

Article

Firearm Evidence Management in Criminal Investigations: Articulated Knowledge, Reported Collection Practices, and Chain-of-Custody Awareness

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Abstract

Background/Objectives: The integrity of firearm evidence is central to solving violent crimes and securing just court outcomes, yet the consistency of investigative practices across policing environments remains uncertain. This study examined the articulated understanding and reported practices related to firearm evidence among investigating officers, crime scene experts from the Local Criminal Record Centre (LCRC), and ballistics experts within the South African Police Service (SAPS). **Materials and Methods:** A qualitative research design was adopted, using semi-structured interviews with 39 participants across the three groups. The study explored participants' knowledge of firearm evidence, types of evidence found at murder crime scenes, procedures for evidence collection, and the concept of chain of custody. Data was analysed thematically to identify patterns and knowledge gaps. **Results:** The findings revealed considerable variation across groups in articulated knowledge and reported procedural awareness, with crime scene experts demonstrating stronger conceptual clarity, while investigating officers showed notable gaps in recognising trace elements and maintaining continuity of possession. Ballistics experts possessed technical expertise but limited familiarity with scene-level protocols. These disparities have the potential to pose risks to evidentiary integrity and evidentiary admissibility if reflected in practice. **Conclusions:** The findings suggest that enhancing shared understanding of firearm evidence handling through reinforced procedural guidance and professional development may support greater consistency at early investigative stages. These conclusions are grounded in participants' articulated knowledge and reported procedural awareness derived from interview data, rather than observed investigative practice or case file compliance. Further research is required to assess how such interventions influence operational practice and to explore the potential role of digital tools in supporting chain-of-custody continuity.



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1. Introduction

Firearm-related crimes remain a global concern, and the integrity of firearm evidence often determines whether justice is served. From the moment a weapon is discharged to its presentation in court, every stage of evidence handling can influence the outcome of an investigation. Firearm evidence encompasses a range of components, including firearms, fired bullets, cartridge cases, and trace elements such as gunshot residue and fingerprints.

These items are critical for forensic analysis and play a pivotal role in linking suspects to crime scenes. However, the complexity of firearm evidence handling, particularly in murder investigations, requires strict adherence to standardised procedures. International best practices emphasise accurate identification, meticulous collection, and the maintenance of the chain-of-custody to preserve evidentiary integrity. Despite the importance of firearm evidence, research indicates inconsistencies in how investigative personnel understand and apply these procedures. While the literature outlines what firearm evidence is and how it should be managed, limited empirical studies explore the practical knowledge and practices of investigators, especially regarding the types of evidence found at murder scenes, collection protocols, and continuity of possession. These gaps raise concerns about contamination, loss of trace evidence, and compromised admissibility in court. Internationally, concerns have been raised regarding declining forensic awareness among first responders and investigative personnel, with studies across multiple jurisdictions reporting missed evidence, inadequate scene recognition, and early-stage procedural failures. Firearm-related investigations are particularly sensitive to such breakdowns, as probative value often depends on the correct identification and preservation of ballistic, trace, and contextual evidence during initial scene engagement. Despite the global relevance of these challenges, empirical studies examining practitioner-level awareness across investigative roles remain limited, particularly outside well-resourced Western policing contexts. This study responds to this gap by providing practice-based insights from the South African policing environment that contribute to international discussions on forensic awareness, evidence recognition, and early-stage evidentiary risk. This study aims to examine investigative personnel's understanding of firearm evidence, the types of evidence typically found at murder crime scenes, the procedures followed during collection, and their knowledge of chain-of-custody principles. It argues that gaps in knowledge and inconsistent practices among investigating officers, crime scene experts, and ballistics experts pose significant risks to the integrity of evidence. Addressing these gaps through standardised guidelines and operational checklists can enhance forensic reliability and strengthen judicial outcomes.

The remainder of this article is structured as follows: the next section reviews the literature on firearm evidence, including its types, collection procedures, and continuity of possession. This is followed by the methodology, which outlines the qualitative approach adopted for the study. The results and discussion present key findings on knowledge gaps and procedural inconsistencies. The article concludes with recommendations for improving firearm evidence handling and maintaining the chain of custody, along with implications for policy and future research.

1.1. Firearm Evidence Handling Within the South African Policing Context

Within the South African Police Service (SAPS), firearm evidence handling is governed by formal training pathways, standing orders, and differentiated operational roles. Investigating officers typically receive foundational training in crime scene management and evidence handling as part of general detective preparation. Specialised crime scene processing is primarily undertaken by Local Criminal Record Centre (LCRC) practitioners, who receive role-specific instruction in evidence documentation, scene processing, and forensic recovery techniques. Ballistic examination and firearm analysis are conducted by Forensic Science Laboratory (FSL) practitioners in laboratory settings. Operational guidance for firearm evidence handling is further informed by standing orders and procedural directives that prescribe requirements for exhibit collection, packaging, documentation, submission, and continuity of possession. While these frameworks establish formal expectations for firearm evidence management, the extent to which conceptual understanding and pro-

cedural awareness are shared consistently across investigative roles has received limited empirical attention. This study examines practitioner-level articulated understanding within this institutional context, providing a basis for interpreting where existing structures align with, or diverge from, reported evidentiary awareness in practice.

1.2. Firearm Evidence in Criminal Investigations and Murder Crime Scenes

Firearm evidence encompasses any firearm and its associated ammunition components, whether discharged or intact, suspected of involvement in a criminal offence. This includes weapons, fired bullets, cartridge cases, gunshot residues, and other ballistic materials recovered from crime scenes [1–9]. The presence of such evidence typically indicates the use of a firearm during the commission of a crime and forms a critical foundation for forensic interpretation and investigative decision making. The types of ballistic evidence found at murder scenes depend largely on the weapon used. Scenes may contain fired bullets, cartridge cases, shot, or wadding, each offering different investigative value [9]. Gunshot residues may also be present, informing determinations of firing distance or shooter positioning. Before any items are collected, proper documentation, including photographs of bullet holes, trajectories, and the location of each item, is essential to preserve investigative integrity [10]. Once recovered, firearms and ammunition components are submitted to forensic laboratories where specialists examine the weapon's condition and conduct test firing to compare ballistic markings with those found on bullets and cartridge cases from the scene [5,11]. These comparisons assist in determining whether a specific firearm discharged the recovered projectiles. Such examinations can also contribute to establishing ownership, linking suspects to weapons, and ultimately assigning criminal responsibility [4,12]. The systematic recovery, documentation, and analysis of firearm-related evidence remain essential for linking weapons to crime scenes and supporting both investigative processes and judicial outcomes. More recent forensic science research has increasingly problematised assumptions about consistency, reliability, and practitioner decision making in firearm and toolmark evidence. International reviews and empirical studies published over the past decade have examined the validity and limitations of firearm examination methods, the influence of cognitive and contextual factors on examiner judgements, and the consequences of early-stage evidentiary errors for subsequent forensic interpretation. Contemporary scholarship emphasises that the probative value of firearm evidence is critically dependent on correct recognition, preservation, and documentation at the crime scene stage, reinforcing the importance of practitioner awareness beyond laboratory-based analysis [13–15]. Beyond the foundational definitions provided in forensic science textbooks, empirical research has increasingly examined practitioner awareness and the consequences of early-stage evidence recognition failures. Peer-reviewed studies across forensic and investigative contexts have demonstrated that an incomplete understanding of evidential processes among first responders is associated with missed trace evidence, scene contamination, and downstream limitations in forensic reconstruction. Research further indicates that such awareness gaps may persist despite the existence of formal training and procedural guidance, suggesting that institutional frameworks do not always translate into consistent practitioner-level knowledge and practice [16,17].

1.3. Procedure for Collecting Firearm Evidence at Crime Scenes

The collection of firearm evidence requires meticulous attention to preserve its integrity and maintain the chain of custody. The priority at any crime scene is to prevent the destruction or contamination of potential evidence, as physical evidence often holds the key to solving the case [18]. Investigators must process the scene carefully, avoiding actions that could disturb cartridge cases, bullets, or gunshot residues. Items most susceptible to

loss or environmental factors should be collected first [1]. Before removal, the position of firearms, bullets, cartridge cases, bullet holes, and trajectories must be accurately documented, and containers—not exhibits—should be marked with case details to ensure proper identification [10,11,18]. Firearms recovered from the scene must be made safe prior to packaging and submission. They should be unloaded, handled by the chequered grip to preserve fingerprints, and never picked up by inserting objects into the barrel, as this can disturb powder deposits or alter rifling marks [1,2,19]. The condition of the weapon, its safety mechanism, and the presence of chambered rounds should be recorded before unloading. For revolvers, the chamber aligned with the barrel must be noted prior to releasing the cylinder [1]. Fired bullets and cartridge cases should be collected without using sharp instruments to avoid damaging comparison markings. Bullets removed from bodies must be rinsed under running water and air-dried immediately, while lead bullets should be wrapped in tissue paper and never placed on cotton wool. All items should be packaged separately in suitable containers, such as envelopes, and clearly labelled with case details [2,11].

Packaging and transport procedures are critical to maintaining evidentiary integrity. Firearms, ammunition, and related components must be packed separately, and loaded firearms or magazines should never be transported. Plastic containers should be avoided for metal components to prevent corrosion, and sturdy boxes should be used to prevent shifting during transit. The serial number, make, and model of the firearm must be recorded conspicuously, and parcels should be sealed securely with identification numbers visible. A copy of the covering minute should be included inside the parcel without requiring the parcel to be opened [20–22]. Firearms should never be cleaned or test-fired before laboratory submission, as this may destroy residues or alter comparison markings [11,20]. Investigators should record the position and inclination of the firearm relative to the body, the location of ejected cartridge cases, and any trajectory indicators to assist in reconstruction. Care must be taken not to remove existing fingerprints or leave new ones, and no marks should be made on bullets or cartridge cases [23,24]. These procedures ensure that firearm evidence remains intact for forensic analysis and judicial proceedings. Recent empirical research has further highlighted the vulnerability of firearm and other forensic evidence during the earliest stages of crime scene management, particularly where first responders or generalist investigators are responsible for initial recognition and recovery. Studies conducted since 2018 consistently demonstrate variability in practitioner-level knowledge of evidence management principles, even in systems where formal training and written procedures exist. This literature underscores the risk that deficiencies in early-stage awareness may constrain subsequent forensic analysis, regardless of later laboratory compliance or specialist intervention [16,25].

1.4. Continuity of Possessions

Maintaining continuity of possession, commonly referred to as the chain of custody, is a cornerstone of forensic integrity. It ensures that physical evidence remains secure, identifiable, and legally defensible from the moment of collection until its presentation in court. According to [26,27] continuous safekeeping and identification of evidence are essential for individualisation and the acceptability of investigative outcomes. The degree to which continuity is maintained directly influences the interpretation and reliability of forensic results. International guidelines define chain of custody as the chronological documentation of all handling stages, beginning at the crime scene and continuing through forensic analysis and judicial proceedings [9,28–30]. This documentation must include every person who had custody of the evidence, the dates and reasons for transfers, and any changes made to the evidence. Failure to maintain this process can result in the exclusion

of critical evidence, as demonstrated in cases such as [31], where flawed marking and poor documentation compromised the chain of custody. More recent forensic literature has expanded the analysis of chain-of-custody requirements, emphasising the distinction between administrative record-keeping and legally robust continuity of possession. Contemporary studies highlight that misunderstandings of chain-of-custody obligations at early investigative stages remain a recurring source of evidentiary vulnerability, particularly in complex or multi-handler cases. Emerging scholarship also notes the growing relevance of technological and system-based solutions to support transparency and traceability, while cautioning that technological tools cannot compensate for foundational awareness deficits among practitioners [32,33].

2. Materials and Methods

A qualitative research design was employed to explore investigative personnel's understanding and practices regarding firearm evidence within the South African Police Service (SAPS). The study was anchored within an interpretivist research paradigm, which assumes that reality is socially constructed and seeks to understand participants' subjective experiences, meanings, and interpretations of firearm evidence handling. A qualitative approach was considered the most appropriate methodological choice for this study, as forensic awareness and procedural understanding are conceptually grounded, experiential, and context-dependent. The research aimed not merely to measure the presence or absence of knowledge, but to explore how investigative personnel conceptualise firearm evidence, interpret their procedural responsibilities, and articulate their understanding of evidentiary processes across different operational roles. Semi-structured interviews enabled participants to explain, clarify, and reflect on their experiences in a manner that would not be adequately captured through structured survey instruments. While quantitative survey methods may be useful for measuring self-reported confidence levels or training exposure, they are limited in their capacity to identify misconceptions, omissions, or nuanced differences in understanding across investigative functions. The interview-based design allowed for probing and follow-up questions, facilitating deeper insight into how awareness is formed, applied, and constrained in practice. Purposive sampling was therefore employed to include participants occupying key positions in firearm evidence handling, ensuring that perspectives were obtained across the full evidentiary lifecycle. Purposive sampling was used to select participants who were directly involved in crime scene processing and firearm evidence handling. The study included 39 participants: 11 investigating officers, 15 Local Criminal Record Centre (LCRC) members, and 13 ballistics experts. Participants represented three functional groups within SAPS and demonstrated variation in professional experience, training exposure, and operational focus. Investigating officers ($n = 11$) had between one and more than ten years of investigative experience, with the majority reporting between five and ten years of service. All had completed the basic detective training course, although only a minority reported routine involvement in murder investigations. This group primarily occupied first-responder and case management roles. Local Criminal Record Centre (LCRC) participants ($n = 15$) included crime scene examiners, fingerprint experts, forensic analysts, and criminalistics practitioners across a range of ranks. Most reported between five and ten years of experience in crime scene and forensic support functions. Participants in this group had completed multiple specialist training courses related to scene processing, evidence documentation, fingerprint analysis, photography, and forensic recovery, reflecting their technical role in scene-level evidence handling. Ballistics practitioners ($n = 13$) were forensic analysts and senior forensic analysts operating primarily within laboratory environments. Most reported between five and ten years of experience in firearm and ballistic examination. All had completed structured in-house

ballistic training programmes, supplemented in some cases by additional courses related to shooting incident reconstruction and crime scene analysis. This group's operational exposure was predominantly laboratory-based rather than scene-focused. Data were collected through semi-structured interviews, which allowed flexibility to probe participants' responses while ensuring coverage of key topics. The interview guide focused on four areas: understanding of firearm evidence, types of evidence found at murder crime scenes, procedures for collecting firearm evidence, and the concept of chain of custody. Data analysis followed an inductive qualitative process informed by Creswell's data analysis spiral. Interview recordings were transcribed verbatim and read repeatedly to achieve immersion and familiarisation with the dataset. Initial codes were generated directly from participants' accounts and iteratively refined through comparison across transcripts. Codes sharing conceptual similarities were grouped into broader categories, from which higher-order themes were developed. Throughout this process, analytic decisions were guided by coherence, recurrence, and relevance to the study objectives, with continual reference back to the original transcripts to ensure that interpretations remained grounded in participants' articulated understanding and reported procedural awareness. Narrative summaries and tables were used to present patterns emerging from the analysis. Data collection continued until recurring patterns of response were evident across interviews, indicating sufficient depth for thematic interpretation within the scope of the study. Triangulation was achieved by comparing responses across the three participant groups to enhance credibility. Ethical clearance was obtained from the relevant institutional review board, and participants were assured of confidentiality and voluntary participation. No identifying information was included in the final report. Although participants varied in experience and training exposure, the study did not seek to systematically compare performance by rank, province, or case file outcomes; findings should therefore be interpreted as reflecting patterns of articulated awareness within this sample rather than comprehensive institutional representation.

3. Results

The findings are presented thematically and are derived from an inductive analysis of the interview transcripts. Following repeated readings of the data, participants' responses were coded and grouped into themes reflecting shared patterns of understanding and emphasis across professional roles. Tables are used to illustrate patterns of emphasis across participants' responses rather than to quantify knowledge, assess competence, or measure procedural compliance. In this qualitative study, the frequency with which items were mentioned reflects relative salience in participants' accounts, not depth of understanding or operational performance. The frequency counts in tables indicate the number of participants who mentioned a particular item or procedure during interviews and are presented for descriptive patterning only; they do not represent quantitative assessment of knowledge or competence.

3.1. Conceptualisation of Firearm Evidence

To explore the participants' conceptual understanding of firearm evidence, the participants were asked, "What is firearm evidence?" Responses varied across investigating officers, crime scene experts, and ballistics experts. Table 1 presents a synthesis of the participants' conceptual understanding of firearm evidence.

Table 1. Participants' understanding of firearm evidence across samples.

Response Category	I/Officers (<i>n</i> = 11)	CS Experts (<i>n</i> = 15)	Ballistics Experts (<i>n</i> = 13)	Total
Firearm evidence includes firearms, cartridges, bullets, primer residue, touch DNA, fingerprints, magazines, and bullet holes	3	8	6	17
Evidence collected from the crime scene where the firearm was used	6	6	1	13
Ballistic reports where cartridges or other items were removed	1	–	–	1
Anything linking the firearm to the crime	–	–	1	1
Marks on the firearm, breech face marks, rifling in the barrel	–	–	1	1
Evidence produced through the firearm mechanism	–	–	1	1
Knowledge obtained during the examination	–	–	1	1
Evidence from or produced by a firearm	–	–	1	1
Results from firearm examination	–	–	1	1
No answer	1	1	–	2
Total	11	15	13	39

The empirical data indicate a divergent conceptual grasp of firearm evidence across operational roles. A substantial portion of participants described firearm evidence broadly as “evidence collected from the crime scene,” while others correctly enumerated specific ballistic and trace elements (e.g., bullets, cartridge cases, primer residue, fingerprints), which aligns with standard forensic definitions [1,2,5]. Ballistics experts referenced toolmarks such as breech face marks and rifling, consistent with the discipline’s focus on individual characteristics and microscopic comparisons [4,5].

3.2. Types of Firearm Evidence Encountered at Murder Scenes

To explore participants’ conceptual understanding of the different types of firearm evidence that can be found at a murder crime scene, participants were asked, “What types of firearm evidence can be found at a murder crime scene?” Responses are summarised in Table 2.

Table 2. Emergent themes on the types of firearm evidence reported by participants across samples.

Type of Evidence	I/Officers (<i>n</i> = 11)	CS Experts (<i>n</i> = 15)	Ballistics Experts (<i>n</i> = 13)	Total
Cartridge cases	9	12	–	21
Firearms	3	10	7	20
Primer residue	2	11	6	19
Bullets	1	6	12	19
Cartridges	8	–	8	16
Projectile	5	5	–	10
Bullet wounds	1	4	2	7
Bullet jackets	–	3	3	6
Ammunition	1	1	3	5
Fingerprints	2	2	–	3
Other (e.g., ricochet marks, ownership)	3	8	12	23
Total	25	62	55	142

The pattern of responses indicates variation in the breadth and specificity of knowledge across roles. Participants' responses illustrate these role-based differences. Investigating officers tended to emphasise cartridge cases and cartridges. One investigating officer focused on visible items, stating that "cartridge cases and cartridges are usually what we look for at the scene." In contrast, a crime scene expert highlighted a broader evidentiary scope, explaining that "primer residue, bullet jackets and ricochet marks are often just as important as the firearm itself for reconstructing what happened". This divergence reflects differences in professional training and routine operational exposure; however, it becomes operationally consequential when investigating officers act as first responders and fail to recognise or preserve trace and secondary firearm-related evidence at the earliest stage of scene engagement. Investigating officers typically described prioritising immediately visible and recoverable items during early scene engagement, whereas crime scene and ballistics specialists are trained to recognise both primary firearm evidence and secondary trace indicators.

3.3. Procedures for Collecting Firearm Evidence

Participants were asked to describe the procedure for collecting firearm evidence. The following question was posed to them: "What is the procedure for collecting firearm evidence from a crime scene?" The responses are summarised in Table 3 below.

Table 3. Participants' responses regarding procedures for collecting firearm evidence.

Procedure Mentioned	I/Officers (n = 11)	CS Experts (n = 15)	Ballistics Experts (n = 13)	Total
Wear personal protective equipment (PPE)	8	5	6	19
Package exhibits separately in forensic bags	9	5	5	19
Send exhibits to FSL (ballistics)	2	13	3	18
Photograph exhibits in situ	4	9	4	17
Book exhibits in SAPS 13 registers	2	12	–	14
Make firearm safe	2	9	2	13
Seal evidence bag at the scene	3	5	4	12
Swab for touch DNA and check for fingerprints	1	8	1	10
Photograph sealed evidence bag	–	6	1	7
Other (mark positions, serial numbers, documentation)	4	10	6	20
No answer	–	1	3	4
Total	35	102	41	178

The empirical data show uneven procedural coverage across groups. Investigating officers frequently mentioned PPE and separate packaging, but less often cited making firearms safe, DNA swabbing, or chain-of-custody documentation. Crime scene experts most consistently referenced documentation and booking (SAPS 13), sealing, in situ photography, and submission to the forensic laboratory, procedures consistent with their formal crime scene responsibilities. Participants' responses illustrate these procedural differences. One investigating officer described the collection process primarily in terms of basic handling, stating that "we wear gloves and package the firearm separately". In contrast, a crime scene expert provided a more detailed procedural account, noting that "the firearm must be made safe, photographed in situ, swabbed for DNA, sealed at the scene, and fully documented before submission to the laboratory". Ballistics experts gave fewer responses overall and were less likely to describe scene-level steps, consistent with their laboratory-centred role. This variation reflects differences in training emphasis and routine operational responsibility; however, because investigating officers are frequently respon-

sible for initial scene control and exhibit recovery, limitations in articulated procedural awareness at this stage may increase the risk of incomplete documentation, contamination, or loss of evidential value. Investigating officers often emphasised rapid scene control and exhibit removal in their accounts, whereas crime scene specialists operate within more formalised procedural frameworks reinforced through forensic training. While this division of labour is institutionalised, limited procedural awareness during initial scene engagement may increase the risk of incomplete documentation, contamination, or loss of critical trace evidence.

3.4. Chain of Custody and Continuity of Possession

Participants were asked to explain their understanding of continuity of possession (chain of custody), and the findings revealed marked variation across the groups. Investigating officers frequently provided responses that were either incomplete or unrelated to the concept. In contrast, most crime scene experts demonstrated a clear and accurate understanding, describing the chain of custody as the documented and uninterrupted process that tracks evidence from the crime scene to its presentation in court. Ballistics experts also generally articulated the concept correctly, although two offered irrelevant responses and one used an alternative term without further clarification. Participants' explanations revealed fundamental differences in how continuity of possession was conceptualised. Analysis of participants' responses indicates that misunderstandings of chain-of-custody requirements clustered around three recurring patterns. First, some investigating officers framed continuity of possession primarily as physical storage or safekeeping of exhibits, with limited reference to documentation or transfer accountability. Second, others equated chain of custody with administrative booking procedures (e.g., SAPS 13 entry), without articulating continuity across multiple handover points. Third, a smaller subset demonstrated awareness of the chain of custody as a legally consequential process requiring continuous documentation from scene recovery through laboratory submission and court presentation. One investigating officer equated chain of custody with storage, stating that it means "keeping the firearm safely until court." Another described it merely as "booking the exhibit into SAPS 13." In contrast, a crime scene expert defined chain of custody as "documenting every movement of the firearm from the scene to the laboratory and ultimately to court," while a ballistics expert emphasised accountability, noting that "any gap in documentation can render the evidence legally vulnerable." These contrasting interpretations are analytically significant because chain-of-custody integrity is established or undermined at the earliest stage of evidence handling. When investigating officers conceptualise continuity of possession as storage or administrative booking alone, rather than as a continuous process of documented transfer and accountability, critical vulnerabilities are introduced at the point of initial evidence recovery.

3.5. Cross-Theme Synthesis of Findings

The cross-theme synthesis integrates findings from four analytically distinct but operationally interconnected domains: (a) conceptualisation of firearm evidence, (b) recognition of primary and secondary firearm-related evidence at murder scenes, (c) procedural approaches to evidence collection and preservation, and (d) understanding of chain-of-custody requirements. The cross-theme analysis reveals a pronounced role-based divergence in how investigative personnel conceptualise, recognise, and manage firearm-related evidence. Variation was evident across four domains: (a) the foundational definition of firearm evidence, (b) the capacity to identify ballistic, trace, and secondary elements at violent crime scenes, (c) adherence to established protocols for the recovery, documentation, and preservation of evidence, and (d) the extent of participants' understanding of chain-of-custody

obligations. These findings demonstrate that articulated understanding and reported treatment of firearm evidence vary across investigative groups, and that such variation becomes operationally significant at points where early-stage decisions shape downstream forensic and legal outcomes.

4. Discussion

4.1. *Interpreting Role-Based Conceptualisations of Firearm Evidence*

This role-contingent understanding has practical implications: a narrow, scene-only view risks under-recognising trace and microscopic elements essential for linking firearms to events and actors, as emphasised in foundational texts [3,9]. This pattern is illustrated in participants' accounts. As demonstrated in the findings, investigating officers tended to adopt a scene-centred conceptualisation of firearm evidence, whereas crime scene experts articulated a more granular evidentiary understanding encompassing ballistic and trace elements. In short, conceptual breadth matters because it shapes what investigators look for, recognise, and recover at the scene and thus affects downstream forensic analysis and court outcomes. These differences appear to reflect role-specific training and task allocation within SAPS; however, the absence of a shared baseline conceptual framework for firearm evidence recognition becomes problematic where early-stage investigative decisions determine whether evidential material is recognised, preserved, or irreversibly lost.

4.2. *Implications of Evidence-Recognition Differences at Murder Scenes*

Crime-scene and ballistics specialists more frequently mentioned bullets, primer residue, bullet jackets, and ricochet marks, elements commonly documented in firearm-related scenes [6–9]. The broader coverage by LCRC and ballistics aligns with their training and forensic remit to recognise both primary evidence (firearms, casings, bullets) and secondary indicators (GSR, jacket fragments, ricochet). These differences matter because the literature stresses that complete recognition and documentation, including bullet holes, trajectories, and scene context, are essential before collection to preserve interpretive value [9,10]. A narrower focus risks missed items, especially trace and secondary evidence, potentially weakening reconstruction and probative strength in court [4,5]. Empirical forensic research supports the observation that recognition failures at the crime scene level frequently limit the evidential value of firearm-related exhibits. Studies examining ballistic and trace-evidence recovery have shown that items such as primer residue, bullet fragments, and contextual damage markers are commonly overlooked during initial scene processing, particularly when awareness is narrowly focused on visible or primary items. Such omissions have been linked to reduced reconstructive capacity and increased evidentiary vulnerability at trial, reinforcing the importance of comprehensive evidential recognition during early investigative stages (e.g., [14,34,35]). While such differentiation aligns with institutional division of labour, limited recognition of secondary and trace evidence at the initial scene response stage may reduce evidentiary completeness. These findings highlight the importance of shared evidentiary awareness across investigative roles, particularly during the earliest stages of murder scene processing, where limitations in articulated awareness may have irreversible downstream consequences.

4.3. *Procedural Awareness and Early-Stage Evidentiary Risk*

The literature emphasises that preserving integrity and preventing contamination are foundational: process the scene so as not to disturb casings, bullets, or residues; collect items at risk of loss first; and document positions and trajectories before movement [1,10,18]. The documentation chain, including marking the container (not the exhibit), detailed labelling, and secure sealing, is critical to downstream analysis and legal robustness [11,18].

Against this benchmark, the investigating officer's selective attention to some steps (e.g., PPE, packaging) and limited emphasis on DNA swabbing, safe firearm handling, and documentation indicate procedural gaps that could increase the risk of contamination, loss of comparison marks, or documentation deficiencies. Peer-reviewed studies examining forensic training and procedural compliance similarly report that awareness-based errors frequently occur not due to the absence of formal guidelines, but due to inconsistent reinforcement and practical application. Research across policing and forensic contexts suggests that procedural knowledge degrades without continuous training reinforcement, particularly in high-pressure operational environments. These findings align with the present study's observation that early-stage procedural weaknesses may persist even where formal standards and training frameworks exist (e.g., [36,37]). This pattern suggests that, while role differentiation is organisationally necessary, inconsistently articulated procedural awareness at early investigative stages may warrant additional mechanisms to support consistency where evidential vulnerability is highest. Because firearm evidence is highly susceptible to contamination and alteration, procedural omissions at the point of collection can compromise both forensic analysis and subsequent legal admissibility, regardless of later laboratory compliance.

4.4. Chain of Custody as a Systemic Vulnerability

The literature defines chain of custody as the chronological documentation of evidence handling from collection through analysis to presentation in court, recording every custodian, date, reason for transfer, and any changes to the evidence [9,28–30]. South African jurisprudence shows that failures in marking or documentation can lead to evidentiary exclusion (e.g., [31]), while forensic scholars emphasise continuous safekeeping and identifiability as prerequisites for individualisation and admissibility [26,27]. Against these standards, the investigating officers' lack of understanding poses a critical risk at the earliest stage of evidence handling. A critical distinction emerging from the findings is the difference between administrative and legal understandings of the chain of custody. While administrative conceptions emphasise storage, booking, or internal record keeping, legal continuity of possession requires demonstrable, uninterrupted documentation of evidence handling across all transfer points. Where investigating officers conceptualise the chain of custody in administrative terms only, evidentiary vulnerability may arise despite later compliance by specialist units. This distinction is particularly consequential because deficiencies at the initial recovery stage cannot be retrospectively corrected through subsequent laboratory handling or courtroom testimony. In contrast, crime scene experts and ballistics experts generally aligned with the operational and legal requirements for continuity. The implication is clear: without correct chain-of-custody practice at the outset, probative firearm evidence may be legally compromised, regardless of later laboratory quality. As South African case law demonstrates, deficiencies in continuity of possession are not technical oversights but substantive evidentiary failures capable of excluding otherwise probative firearm evidence. The findings therefore suggest that chain-of-custody awareness is not merely a procedural formality but a legally anchored concept that must be correctly understood at the earliest stages of evidence handling.

4.5. Integrated Discussion and System-Wide Implications

The extant forensic literature provides clear, comprehensive, and longstanding standards for the identification, documentation, collection, packaging, transport, and preservation of firearm evidence, including the maintenance of continuous custodial integrity throughout all investigative and judicial stages. These internationally anchored standards serve as robust procedural benchmarks. When the present findings are evaluated against

these established guidelines, the observed shortcomings among investigating officers and the selective procedural omissions among crime scene and ballistics specialists may reflect the influence of uneven training reinforcement, variability in operational exposure, and differences in role-specific emphasis, rather than definitive deficiencies in policy or guidance. Rather than indicating deliberate non-compliance, these patterns suggest uneven procedural reinforcement and variability in role-specific training exposure across investigative functions.

The identified discrepancies underscore the need for coherent, competency-driven approaches spanning all stages of evidence handling. Ensuring that personnel operate from a shared, precise, and operationally grounded understanding of firearm evidence procedures is essential to maintaining evidentiary integrity, strengthening the admissibility of evidence in court, and enhancing the overall reliability of investigative processes. The findings indicate that limitations at one stage of the evidentiary process amplify risks at subsequent stages. Narrow conceptual understandings of firearm evidence shape what investigators recognise at the scene; incomplete recognition constrains collection practices; and procedural shortcomings at the point of recovery directly undermine the integrity of chain-of-custody documentation. These stages operate sequentially, meaning early-stage deficiencies cannot be corrected through later laboratory compliance. While the findings are grounded in the South African policing context, the patterns identified align with the international forensic literature, highlighting vulnerabilities in first-responder awareness, early-stage evidence recognition, and procedural consistency. Jurisdictions with similar investigative structures may encounter comparable risks at the interface between scene response and forensic analysis, particularly where training reinforcement and cross-role standardisation are uneven. In this regard, the study offers transferable insights for global forensic and investigative audiences by illustrating how gaps in awareness at the earliest stages of evidence handling may cascade into downstream forensic and legal consequences. The analytical convergence of these themes underscores the need for interventions that address firearm evidence handling as a continuous process rather than as isolated procedural tasks. Effective improvement therefore requires standardisation across investigative roles, reinforcement of shared evidentiary concepts, and practical tools that support consistent application at the earliest and most evidentially critical stages of scene engagement.

4.6. Recommendations

Based on the above findings, several practice-oriented implications are proposed. First, the consistent reinforcement of standardised operational guidelines and structured evidence-handling checklists may support greater consistency across investigative units. These tools can assist in the recognition of diverse evidence types, promote appropriate handling practices, and support complete documentation. Second, continuous professional development (CPD) programmes may prioritise strengthening personnel competencies in three core domains:

- The identification of trace and secondary evidence (e.g., primer residue, bullet jackets);
- The application of appropriate firearm-safety and weapon-neutralisation procedures during initial evidence recovery;
- The precise, end-to-end completion of chain-of-custody documentation, including the accurate recording of transfers and evidence storage entries.

Third, embedding these enhanced practices within formal operational protocols, combined with structured training initiatives, supervisory oversight, and routine compliance assessments (e.g., audits and performance reviews), can help reduce the discrepancy between policy expectations and field-level implementation. Finally, the adoption of digital

chain-of-custody platforms presents an opportunity to strengthen evidentiary defensibility through improved traceability, reduced administrative error, and enhanced procedural transparency. Such systems may support more reliable custodial continuity and enhance confidence in the evidentiary material presented in judicial proceedings. These implications underscore the need for a coordinated, system-wide approach to improving firearm evidence management. Aligning practice with established forensic standards is essential to safeguarding evidentiary value and ensuring the integrity of investigative and judicial outcomes.

4.6.1. Continuous Professional Development (CPD)

Investigating officers, crime scene experts, and ballistics experts are encouraged to participate in regular CPD initiatives focused on crime scene management, the identification of firearm-related evidence, and appropriate collection and preservation procedures. Training may emphasise recognition of a broad spectrum of firearm evidence, including bullets, cartridge cases, primer residue, touch DNA, and secondary indicators, as reflected in the existing forensic literature. Continuous skills enhancement may help address the knowledge disparities identified among investigative personnel.

4.6.2. Standardised Firearm-Evidence-Handling Guidelines

The findings support the development of detailed, step-by-step guidelines for handling firearm evidence from initial scene entry through submission to the forensic laboratory. These guidelines should incorporate best-practice principles for contamination prevention, trace-evidence preservation, firearm handling, and documentation, consistent with national and international standards. Standardised procedures may contribute to more consistent practices across investigative units.

4.6.3. Operational Support and Compliance Monitoring

To promote accuracy, reduce contamination risks, and improve chain-of-custody reliability, an operational checklist is recommended. This checklist should accompany investigators during all firearm-related crime scene operations. An illustrative operational checklist derived from the findings and existing forensic standards is provided in Appendix A. The checklist presented in Appendix A is not proposed as a novel procedural standard, but as an illustrative synthesis of issues repeatedly emphasised by participants and reinforced by existing forensic guidance, intended to support reflective practice rather than prescribe operational compliance.

For these measures to be effective, they may be integrated into operational protocols and supported through routine training workshops. Compliance monitoring through periodic audits, case file reviews, and feedback mechanisms may help reduce procedural inconsistencies, support evidence integrity, and strengthen confidence in forensic findings presented in court.

5. Conclusions

This study demonstrates that variations in investigative personnel's understanding of firearm evidence, recognition of trace and ballistic components, adherence to evidence collection procedures, and knowledge of chain-of-custody principles have the potential to undermine evidentiary integrity. While crime scene experts displayed strong procedural competence, the limited conceptual and operational knowledge among investigating officers and, to some extent, ballistics experts reveals vulnerabilities at the earliest point of the forensic chain. These findings reinforce the importance of consistent, standardised practice across investigative units as a potential means of safeguarding the reliability and admissibility of firearm evidence.

Conceptually, the study highlights that firearm evidence management is not merely a technical process but a multi-stage system in which conceptual understanding, operational competence, and legal awareness must intersect. Breakdowns at any stage of scene recognition, collection, packaging, documentation, or continuity threaten the evidentiary value of ballistic material and undermine both investigative outcomes and judicial fairness. By mapping these gaps across role groups, this study contributes to the broader literature by demonstrating how variation in knowledge and practice can weaken the integrity of the forensic chain.

The findings carry important implications for policing practice and organisational policy. Integrating standardised guidelines, operational checklists, and continuous professional development into SAPS protocols may contribute to more harmonised practices by addressing areas where participants' articulated understanding and reported procedural awareness diverged. Strengthening collaboration between investigating officers, LCRC practitioners, and forensic laboratories will also support a more coherent and defensible investigative process. Implementation of systematic audits and feedback mechanisms can further reinforce compliance and promote a culture of evidence integrity. These conclusions are grounded in qualitative insights from a specific provincial policing context and are intended to provide analytical rather than statistical generalisation.

Future research should examine the effectiveness of structured training and checklist-based interventions in improving firearm evidence management. There is scope to explore how digital tools, such as electronic chain-of-custody systems, may enhance traceability and reduce administrative errors. Comparative studies across policing jurisdictions would also help identify best practices that could inform national and international standards. Ultimately, improving firearm evidence handling is central to strengthening investigative accuracy, promoting procedural justice, and enhancing public confidence in the criminal justice system.

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Informed Consent Statement: Informed consent was obtained from all subjects in the study. All participants were informed of the purpose of the research, their voluntary participation, and their right to withdraw at any time. No identifiable personal information was collected, and all responses were anonymised to ensure confidentiality. No identifiable individual data are presented in this manuscript.

Data Availability Statement: Due to the sensitivity of the qualitative data and confidentiality agreements with participants, the interview transcripts and raw data are not publicly available. Anonymised excerpts may be provided by the author upon reasonable request, subject to approval by the UNISA College of Law Research Ethics Review Committee.

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Appendix A. Recommended Operational Checklist for Firearm Evidence Collection

Recommended Checklist for Firearm Evidence Collection

Category	Checklist Items
Scene Management	-Secure the scene to prevent contamination or loss of evidence. -Avoid stepping on or disturbing cartridge cases, bullets, or residues.
Documentation	-Record the position of firearms, bullets, cartridge cases, bullet holes, and trajectories. -Photograph and sketch the scene. -Mark containers (not exhibits) with case details.
Firearm Handling	-Make the firearm safe before packaging; unload it carefully. -Handle by the chequered grip to preserve fingerprints. -Never insert objects into the barrel or clean the weapon before submission. -Record firearm condition, safety mechanism, and chambered rounds.
Bullet & Cartridge Collection	-Collect without sharp instruments to avoid damaging markings. -Rinse bullets removed from bodies under running water and air-dry. -Wrap lead bullets in tissue paper; never use cotton wool. -Package each item separately in suitable containers.
Residue Collection	-Collect gunshot residue (GSR) from hands, clothing, and nearby surfaces using approved swabs or adhesive kits. -Package residue samples separately and label clearly to avoid cross-contamination.
Packaging & Transport	-Do not transport loaded firearms or magazines. -Avoid plastic containers for metal components; use sturdy boxes. -Record serial number, make, and model of the firearm. -Seal parcels securely and include the covering minute inside.
Laboratory Submission	-Submit all fired bullets and cartridge cases for examination. -Do not clean or test-fire firearms before submission.
Additional Precautions	-Avoid leaving new fingerprints or removing existing ones. -Do not mark bullets or cartridge cases. -Ensure chain-of-custody documentation is complete and accurate.

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