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Comparison of Forensic Techniques Utilized in Major and Minor Crimes: Biological Evidence Techniques, Fingerprint and Toxicology Analysis

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Abstract. Forensic techniques are essential to criminal investigations, offering scientific means to identify suspects and reconstruct crime scenes. Even the same method will have different results given the severity of the crimes. The purpose of this paper is to set up an application standard for the four frequently used forensic techniques in major and minor crimes: DNA profiling, body fluid analysis, fingerprint analysis and toxicological analysis. Based on a review of the previous studies and research activities, the strengths and shortcomings of each method are presented here. Based on the above findings, DNA profiling and body fluid analysis are highly accurate and have strong evidential value, thus being widely used in serious crimes, although they are generally more time-consuming and resource-intensive. Fingerprint analysis is slower and more expensive to conduct than minor crimes investigation, so it is not used for that purpose. Most toxicology tests are for poisoning and drug overdose cases. However, in most minor offences, this kind of analysis is generally not needed as toxic substances are seldom associated with the offensive behavior.

Keywords: Forensic technique, Crime investigation, Crime severity, Major and minor crime

1. Introduction

All societies around the world experience crime, ranging from minor offenses to more serious crimes. Major crimes are crimes that cause serious injury to the body or mind, damage to society, and require high-resource investigation, such as murder, sexual assault, poisoning, etc. Minor offenses are less harmful and easier to investigate. But they are more common, such as theft, shoplifting, and minor traffic violations. Major crimes and minor crimes are differentiated according to the severity of the crimes. The Office for National Statistics argues that an analysis of the seriousness of a crime helps in understanding of the demand crime places on the police [1]. It is more sensitive to serious crimes, which typically need more police per case. According to Statistics Canada, the Crime Severity Index (CSI) increased from 73.92 in 2020 to 81.20 in 2023, indicating that investigative demands grew (Fig. 1).

Forensic techniques are scientific methods utilized by investigators to collect and analyze evidence in a criminal case. These methods can be employed to identify suspects or victims, or even

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to reconstruct a crime scene. Various areas of science are involved in this process, including forensic biology and forensic chemistry. There are various factors that influence the results obtained by forensic science, such as the speed with which evidence can be processed, the resources available for investigators and the way forensic work is organized within an agency [2]. The methods used for crimes of different severity are supposed to be different to meet the differing requirements of the cases.

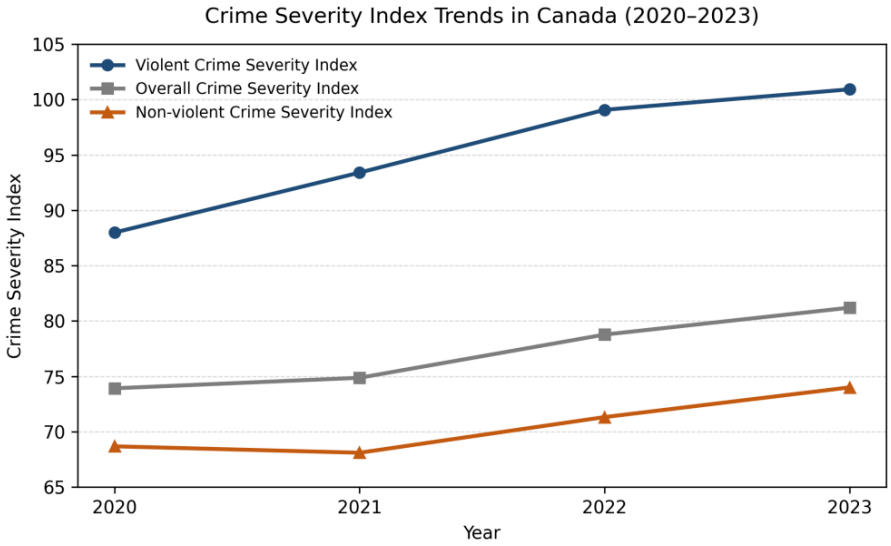

Figure 1. Crime severity index trends in Canada, 2020–2023 (data from: Statistics Canada [3])

Selecting the most appropriate technique for a certain crime contributes to saving time and reducing the waste of police force. At present, the main problem is that forensic techniques are overused in minor crimes and underutilized in major crimes, such as DNA profiling. The rising demand for investigation of major crimes creates conflicts with limited investigative and forensic identification resources. Therefore, it is necessary to establish a better way to decide which forensic techniques to apply. Thus, to offer effective technical support for serious felony cases and to allow for the expedient, convenient, and scientific examination of misdemeanor cases as much as possible, the investigation strategies and forensic resource allocation should be consistent with the severity of the criminal act. Such an alignment can help to optimize the use of investigative and forensic resources.

The purpose of this essay is to systematically organize and compare several commonly used forensic techniques in the investigation of serious felonies and misdemeanors, analyze their strengths and weaknesses and appropriate uses, and clarify the appropriate application methods of forensic techniques in cases of different seriousness.

2. Biological evidence techniques

2.1. DNA profiling

DNA profiling is one of the most critical forensic techniques in modern criminal investigation. It can accurately identify individuals by analyzing genetic markers recovered from biological evidence, which allows investigators to link suspects to a crime scene. Also, advances in molecular genomic technologies have improved the accuracy and efficiency of DNA analysis [4]. Despite these

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technological advances, several challenges remain in DNA profiling. For example, forensic samples often contain degraded DNA, very small amounts of genetic material, or substances that inhibit PCR amplification, which can reduce the quality and reliability of DNA profiles [5]. These increase the complexity of analysis, which make DNA analysis demand more time and resources. As a result, DNA profiling is generally more appropriate for major crimes instead of minor crimes. In major crimes, evidential certainty is critical and the consequences of investigative error are severe, so the higher costs and longer processing times are considered necessary. In contrast, faster and less resource-intensive techniques are sufficient in minor crimes. Overuse of DNA analysis in minor cases may lead to more severe laboratory backlogs and delayed processing of serious cases. Therefore, DNA profiling should be prioritized when the offense justifies the required time and resources.

2.2. Body fluid analysis

Body fluid analysis is a common method in forensic investigation. It aims to identify body fluid left at a crime scene, such as blood, semen, saliva, and vaginal secretions, and link the source and distribution to the offense. Major crimes usually involve the exchange or transfer of body fluids between the victim and the suspect, and therefore, the analysis of major crimes can also be carried out through body fluid analysis. By identifying the type and distribution of body fluids, forensic scientists can reconstruct the essential circumstances (e.g., sexual contact and movement during a fight) of a crime and locate the area where DNA can be collected; this information can then be used as supporting evidence to either include or exclude a suspect from further investigation.

At the same time, body fluid analysis is generally not applied to minor offences. Often, there is little or no biological material left behind; therefore, extended experiments will not be feasible. The two main causes are as follows. First, the probability that evidence remains is considerably low. Minor crimes are generally performed as non-violent or low-violent actions so there is little visible or stable body fluid left at the crime scene. Even though there is a trace amount of body fluid (e.g., blood stains from contact with broken skin), it is highly influenced by environmental humidity, surface material, and degradation factors, and the probability of recovery is definitely lower than that in major crimes. Second, the cost and benefit are imbalanced. Traditional body fluid identification relies on biochemical and enzymatic tests (e.g., acid phosphatase for semen screening and Kastle–Meyer test for bloodstains). Not only is it time-consuming and resource-intensive, but some test methods may consume or even damage evidence, which would influence subsequent DNA analysis. If body fluid tests are used indiscriminately in routine minor crimes, laboratory workloads would be increased, exacerbating the already widespread case backlog and causing delays in body fluid testing for major crimes, which may miss the golden hour of investigation [2].

There would be three core standards used to determine whether body fluid testing should be applied: possibility of body fluid exchange in criminal action — whether the offense has a high likelihood of biological fluid transfer; the evidential attribution value of biological evidence — whether the body fluid offers information which links the offense to a suspect (e.g. suspect's semen is present in victim's body); resource allocation priority — due to limited laboratory resources, body fluid analysis should be prioritized in major crime investigations, while analysis in minor crimes should be applied only where biological fluid evidence is likely to be relevant.

Overall, body fluid testing should focus on major offense investigations. In minor crime investigations, rapid and less resource-intensive on-site body fluid screening methods may provide a more proportionate alternative to conventional laboratory-based analysis, improving investigative efficiency while reducing unnecessary forensic resource consumption [6].

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3. Fingerprint analysis

Fingerprints are individual characteristics, remain unchanged throughout life and can be systematically classified [7]. Because of these properties, fingerprints were applied to sign legal documents as far back as three thousand years ago. Nowadays, fingerprint analysis has become one of the most widely used techniques in crime investigations. Meanwhile, the advanced digital techniques and artificial intelligence contribute to greater speed and accuracy of fingerprint analysis. Nevertheless, fingerprint analysis also presents some challenges. When residue is minute, highly sensitive analytical techniques are required for specific identification. In addition, separating exogenous compounds from the endogenous ones is necessary due to the complex environment in practice [8]. Benefiting from the integration of digital comparison systems, such as Automated Fingerprint Identification Systems (AFIS), with artificial intelligence algorithms, modern fingerprint analysis enables rapid, high-throughput, and highly accurate comparison, which significantly improves the efficiency of latent fingerprint identification at crime scenes.

However, the applicability of fingerprint analysis differs in offenses with different severity: This technique is primarily applicable to property-related minor offenses, such as burglary, theft, and vehicle-related property crime, whereas it generally plays a more limited or supplementary role in major crimes such as homicide, sexual assault, and offenses involving serious bodily harm. The differences are not caused by the accuracy of the technique itself, but are determined by evidence preservation conditions, strength of the evidentiary link and cost-benefit ratio of resources in the two types of crimes.

The reason why fingerprint analysis is effective in minor offenses is that minor offenses are often characterized by direct physical contact, opportunistic behavior, and rapid departure from the crime scene. Suspects usually touch smooth surfaces with bare hands (e.g., handles of windows or doors, glass, safe panels, vehicle exterior surfaces) so that latent fingerprints with clearly preserved ridge details are left. These substrates typically present relatively clean backgrounds, allowing efficient fingerprint recovery using conventional methods such as powder development and cyanoacrylate fuming. Fingerprint evidence provides direct evidence of physical contact between the suspect and the crime scene or relevant object. In cases where DNA or other trace evidence is unavailable, such evidence may provide important investigative leads. Meanwhile, a large number of minor crimes bring high demand for rapid investigation. Fingerprint comparison can be completed in hours, aligning with policing demands for rapid case triage and high-volume case processing [8].

The following three reasons mainly explain why it is difficult for fingerprint testing to be applied in major crimes. Firstly, fingerprints are hard to preserve. In major crimes (e.g., homicide, arson and explosion), there is often violent destruction, high-temperature combustion, blood or pollution from fire-extinguishing agents. The fine structures such as fingerprint ridges are easily damaged or covered. Under pollution from blood and smoke, even if a suspect touches objects with bare hands, the secreted sweat and sebum cannot produce distinguishable line patterns. Secondly, in premeditated major crimes, offenders are more likely to deliberately avoid leaving identifiable fingerprints, for example by wearing gloves. Consequently, latent fingerprints may be difficult to recover or insufficient for reliable identification [9]. Thirdly, the weight of fingerprint testing in the evidence chain is relatively low. Major crimes rely on techniques with higher identification accuracy such as DNA typing, body fluid analysis and toxicology. What fingerprint evidence can only offer is a "connection", instead of connecting time or type (active or passive). Also, there is possibility of innocent transfer of fingerprints. When resources are limited, priority should be given to conducting

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DNA testing for serious crime cases, while fingerprint examination can be used as an auxiliary or reinforcing method [8].

Fingerprint analysis should be considered as a major technique in minor offense investigations and an auxiliary technique in major offenses. The following four standards can determine whether fingerprint analysis should be applied:

• smoothness and cleanliness of surfaces at the crime scene — non-permeable smooth surfaces such as glass, metal and plastic should be given priority; rough, porous or dirty surfaces should not be prioritized.

• degree of scene damage — give priority to scenes without flame, flood or bloodstain coverage; do not use fingerprint analysis in a scene that is seriously damaged or polluted.

• prediction of suspect's action — give priority to rapid invasion without gloves; for premeditated crimes, crimes where gloves are worn, or scenes where traces are cleared after offenses, fingerprint analysis may not be considered as a routine method.

• resource priority — for evidence identification in minor crimes, fingerprint analysis may be put in the first place, while in major crimes, fingerprint testing can only perform as a reinforcing method when DNA testing has failed or provides clear directional evidence.

4. Toxicology analysis

Forensic toxicology testing focuses on the test and analysis of toxins, drugs, heavy metals and alcohol in biological testing materials. Forensic toxicological analysis commonly employs highly sensitive techniques such as gas chromatography–mass spectrometry (GC–MS) and liquid chromatography–mass spectrometry (LC–MS) to achieve qualitative and quantitative analysis of trace substances. This technique has irreplaceable value in major crimes involving suspected poisoning, fatal drug overdose, and drug-facilitated robbery, but has very limited applicability in most minor offences, such as theft, minor assault, and traffic violations [10].

The reason why forensic toxicology focuses on certain major crimes is that in poisoning or fatal drug overdose cases, the core forensic evidence consists of toxic substances remaining inside or outside the body, and such substances cannot be traced through traditional comparative techniques such as DNA profiling or fingerprint analysis. Toxicological analysis is the only forensic approach capable of identifying the type, concentration, and potentially lethal dosage of toxic substances. For example, in the Chicago Tylenol poisoning case, only toxicological testing could detect cyanide in the victims' blood, thereby establishing the homicidal nature of the deaths. In addition, such cases often lack direct signs of physical struggle or biological fluid exchange, making toxicological analysis a necessary component of the evidential chain linking the suspect to the criminal act [10].

The fundamental reasons why toxicological analysis is unsuitable for minor offences are mainly reflected in two aspects. Firstly, the offensive behavior is unrelated to toxic substances. Most minor offences, such as theft or criminal damage, do not involve any toxic substance ingestion or exposure, so sending samples for toxicological analysis would be a pure waste of forensic resources. Secondly, the testing costs and processing period are unacceptable. Comprehensive toxicological screening involves complex analytical procedures, and single-sample testing may take from several days to weeks, while also requiring advanced instruments and specialized interpretation personnel. Considering the large volume of minor offences, routine toxicological testing would cause a backlog in major crime investigations and delay the critical investigative window.

The three aspects below represent the core criteria to consider when determining whether to conduct toxicological analysis. First, whether the characteristics of the case fit with poisoning or abnormal drug exposure, for example, unexplained convulsions, vomiting, or loss of consciousness

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prior to death, or suspicious medicine bottles or liquids remaining at the scene. Second, whether the cause of death remains unexplained after natural disease has been ruled out. Thirdly, where there is suspicion of a drug-facilitated offence such as drug-facilitated sexual assault or robbery, and sedative or hypnotic substances are detected in the blood or urine of the victim. Cases not fulfilling any of the above criteria should not be subjected to toxicological analysis [10].

5. Conclusion

Forensic techniques are essential in modern society when it comes to crime investigations. They rely on scientific methods to link victims or suspects to a crime scene and criminal behavior. Nevertheless the effectiveness of such techniques depends heavily on how well they match the nature and severity of the offence.

According to the severity and type of crime, different techniques are employed. Serious major crimes such as homicide and assault are mainly attributed to the use of biological evidence techniques such as DNA profiling and body fluid analysis. The methods used are accurate in identifying suspects but time-consuming. In contrast, fingerprint analysis is most frequently utilized in minor crimes owing to the strict conditions necessary for fingerprints to remain clear. The added speed also helps solve minor crimes, which are much more common than major crimes. Toxicology analysis, at the same time, is important for cases involving poisons or drug overdoses. The techniques have effectively improved the investigation, but their existing shortcomings indicate the need for continued development of technology in the methods of forensic science.

Future development of forensic techniques should concentrate on more sensitive and portable detection technologies to allow for more rapid preliminary screening in major crimes, while also supporting the efficiency of minor crimes. Moreover, the combination of artificial intelligence and several forensic techniques can enable the development of analysis platforms. Establishing dynamic resource-allocation systems could further improve the efficiency of forensic laboratories and ensure that limited forensic resources are directed toward cases with the greatest investigative and evidential demands.

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