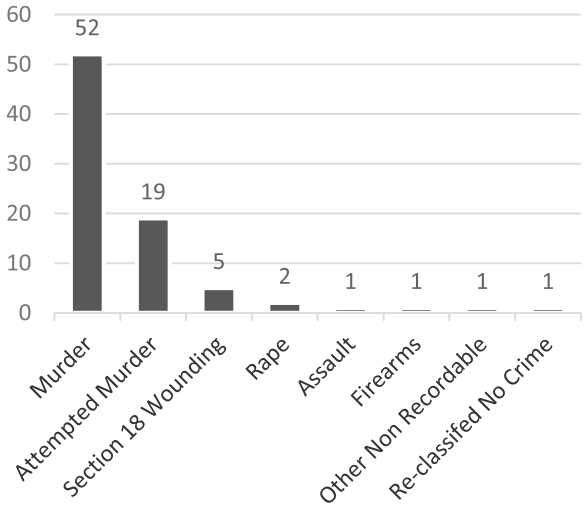

Fig. 1. Crime/charge frequency.

Table 1
Injured Party (IP) frequency and gender.

One IP	56
Two IPs	7
Three IPs	2
Undefined	13
Male	32
Female	24
Undefined	33

than the total number of investigations (78). 0 investigations were categorised as suicides on the police database.

Table 1 details the number of IPs involved in the cases. In the 65 cases where the number of IPs could be defined from the available data: 86% had 1 IP, 11% had 2%, and 3% had 3. Where the gender of an IP was defined within the available data, the majority were male.

As shown in Table 2, the most common number of suspects/defendants was 1, and in the 60 instances where the gender of a defendant was identified from the available data, only 3 were female. This contrasts with the 56 instances where the IP gender was identified and 24 were female.

Fig. 2 displays how frequently different mechanisms of assault were identified within the 78 investigations. In some instances, there were combinations of different mechanisms of assault, resulting in a higher total number of assault types than cases. Fig. 2 illustrates that the most common method of assault in BPA cases was sharp-force trauma, reported in 68% of cases. Blunt-force assaults occurred in 31% of cases. A knife was confirmed to be involved in the assault at 53% of cases. In 28% of cases the researcher was unable to find any information regarding a definitive weapon. (Fig. 3).

Fig. 4 displays how frequently BPA analyses were conducted in a range of different spaces. 6 scenes involved analysis of the interior of a vehicle, with 5 of these scenes being solely a vehicle. 12 scenes involved a combination of indoor and outdoor spaces, and 1 scene involved BPA analysis of a vehicle, an indoor and an outdoor space. Wholly outdoor scenes were only encountered in 3 instances. Indoor areas were the most examined for BPA with bedrooms being the most frequently bloodstained room type.

Fig. 5 illustrates how often bloodstaining was documented in different room types at indoor crime scenes. Bloodstaining was most frequently found in bedrooms of crime scenes, in 28 of 69 indoor scenes. The positioning of the IP during an assault was unreferred to for 65% of the BPA scenes. In two cases, the assault location was referred to but undetermined. When it was referred to, (in 33% of scenes) a specific IP positioning (Low-level: crouching, sitting, lying. High-level: standing) during the assault was established by BPA less often, in 21% of cases. (Figs. 6 and 7).

Fig. 8 illustrates how frequently different patterns were classified in cases and demonstrates that transfer stains were the most classified pattern/stain and were noted in 81% of scene files. Spatter stains were identified at 75% of the scenes. Impact patterns were identified in 22% of scenes, projected patterns in 16% and cast-off in 30%. Where a pattern did not fit the definition of any term listed in

Table 2
Defendant/Suspect frequency and gender.

One Defendant/Suspect	47
Two Defendants/Suspects	4
Three Defendants/Suspects	6
Four Defendants/Suspects	4
Undefined	17
Female	3
Male	57
Undefined	46

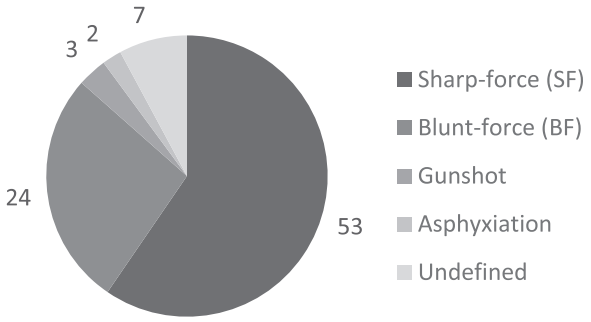

Fig. 2. Assault type frequency.

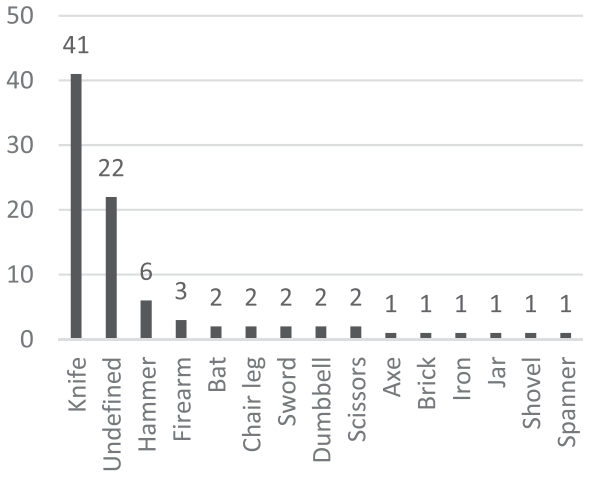

Fig. 3. Weapon involved in assault.

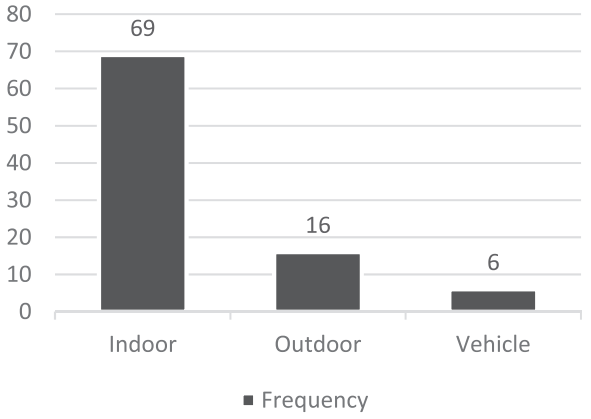

Fig. 4. BPA Scene locations.

ASB Technical Report 033 [1], it has been given in Fig. 8 as it was written in the reports, in inverted commas.

3. Discussion

The data for this study was collected from forensic reports and notes produced by a forensic team of 3 BPA scientists operating in a densely populated urban area in the UK. The content of these reports will have been influenced by the scientists' training, experience, and the processes their lab had accreditation to conduct. Therefore, a study using other BPA scientists with a similar demographic in the UK could have potentially yielded different data fields. The scientists attended crime scenes at the request of crime scene managers. Notably, none of the 78 cases in this study were classified as suicides.

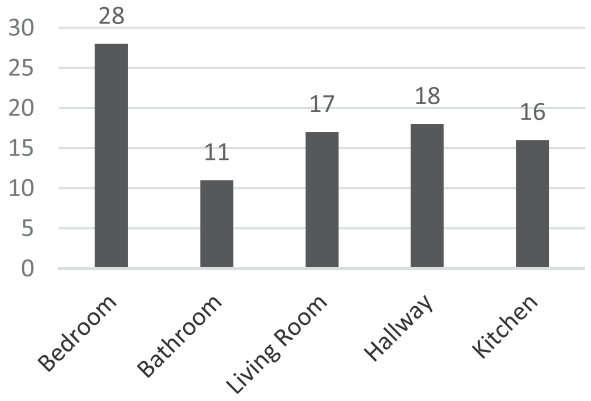

Fig. 5. Bloodstained room types.

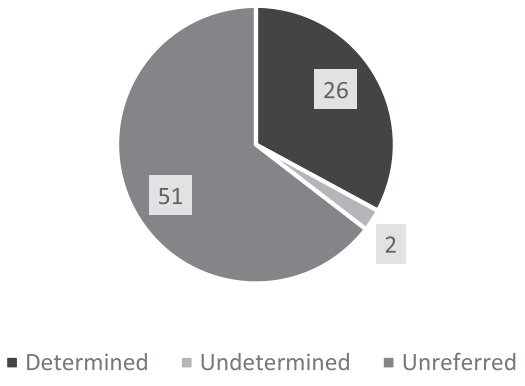

Fig. 6. Assault location.

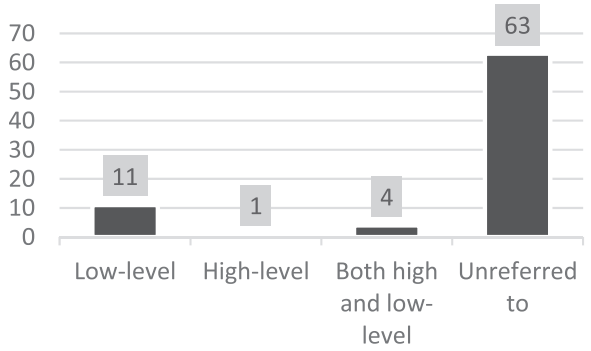

Fig. 7. IP positioning during assault according to BPA.

This is likely due to decision making by crime scene managers to negate BPA in these instances, rather than a lack of suicide occurrence in the area. In other jurisdictions, BPA for suicide investigations may be conducted more frequently. Readers should be aware of the potential for this study's biases when interpreting the results of this study. The physical files and databases contained varying amounts of contextual information per case, so it was not possible to collect data on every parameter in every instance, although every file contained either a BPA witness statement, preliminary report, or notes produced at the scene. Given the limitations of this sample of BPA casework, further work using other demographics and geographical regions with a different group of scientists may yield different data trends.

Damelio and Gardner's [10] "Bloodstain Pattern Analysis" appears to be one of the most cited BPA texts (cited by 551 according to Google Scholar, June 2022). This textbook consists of 4 chapters dedicated to directional bloodstains for the purpose of determining

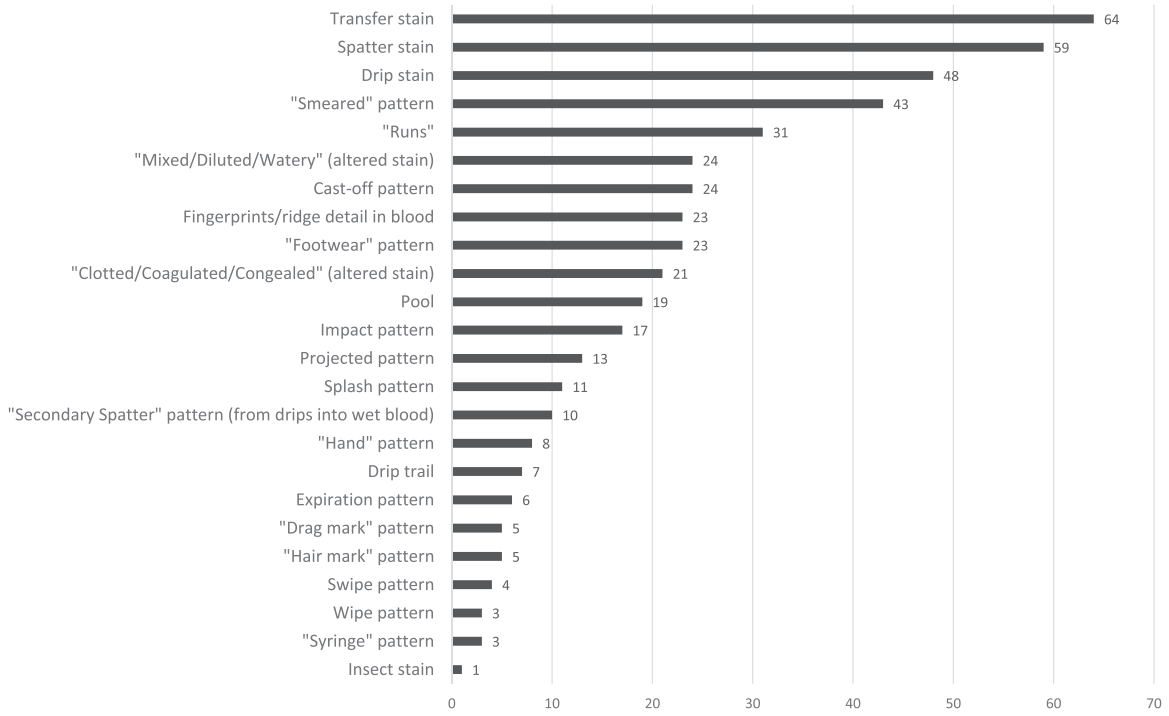

Fig. 8. Stain/Pattern classification frequency.

the Area of Origin (AO) or Area of Convergence (AC), either manually or through digital applications. Home, Norman and Williams [24] reviewed 92 sources related to software-based AO methods between 1987 and 2020, an average of 2–3 publications per year. With such significant bodies of literature focussed on methods of calculating the AO, it was interesting to find AO supposition so rarely referred to in casework, with impact patterns identified at 22% of the scenes and sharp-force trauma being the most common method of assault at BPA scenes.

Swipe and wipe patterns were infrequently identified in this case review. However, it is feasible that these could have been grouped within the broader term of transfer stain and/or “smeared” pattern. Through consultation with the reporting scientists, the “smeared” staining was explained as directional transfer which included swipes and wipes without proceeding towards a narrower classification. Yuen and colleagues [22] found a 32% error rate in the differentiation between swipes and wipes which could explain why the scientists preferred a broader classification. If swipes and wipes have been defined infrequently due to a lack of practitioner confidence because of high error rates [22] further research and training should address this in future. Research could also examine the risk-benefit between broad and specific classifications of “directional transfer”/“smears” or swipes and wipes, respectively.

ASB 033 [1] did not include all the commonly referred patterns identified within the casefiles. It is likely that the “runs” described frequently in the data could fit the description of a “flow” as outlined in the terminology, although this could not be determined with absolute confidence. Distinction between flow and “runs” would aid in the appropriate classification of patterns. ASB 033 [1] did include a definition of a “blood clot” and “altered blood” although this was not fully fitting with the descriptions of incomplete clotting/coagulation that was commonly encountered by the scientists in casework and noted in the BPA files. An update to the BPA terminology could include appropriate terminology for blood that appears to have partly undergone the effects of coagulation prior to deposition. An inclusion of photographic examples in reviewed terminology documents could encourage greater clarity, understanding and adoption of the recommended terminology by more analysts, and authors in future. As Hicklin and colleagues [25] concluded, there remains discrepancies amongst practitioners with regards to classification of bloodstain patterns which could be addressed by a further review of standardised terminology.

4. Conclusion

BPA literature has examined AO methodologies extensively, however this case-review found impact pattern to be classified at less than a quarter of real crime scenes, and sharp-force trauma was far more common than blunt-force trauma. Trauma type frequencies may differ in other regions; for example, rural UK and the USA where firearms are more prevalent [13]. Further case research from a range of different geographic regions will help quantify these potential differences.

The most recent terminology standardisation [1] does not include definitions of some commonly identified patterns from this case-review. “Secondary spatter” is referred to in the Forensic Science Regulator’s BPA guidelines [11] but is not defined in the current terminology. Patterns including “clotted” and “secondary spatter” are likely to continue being included in scientist’s reports, but without standardisation, disparity between expert’s definitions may persist. A further review of the terminology to include these patterns and other’s recommended by forensic scientists globally would improve the standardisation of the field.

Some patterns, such as cessation pattern [1], were not classified at all within this group’s casework. Future research could aim to explain why this pattern, and others, may have been classified infrequently, potentially examining its prevalence and likelihood of being generated, practitioner confidence and knowledge, or the utility of classifying cessation for reconstruction purposes. To the best of these author’s knowledge, there is little literature regarding cessation patterns.

Previous work has noted high error-rates in the distinction of swipes and wipes [22] and this review found the two patterns to be very rarely classified, potentially being more broadly defined as

"smeared" blood. This author recommends the introduction of the broad terms "directional transfer" and "static transfer" in further terminology reviews, and/or further research examining features that can aid in defining swipes and wipes specifically. The inclusion of broad terminology has precedent, as spatter is currently included in ASB 033 [1] and is a broad term that can be used to non-specifically define several patterns including impact, cast-off and projected.

The data produced from this study may be used to inform researchers and forensic training providers that simulate BPA scenes in future work. For example, a simulated scene within an urban area in the UK with commonly encountered characteristics would include sharp-force trauma in a bedroom environment and include transfer, spatter and drip staining. The output from this study will help develop BPA training programmes to meet specific requirements of law enforcement.

CRediT authorship contribution statement

Patrick H. Home: Study Conceptualization, Data collection, Data analysis, Manuscript writing. **Danielle G. Norman:** Study conceptualization, Academic input, Manuscript editing. **Phil Field**: Manuscript proofing, Data collection. **Andrew Palmer:** Manuscript proofing, Data collection. **Mark A. Williams:** Study conceptualization, Academic input, Manuscript editing and proofing.

Declarations of Interest

The authors declare that they have no conflict of interest.

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