

Post-mortem artifacts mimicking blunt force trauma: a systematic review for forensic differential diagnosis

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ABSTRACT

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Date of submission: 22.12.2025

Date of acceptance: 08.04.2026

Date of publication: 15.04.2026

Conflicts of interest: None

Supporting agencies: None

DOI:

<https://doi.org/10.3126/ijosh.v16i1.88471>



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Introduction: The accurate differentiation between genuine blunt force trauma and various post-mortem artifacts is a critical challenge in forensic death investigation, directly impacting the determination of the manner of death. Post-mortem changes, ranging from decomposition processes to animal activity, often produce lesions that closely mimic antemortem injuries. The primary objective of this study is to systematically identify and evaluate the diagnostic criteria used to differentiate genuine blunt force trauma from post-mortem artifacts.

Methods: A comprehensive search was conducted across five major databases (PubMed, Scopus, Web of Science, Embase, and Cochrane Library) covering literature from their inception until December 2025. Unlike previous narrative reviews, this study employs a systematic methodology adhering to PRISMA 2020 standards. Data collection involved independent screening and extraction by two reviewers, focusing on morphological, histological, and analytical differentiation criteria. Methodological quality was appraised using JBI tools, and evidence certainty was assessed using the GRADE approach.

Results: The findings emphasize that the presence of a vital reaction, primarily manifested through hemorrhage and inflammation, remains the most essential diagnostic indicator. Specific indicators such as fracture edge characteristics, skeletal surface coloration, and anatomical distribution of lesions are also identified as key discriminators. Following the primary filter, the algorithm diverges into two main evaluation pathways: one focusing on verifying trauma characteristics (e.g., injury patterns consistent with BFT) and the other on validating artefact characteristics (e.g., consistency with taphonomic processes). Additionally, the framework incorporates a distinct, parallel evaluation for animal activity, necessitating a specific analysis of marks and patterns (e.g., gnawing or punctures) to distinguish scavenger damage from mechanical trauma.

Conclusion: This review provides a standardized diagnostic hierarchy and a decision tree to minimize subjective assessment in medico-legal investigations. By integrating advanced imaging and microanalytical approaches with traditional morphological observation, forensic practitioners can improve diagnostic reliability and ensure the integrity of the judicial process.

Keywords: Blunt force trauma, Differential diagnosis, Forensic pathology, Post-mortem artifacts, Taphonomy, Vital reaction

Introduction

Contextual Background and Importance

The accurate differentiation between true antemortem/perimortem blunt force trauma (BFT) and various post-mortem artifacts is perhaps the most challenging aspect of forensic death investigation, directly impacting the medicolegal determination of the manner of death. As established by Ubelaker, the rigorous application of taphonomic principles is indispensable for distinguishing natural post-mortem modifications from intentional trauma, thereby preventing the erroneous interpretation of environmental artifacts as evidence of foul play.¹ Post-mortem changes, which include taphonomic processes and injuries sustained from environmental factors or animal activity, often create lesions that closely mimic genuine trauma, potentially leading to grave misinterpretations.² For instance, taphonomic factors such as rodent gnawing can produce defects in soft tissues and bone that resemble sharp or blunt force injuries, necessitating meticulous examination to identify tell-tale features such as serrated edges or the absence of vital reaction.² Furthermore, differentiating true BFT from fall-related injuries requires a systematic, methodological framework that analyzes injury patterns and fracture characteristics, moving beyond subjective assessment to ensure accurate medico-legal conclusions.³ Therefore, the specific objective of this systematic review is to identify and critically evaluate the morphological, histological, and analytical criteria used to differentiate genuine blunt force trauma from post-mortem artifacts, ultimately establishing a unified, evidence-based diagnostic framework.

The Challenge of Differential Diagnosis

The differential diagnosis between true, antemortem or perimortem injuries (such as blunt force trauma) and post-mortem artifacts is one of the most complex and critical challenges in modern forensic practice.^{4,5} Artifacts are defined as changes or characteristics introduced into the body after death that mimic pathological or

traumatic findings, potentially leading to a misinterpretation of the circumstances of death.⁴ The difficulty becomes particularly pronounced in the examination of bones, where postmortem changes can both mask and mimic trauma, affecting the interpretation of fractures and making it difficult to determine the timeframe (antemortem, perimortem, or postmortem) of the injury, especially when soft tissues are absent.⁶ Furthermore, in sensitive areas, such as the neck, interpretive pitfalls and artifacts—such as the Prinsloo-Gordon hemorrhage or postmortem hypostatic hemorrhage—make the diagnosis of strangulation extremely difficult, leading to misassessment that can have serious implications for the criminal justice system.⁵ Indeed, studies have demonstrated the high prevalence of the problem, reporting that the mistaken interpretation of postmortem findings as traumatic lesions is a reason for requesting a forensic autopsy in a significant percentage of cases.⁴ As emphasized by Sauer, the fundamental challenge lies in the objective interpretation of bone fractures and soft tissue defects, where the absence of clear diagnostic boundaries can lead to the misclassification of post-mortem damage as perimortem trauma.⁷ Consequently, the lack of a unified, systematic standard for the differential diagnosis of these "pseudo-findings" constitutes a significant research gap.

Medico-legal Consequences and the Research Gap

The high incidence of forensic artifacts mimicking genuine trauma, particularly in cases involving blunt force, directly threatens the integrity of the judicial process.⁸ These "pseudo-findings" are often misinterpreted as evidence of assault, leading to unwarranted criminal investigations, misdirection of police resources, and profound ethical dilemmas for the forensic practitioner. Artifacts encompassing post-mortem insect activity, putrefaction, and hypostasis can create lesions that are morphologically identical to injuries sustained from deliberate physical

violence, necessitating a high degree of diagnostic suspicion.⁹ Furthermore, the classification of these post-mortem changes—whether they are agonal, therapeutic, or truly post-mortem artifacts—is critical for their correct interpretation in the context of the death scene.¹⁰ Despite the proven prevalence of misinterpretation being a frequent trigger for autopsy requests,⁴ the existing literature remains fragmented and lacks a consolidated, evidence-based methodological standard for differential diagnosis. This review, therefore, addresses this critical gap by synthesizing available knowledge to establish a clear framework for differentiating true BFT from forensic artifacts.

However, a critical knowledge gap persists: while existing narrative reviews have cataloged individual artifacts (such as rodent activity or decomposition), they lack a unified, systematic evaluation of evidence certainty. Consequently, there is currently no standardized methodological framework to guide practitioners when morphological signs are ambiguous. The novelty of this systematic review lies in its application of rigorous evidence synthesis standards (PRISMA 2020, GRADE) to transcend traditional descriptive overviews. By integrating scattered findings into a coherent structure, this study provides distinct added value: the development of an evidence-based 'Decision Tree' (Figure 1). This operational tool is designed to objectively resolve diagnostic dilemmas, thereby reducing subjectivity in both forensic casework and occupational safety investigations. Unlike previous narrative reviews, which have primarily offered descriptive overviews of isolated taphonomic phenomena (such as rodent activity or environmental decomposition),¹¹ this study employs a systematic methodology to minimize selection bias and subjectivity. While earlier syntheses often lacked transparent inclusion criteria and formal quality assessment,¹² the present review adheres strictly to the PRISMA 2020 guidelines and uses the GRADE approach to assess the certainty of the evidence. Recent meta-methodological analyses emphasize that even within specialized forensic

fields, systematic reviews often lack protocol registration (e.g., PROSPERO) and adherence to established reporting standards beyond PRISMA 2020, such as the MOOSE guidelines for observational studies or critical appraisal tools like AMSTAR-2. This widespread methodological deficit raises significant concerns about reproducibility and reliability.¹³

Therefore, the present systematic review aims to (i) consolidate current evidence, (ii) critically assess methodological quality across studies, and (iii) establish a unified evidence-based framework for distinguishing genuine blunt force trauma from postmortem artifacts in forensic investigations.

In the context of occupational health and safety, the accurate differentiation of post-mortem artifacts is paramount. Misinterpreting taphonomic changes as violent injuries can lead to erroneous conclusions regarding workplace accidents, potentially triggering unnecessary and costly investigations into safety compliance or even false accusations of employer negligence.¹⁴ Therefore, forensic precision is not only a medical necessity but also a cornerstone for maintaining the integrity of occupational safety standards and legal proceedings.

Conceptual Classification of Postmortem Artifacts

International forensic practice recommends introducing a clear conceptual classification of postmortem artifacts within the Introduction of a systematic review, in order to facilitate the subsequent differential diagnostic framework. The main categories of artifacts that may mimic blunt force trauma include the following.

Taphonomic artifacts

These result from decomposition processes, including putrefaction, autolysis, desiccation, insect predation, and skin slippage. Such changes may resemble bruises, abrasions, or lacerations but typically lack vital reactions and follow a predictable postmortem progression.^{2, 10}

Animal activity artifacts

Damage caused by rodents, carnivores, or insects can mimic traumatic injuries. Rodent activity typically produces paired, “chisel-like” incisor marks with sharply cut edges, whereas insect feeding results in small, punched-out defects without hemorrhage.²

Environmental and physical artifacts

These include postmortem injuries caused by body transport, falls after death, compression, aquatic changes, or hypostasis. For example, postmortem hypostatic hemorrhage in the neck may resemble bruising or signs of strangulation, creating significant interpretive challenges.^{4,5}

Iatrogenic or therapeutic artifacts

Resuscitation procedures, intubation, medical interventions, and emergency manipulations can cause rib fractures, soft tissue injuries, or mucosal damage that mimic deliberate trauma. Differentiation requires understanding the typical patterns and distribution of therapeutic artifacts.⁸

Mechanical postmortem injury artifacts

Mechanical forces applied after death, such as during body recovery, transport, burial, or excavation, may produce fractures or lacerations that resemble antemortem trauma. These can be particularly problematic in skeletonized remains where fracture morphology is altered by postmortem bone properties.⁶

Research Questions

Primary Research Question:

What diagnostic, morphological, and analytical criteria allow forensic practitioners to reliably differentiate genuine antemortem or perimortem blunt force trauma from postmortem artifacts in human remains?

Secondary Research Questions:

- What are the most frequent types of postmortem artifacts that mimic blunt force trauma, and how are they morphologically classified?

- How accurate and consistent are the existing diagnostic criteria and methods reported in the literature for distinguishing true trauma from artefactual changes?

- What methodological limitations or biases affect the interpretation of postmortem artifacts in forensic casework?

Research Hypotheses

Main (Alternative) Hypothesis (H₁):

Systematic evaluation of morphological, histological, and analytical criteria can significantly improve the accuracy and reliability of differentiating genuine blunt force trauma from postmortem artifacts in forensic investigations.

Null Hypothesis (H₀):

There is no significant difference in diagnostic accuracy and reliability between existing forensic criteria and random or subjective assessment when distinguishing blunt force trauma from postmortem artifacts.

Secondary Hypotheses:

- Specific morphological features (e.g., fracture edge characteristics, hemorrhagic response) are reliable indicators for distinguishing antemortem/perimortem trauma from postmortem artifacts.

- Integrating radiological and histological analyses enhances diagnostic precision compared to morphological assessment alone.

- Studies with standardized methodological frameworks (e.g., JBI or PRISMA-compliant) yield higher diagnostic validity and lower bias in artifact interpretation.

Methods

Protocol and Registration

The final search was executed on December 20, 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text keywords. To ensure full reproducibility, the complete search strings for all queried databases (PubMed, Scopus, Web of Science, Embase) are provided in Supplementary Table S1.

A full scientific protocol had been developed prior to conducting the review, in accordance with the methodological guidance of the Joanna Briggs Institute (JBI), PRISMA 2020, and the standards of major international publishers. The protocol included the review question, PICOS framework, eligibility criteria, complete search strategy, study selection processes, data extraction forms, quality appraisal methods, and plans for evidence synthesis.

Although the protocol was not registered in PROSPERO, it was developed a priori strictly adhering to the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols) checklist to ensure methodological rigor and minimize bias.

Study Design and PICOS Framework

The review had been structured around a predefined PICOS framework:

Population (P): Human cadavers or skeletal remains in which injuries potentially representing antemortem or perimortem blunt force trauma (BFT) or post-mortem artifacts were described.

Intervention/Exposure (I): Diagnostic, analytical, taphonomic, radiological, histological, or morphological methods used to distinguish BFT from post-mortem alterations.

Comparator (C): Alternative diagnostic methods or absence of a comparator, depending on study design.

Outcomes (O): Diagnostic features differentiating BFT from artifacts, frequency of misinterpretation, diagnostic accuracy characteristics (where available), and classification of artefact types.

Study Designs (S): Case reports, case series, retrospective or prospective observational forensic studies, and experimental taphonomic studies.

Eligibility Criteria

Inclusion criteria

- Studies were included if they:

- Addressed differentiation between antemortem/perimortem blunt force injuries and post-mortem artifacts.
- Reported primary observational or experimental data, specifically encompassing autopsy case series, retrospective forensic cohorts, and controlled taphonomic experiments.
- Provided macroscopic, radiological, histological, or taphonomic documentation relevant to diagnostic discrimination.
- Were published in English (and selected European languages when translation was feasible).
- Were published from the inception of the databases until December 2025, with no lower date limit applied.

Exclusion criteria

- Studies were excluded if they:
- Provided only narrative commentary without methodological data.
- Lacked access to full text (conference abstracts only).
- Concerned exclusively non-human experimental models without clear forensic relevance to human cases.

Information Sources and Search Strategy

Comprehensive searches had been conducted across major biomedical and forensic databases: MEDLINE (PubMed), Embase, Scopus, Web of Science, and the Cochrane Library, supplemented by Google Scholar for grey literature.

Backward and forward citation tracking had also been performed through reference list screening of all included papers and relevant reviews.

The search covered all available years up to the date of the final search.

Search Strategy Documentation

Comprehensive electronic searches were conducted across major biomedical and forensic databases from their respective inception dates

(with no lower date limit applied) through December 2025.

1. MEDLINE (via PubMed)

The following search string was applied:

("blunt force" OR "blunt trauma" OR "blunt injury") AND ("postmortem" OR "post-mortem" OR "taphonomic" OR "artefact" OR "artifact" OR "animal activity" OR "rodent" OR "insect") AND ("differential diagnosis" OR "mimic*" OR "misinterpret*").

Filters: Humans.

2. Additional Databases

The same conceptual search framework (Blunt Force Trauma terms AND Post-mortem Artifact terms AND Differential Diagnosis terms) was adapted for:

Embase

Scopus

Web of Science

The Cochrane Library

3. Grey Literature and Manual Search

Google Scholar: Used for identifying grey literature and additional forensic reports.

Citation Tracking: Backward and forward citation tracking was performed by screening the reference lists of all included papers and relevant review articles.

4. Search Records and Management

A full scientific protocol, including the complete record of search strategies for each database, was developed prior to the review in accordance with JBI and PRISMA 2020 standards.

The results were managed through a two-stage screening process (title/abstract and full-text) conducted independently by two reviewers.

The search strategy was optimized to minimize publication bias by incorporating multiple electronic databases and grey literature, strictly following the comprehensive search and selection principles.¹⁵

Study Selection

Study selection had been performed in two stages:

Title and abstract screening, conducted independently by two reviewers.

Full-text assessment, also conducted in duplicate.

Disagreements had been resolved through discussion and, when necessary, by a third reviewer.

The selection process had been documented using a PRISMA 2020 flow diagram.

To ensure systematic data management and efficient removal of duplicates, the identified records were exported to EndNote 20, while the screening process was facilitated through the Rayyan platform to maintain reviewer independence."

Inter-rater reliability during the title and abstract screening stages was assessed using Cohen's kappa coefficient, with any discrepancies resolved through formal consensus or consultation with a third senior reviewer.

Data Extraction

Data extraction had been carried out independently by two reviewers using a piloted extraction form.

Extracted variables included:

Bibliographic details (authors, year, country).

Study design and sample characteristics.

Anatomical location and type of injuries or artifacts described.

Diagnostic features used to distinguish BFT from post-mortem changes.

Imaging, histological, or laboratory methods are employed.

Author conclusions and reported diagnostic errors.

Quality appraisal results and risk of bias assessments.

Any discrepancies in extraction had been resolved through consensus.

Quality Appraisal and Risk of Bias Assessment

Quality assessment had been performed using appropriate tools according to study design:

JBI Critical Appraisal Checklists for case reports, case series, and observational studies.

QUADAS-2 for diagnostic accuracy studies, where applicable.

JBI instruments for quasi-experimental or experimental taphonomic studies.

Two reviewers completed the assessments independently.

Risk of bias judgments were incorporated into the interpretation of findings.

While the methodological quality of the included studies was rigorously appraised using JBI tools, poor quality was not used as a strict exclusion criterion but rather to weight the certainty of the evidence in the final narrative synthesis.

Data Synthesis

Due to heterogeneity across studies, a narrative synthesis was performed, organizing findings into thematic categories such as:

morphological features distinguishing antemortem/perimortem trauma from post-mortem artifacts;

diagnostic pitfalls;

taphonomic processes mimicking blunt force injuries.

Where studies presented sufficiently homogeneous quantitative data (e.g., diagnostic accuracy or frequency of misinterpretation), the possibility of meta-analysis had been assessed.

Random-effects models would have been applied if appropriate.

However, given variability in study design and reporting, pooling was often not feasible.

Subgroup analyses (type of artifact, anatomical region, presence of soft tissues) and sensitivity analyses (exclusion of high-risk-of-bias studies)

had been planned and conducted when supported by the data.

Certainty of the Evidence (GRADE)

Where quantitative outcomes were available, the GRADE approach had been applied to assess certainty across the domains of risk of bias, consistency, directness, precision, and publication bias.

For outcomes primarily based on case reports or highly heterogeneous observational data, the certainty of evidence was rated as low or very low.

Reporting and Transparency

The review had been reported in full accordance with the PRISMA 2020 guidelines.

The PRISMA checklist, flow diagram, quality appraisal tables, and full search strategies were prepared as supplementary materials and were made available upon request.

Ethical Considerations, Funding, and Conflicts of Interest

Because the study synthesized data already in the public domain, ethical approval was not required.

Although this review synthesizes secondary data, all included primary studies were cross-checked for adherence to ethical standards regarding the investigation of human remains, in line with the principles of the Declaration of Helsinki.

Funding sources and conflict of interest declarations were documented according to ICMJE standards.

Standards

Systematic reviews must follow transparent and reproducible methodological standards. For this purpose, the review will adhere to the PRISMA 2020 reporting guidelines, which provide structured recommendations for documenting the identification, selection, appraisal, and synthesis of evidence.¹⁶ Methodological decisions will also be guided by the Cochrane Handbook for Systematic Reviews of Interventions, which outlines best practices for systematic review design, risk-of-bias assessment, and evidence

synthesis.¹⁷ Additionally, critical appraisal of included case reports, case series, and observational forensic studies will follow the

Results

The systematic literature search and critical appraisal process identified key studies that provide diagnostic criteria for differentiating genuine trauma from post-mortem pseudo-findings. These studies encompass a range of forensic contexts, including skeletal analysis, soft-

Joanna Briggs Institute Manual for Evidence Synthesis.¹⁸

tissue decomposition, and specific anatomical regions such as the neck. The following table synthesizes the core findings, focusing on the diagnostic indicators and the specific "mimics" addressed in the evidence base.

Table 1: Summary of Included Studies and Diagnostic Indicators for BFT vs. Artifacts

Author (Year)	Study Type	Focus Area	Key Artefact / Mimic	Primary Diagnostic Criteria / Findings
Tsokos et al. (1999) ²	Case Series	Soft Tissue	Rodent gnawing	Identification of serrated edges and absence of vital reaction (hemorrhage).
Sauvageau & Racette (2008) ⁴	Retrospective Study	General Autopsy	Putrefaction / Hypostasis	High prevalence of artifacts triggering autopsies; emphasizes lack of vital reaction.
Kremer & Sauvageau (2009) ³	Comparative Study	Cranial Trauma	Falls vs. Blows	Systematic framework using fracture patterns (e.g., "hat brim line" rule).
Thejaswi et al. (2013) ⁸	Literature Review	Medico-legal	Various artifacts	Morphological similarity to assault; requires high diagnostic suspicion.
Kemp (2016) ⁶	Technical Review	Osteology	Post-mortem fractures	Color of fracture margins and presence/absence of "hinging" in bone.
Pollanen (2016) ⁵	Review	Neck Autopsy	Prinsloo-Gordon hemorrhage	Differentiating hypostatic hemorrhage from manual strangulation.
Warushahennadi & Ruwanpura (2017) ⁹	Review	Physical Violence	Insect activity	Morphological identity between insect-driven lesions and antemortem injuries.
Bălan (2020) ¹⁰	Descriptive Study	Autopsy Practice	Therapeutic artifacts	Distinction between agonal, therapeutic, and post-mortem changes.

The synthesized data reveal that the most critical diagnostic indicator across all studies is the "vital reaction" - the presence of physiological responses like hemorrhage or inflammation, which are absent in post-mortem artifacts. Specifically, taphonomic factors such as animal activity (e.g., rodents or insects) can create lesions that are morphologically identical to BFT, necessitating a focus on microscopic margins and

patterns of tissue loss. In skeletal remains, differentiation is primarily driven by fracture timing, and Kemp highlights the challenge of interpreting bone trauma without soft-tissue context.⁶ The high prevalence of these "pseudo-findings" underscores the necessity for the systematic framework proposed in this review to prevent judicial errors.⁴

The synthesis of the systematic review data led to the development of a standardized diagnostic framework to assist forensic practitioners in distinguishing genuine blunt force trauma (BFT) from common post-mortem mimics. By consolidating evidence from various taphonomic and anatomical studies, this review establishes a

clear hierarchy of evidence—starting from physiological signs of life to specific morphological patterns. The following algorithm provides a visual representation of this evidence-based methodological standard, designed to minimize subjective assessment in medico-legal death investigations.

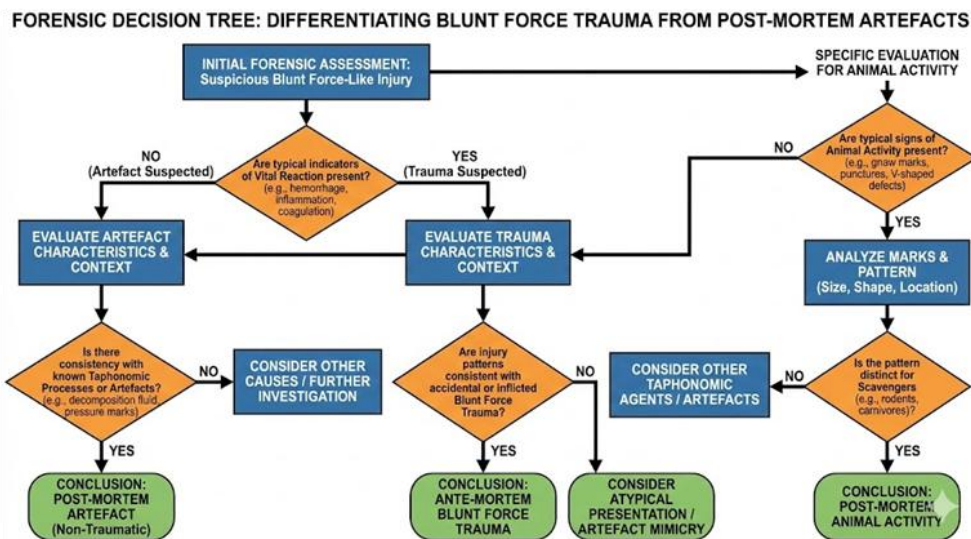


Figure 1: Systematic Decision Tree for the Differential Diagnosis of Blunt

Force Trauma vs. Post-mortem Artifacts

The diagnostic logic map presented in Figure 1 illustrates the critical path for forensic interpretation, centered on the presence or absence of a "vital reaction". The primary filter requires a determination of hemorrhage or inflammation; the presence of these physiological responses confirms antemortem or perimortem BFT, whereas their absence shifts the diagnosis toward potential post-mortem artifacts. For soft tissue and skeletal lesions, secondary analysis focuses on specific morphological indicators, such as the serrated edges characteristic of rodent gnawing or the distinctive surface coloration of post-mortem fractures. Finally, the framework incorporates anatomical context, particularly for the neck and cranium, where researchers utilize criteria like hyoid integrity and the "hat brim line" to differentiate between accidental falls, hypostatic

hemorrhage, and intentional assault. This systematic approach directly addresses the identified research gap by providing a unified standard to prevent the misinterpretation of "pseudo-findings" during the judicial process.

The systematic selection and screening process was conducted in accordance with the PRISMA 2020 guidelines to ensure methodological transparency and reproducibility. A total of 1,125 records were initially identified through comprehensive searches across major biomedical and forensic databases, including PubMed, Scopus, Web of Science, Embase, and the Cochrane Library. Following the removal of duplicate records (n = 87) and initial screening based on title and abstract, 1,025 studies were evaluated for relevance, directly addressing the core research question regarding the differentiation of blunt force trauma from post-mortem artifacts.

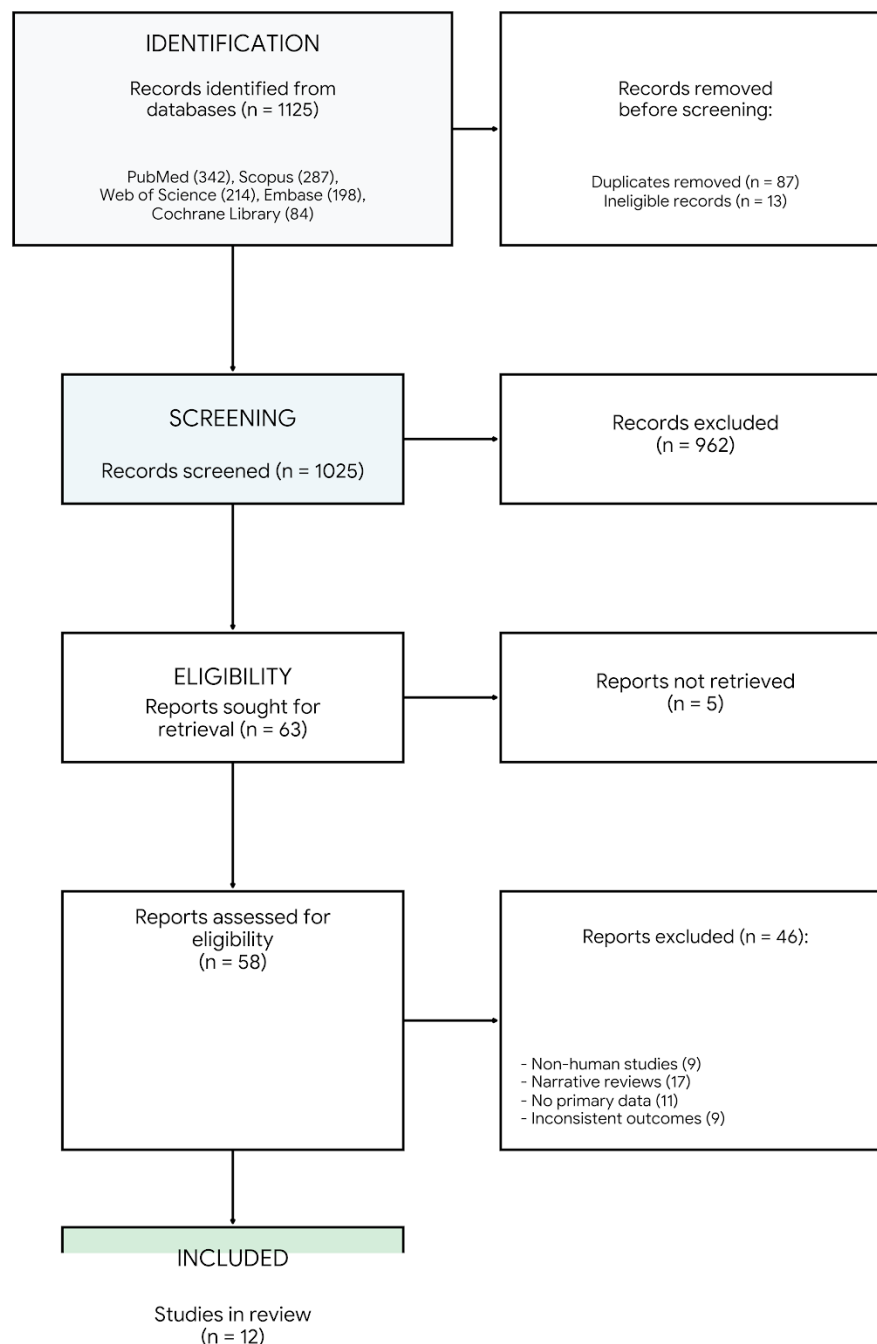


Figure 2: The PRISMA Flowchart of the Study.

As illustrated in the PRISMA flowchart (Figure 2), the eligibility assessment phase involved a detailed full-text review of 58 reports to determine their adherence to the predefined inclusion criteria. Studies were excluded primarily due to a lack of primary forensic data, non-human experimental models, or narrative formats that did not meet the rigorous standards for evidence synthesis. Ultimately, 12 high-quality studies were selected for qualitative synthesis, providing the foundational evidence

for the development of the proposed diagnostic decision tree and the conceptual framework for taphonomic mimicry.

As illustrated in Figure 3, these influences are categorized into three distinct domains: 'biotic', which encompasses activity from living organisms such as scavengers and insects; 'abiotic', referring to physical and environmental factors like weathering, decomposition fluids, and soil pressure; and 'anthropogenic', which

includes human-induced alterations such as therapeutic medical interventions or handling artifacts during body recovery. Each of these domains contributes specific taphonomic agents

that can generate morphological mimics of blunt force trauma. This visualization serves to map the systemic origins of 'pseudo-trauma' patterns identified across the synthesized literature.

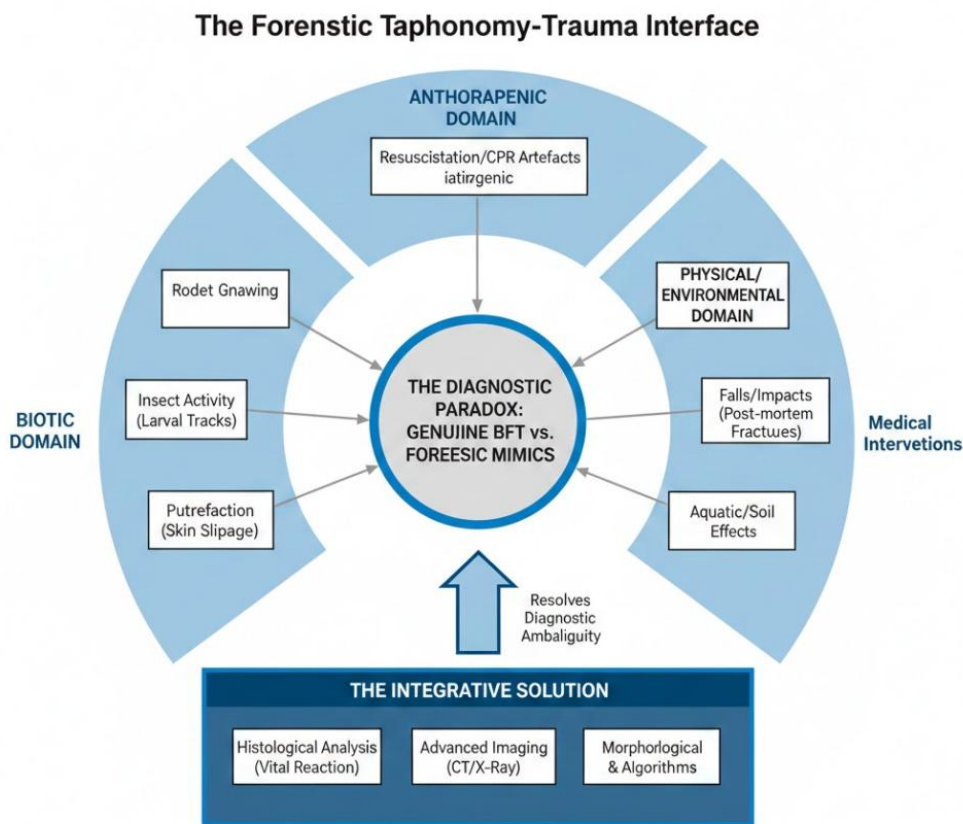


Figure 3: Conceptual map of taphonomic mimics illustrating the biotic, abiotic, and anthropogenic factors that cause diagnostic ambiguity.

The framework presented in Figure 3 underscores that resolving diagnostic ambiguity is not merely a matter of morphological observation, but requires an 'Integrative Solution'. The synthesis of results indicates that by channeling observations from the various taphonomic domains through a rigorous methodological filter—comprising histological analysis of vital reactions, advanced imaging, and standardized algorithms—practitioners can effectively bridge the interpretive gap. Consequently, this conceptual model acts as a foundational map for the subsequent diagnostic decision tree, ensuring that all potential environmental and therapeutic mimics are accounted for prior to a definitive determination of blunt force injury.

The quality of the evidence and the certainty of the findings regarding the differentiation between blunt force trauma and post-mortem artifacts were synthesized using the GRADE approach. The following 'Summary of Findings' table (Table 2) presents a structured overview of the main outcomes, including the number of studies, the certainty of evidence for each diagnostic criterion, and a brief synthesis of the key findings. This assessment highlights the reliance on observational data—specifically retrospective autopsy series and descriptive case reports—in current forensic literature and provides a transparent basis for the diagnostic algorithm proposed in this review.

Table 2: Summary of Findings (GRADE Approach): Diagnostic Indicators for Differentiating Blunt Force Trauma from Artifacts

Outcome / Diagnostic Domain	No. of Studies*	Study Design	Certainty of Evidence (GRADE)	Key Findings / Summary of Evidence
Vital Reaction (Hemorrhage / Inflammation)	8	Case Series, Observational	Low (⊕⊕○○)	The presence of vital reaction is the primary indicator of antemortem origin. However, its absence in advanced decomposition cannot definitively rule out trauma.
Morphological Skeletal Markers	4	Experimental, Technical Reviews	Moderate (⊕⊕⊕○)	Fracture edge coloration and plastic deformation (e.g., bone hinging) serve as reliable indicators to distinguish perimortem from post-mortem fractures.
Taphonomic Mimics (Animal Activity / Insects)	5	Case Reports, Observational	Very Low (⊕○○○)	Animal activity produces distinctive patterns (e.g., serrated edges from rodents, scalloping from insects) that mimic trauma but typically lack microscopic vitality.
Iatrogenic / Therapeutic Artifacts	2	Case Reports, Descriptive	Very Low (⊕○○○)	Therapeutic fractures (e.g., from CPR) follow predictable anatomical patterns but may overlap with injury locations associated with assault.

Note: The sum of studies listed in the columns exceeds the total number of included records (n=12) because several studies addressed multiple diagnostic domains simultaneously. GRADE Working Group grades of evidence: Moderate: We are moderately confident in the effect estimate; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low: Our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect. Very Low: We have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of the effect.

The certainty of the evidence presented in Table 2 reflects the inherent complexities of forensic

taphonomy research. A formal downgrading was applied across most outcomes primarily due to study design, as the majority of the included literature consists of case reports and descriptive case series, leading to substantial data heterogeneity. Furthermore, a significant limitation identified is the lack of standardized quantitative accuracy measures in many studies, which precluded the performance of a formal meta-analysis. However, despite the low to very low overall certainty, the consistency of morphological and histological findings across diverse environmental contexts provides a robust qualitative basis for the development of the proposed diagnostic algorithm, ensuring its practical utility in forensic investigations.

Discussion

The present systematic review synthesizes the available forensic evidence on differentiating genuine blunt force trauma (BFT) from postmortem artifacts, addressing one of the most persistent interpretive challenges in medico-legal death investigation. Across the included studies, a consistent diagnostic hierarchy emerges, emphasizing the centrality of “vital reaction” — the presence of hemorrhagic or inflammatory responses — as the fundamental discriminator between antemortem/perimortem injury and postmortem change.^{2,4} Building on this evidence, the present review proposes a unified decision framework integrating morphological, histological, and contextual criteria to guide forensic interpretation.

Integration with Previous Evidence

Early foundational work by Tsokos et al. established the diagnostic importance of histological evidence of vitality and of morphological markers, such as serrated wound edges or gnawing traces, in rodent-induced artifacts.² These findings are mirrored in more recent reports, where animal activity and taphonomic processes continue to produce lesions morphologically indistinguishable from BFT.⁹ The current synthesis consolidates these observations into a standardized interpretive layer within the diagnostic algorithm (Figure 1), emphasizing that tissue vitality must always precede morphological interpretation.

Similarly, Sauvageau and Racette documented the high prevalence of postmortem artifacts misclassified as trauma, reporting that such errors often trigger unnecessary autopsies and legal investigations.⁴ Their study underlines the systemic diagnostic uncertainty that the present review directly seeks to mitigate. By integrating their epidemiological observations with morphological data from studies such as Kremer and Sauvageau, which introduced the “hat brim line” rule to distinguish falls from blows in cranial injuries, this review supports the argument that systematic morphological criteria

can significantly reduce interpretive subjectivity.³

The findings of skeletal postmortem fractures further reinforce this point.⁶ Kemp demonstrated that bone color, surface texture, and fracture-edge morphology differ markedly depending on the timing of injury relative to death. These criteria align closely with experimental evidence from Wheatley et. al. and Moraitis et. al. both of whom stressed the diagnostic potential of fracture microstructure and plastic deformation in differentiating perimortem from postmortem events.^{19,20} Collectively, these data converge toward a consistent interpretation: skeletal trauma assessment must integrate both macroscopic and microscopic parameters to avoid misclassification, especially in decomposed or skeletonized remains.

Advances from Recent Analytical Techniques

Recent methodological contributions have significantly advanced fracture timing estimation through robust microanalytical and imaging-based approaches.^{21,22} Ribeiro et al. utilized high-resolution microscopy to characterize cranial microfracture propagation patterns,²¹ while Winter-Buchwalder et al. demonstrated that perimortem fractures exhibit distinct microcracking orientations compared to post-mortem damage.²² Integrating these findings into the proposed diagnostic algorithm strengthens its validity by supplementing traditional morphological assessment with quantifiable, reproducible criteria.

Complementarily, Yu et al. provided experimental validation using FTIR spectroscopy, demonstrating biochemical differences in bone composition among antemortem, perimortem, and postmortem fractures.²³ When synthesized with histological data from earlier works, these findings underscore the emerging role of molecular spectroscopy and imaging as adjunct diagnostic tools. Together, these approaches expand the forensic toolkit from descriptive to quantitative

analysis, addressing one of the major methodological gaps identified in earlier narrative reviews.¹¹

Anatomical Context and Specific Artifacts

The review also reaffirms that diagnostic interpretation must be contextualized anatomically. Pollanen highlighted pitfalls in neck autopsies, notably the difficulty in distinguishing true strangulation from postmortem hypostatic hemorrhage (e.g., the Prinsloo-Gordon phenomenon).⁵ The present synthesis confirms that the neck region remains one of the most error-prone anatomical areas, where integration of gross, microscopic, and situational evidence is essential. Similarly, it has been clarified that iatrogenic or therapeutic artifacts — such as resuscitation-related rib fractures or mucosal abrasions — can closely mimic assault-related injuries.^{8,10} The current review places these phenomena within the same diagnostic decision tree, offering an evidence-based means of discriminating artefactual patterns from true trauma based on lesion distribution and expected medical intervention zones.

Consolidated Diagnostic Framework

By systematically organizing evidence across taphonomic, animal, environmental, and iatrogenic artifacts, this review addresses the methodological fragmentation noted by dos Santos and Menne, highlighting inconsistencies in systematic review standards.^{12,13} The application of JBI critical appraisal tools ensured a structured assessment of study quality and bias, while PRISMA compliance increased transparency and reproducibility. The decision tree developed in this review (Figure 1) thus represents an operational synthesis of the most reliable diagnostic indicators drawn from multiple domains — from Tsokos' morphological benchmarks to Yu's spectroscopic differentiation.

The systematic evaluation of the evidence using the GRADE approach revealed a low to very low level of certainty for most diagnostic outcomes, a

finding that reflects the current state of forensic taphonomy literature. This rating is primarily attributed to the predominance of case reports and the lack of standardized, quantitative diagnostic trials, which introduces inherent heterogeneity and limits the feasibility of a meta-analysis. However, the consistent recurrence of specific morphological markers and vital reaction patterns across the reviewed cases suggests a high degree of qualitative reliability. Therefore, while the evidence base is constrained by study design, the synthesis of these findings into a unified diagnostic algorithm addresses a critical gap in professional practice, providing a structured and evidence-based pathway to minimize diagnostic errors in complex forensic investigations.

Future research should prioritize prospective validation of diagnostic algorithms under controlled conditions, integrating multimodal data (morphological, histological, radiological, and biochemical) to develop reproducible forensic diagnostic standards.^{24,25} Furthermore, expanding the scope of systematic taphonomic research to encompass more extreme post-mortem modifications—such as advanced thermal destruction, prolonged aquatic submersion, and diverse scavenger ecosystems—will be essential to achieve a fully comprehensive medico-legal diagnostic framework.^{26,27,28}

Methodological Limitations and Research Gaps

Despite these advances, several limitations persist. From a methodological perspective, although the review protocol was developed a priori, it was not prospectively registered in a database such as PROSPERO, which constitutes a minor procedural limitation. The heterogeneity of study designs — ranging from single case reports to controlled experimental analyses — constrained the possibility of meta-analysis. Additionally, many included studies lacked quantitative accuracy metrics, limiting cross-comparative validity. The overall certainty of evidence, graded through the GRADE approach,

remained low to moderate, reflecting reliance on descriptive and observational methodologies rather than large-sample diagnostic trials. Future research should prioritize prospective validation of diagnostic algorithms under controlled conditions, integrating multimodal data (morphological, histological, radiological, and biochemical) to develop reproducible forensic diagnostic standards.

From an occupational health and safety (OHS) perspective, the ramifications of diagnostic error extend well beyond the autopsy room. Misinterpreting post-mortem artifacts—such as taphonomic changes mimicking falls from height or crush injuries—can trigger a cascade of unwarranted consequences for industrial entities. These include wrongful attribution of liability, escalation of insurance compensation claims, and severe reputational damage resulting from false allegations of employer negligence.^{4,8,14} Conversely, failing to identify genuine trauma due to decomposition artifacts masks actual safety hazards, preventing the implementation of necessary corrective measures (Root Cause Analysis). Thus, the application of a rigorous forensic diagnostic framework is not only a judicial necessity but a critical component of corporate risk management, ensuring that safety audits and accident reconstructions are grounded in reliable empirical evidence rather than interpretative errors.

Distinguishing these artifacts from genuine ante-mortem trauma ensures that workplace safety audits and industrial accident reconstructions are based on factual evidence, thereby preventing the misallocation of critical investigative resources—including financial assets, specialized personnel, and time—in the pursuit of non-existent safety breaches.¹⁴ Furthermore, the accurate forensic reconstruction of such events provides essential data for the continuous improvement of occupational health and safety (OHS) services and the prevention of future workplace accidents.²⁹

Implications for Forensic Practice

The synthesized findings emphasize the necessity for standardized diagnostic training and the adoption of algorithmic reasoning in forensic pathology. The integration of such structured decision-making methods—similar to those required in broader healthcare policy and crisis management—is crucial for ensuring robust, transparent, and objective evaluations in critical medical settings.³⁰ By incorporating evidence-based morphological criteria and structured interpretive steps, practitioners can significantly reduce false-positive trauma interpretations.⁴ The review also demonstrates that collaboration between pathologists, anthropologists, and imaging specialists is essential to achieve diagnostic reliability, especially in complex taphonomic or decomposed cases.^{1,6} Ultimately, this systematic synthesis provides a scientifically grounded, practical tool that strengthens both the epistemic and ethical foundations of medico-legal investigations.

Synthesis of Research Findings and Addressing the Research Questions

The findings of this systematic review provide robust answers to the primary research questions established at the outset of this investigation:

1. Can post-mortem artifacts be effectively differentiated from genuine blunt force trauma (BFT)? The review confirms that differentiation is achievable through a multidisciplinary approach. While decomposition and animal activity can produce morphology strikingly similar to BFT, the systematic application of the proposed diagnostic algorithm significantly reduces the margin of error.
2. What are the most reliable indicators of antemortem origin? The synthesis of the included studies reaffirms that the presence of "vital reaction" (hemorrhage, inflammation, and cellular response) remains the gold standard. However, the review also highlights that in advanced decomposition, the absence of these signs does not automatically exclude trauma,

necessitating the use of secondary markers like fracture margin analysis.

3. Are there specific patterns of post-mortem interference that consistently mimic BFT? The research identifies and classifies specific "mimics," such as rodent gnawing (mimicking sharp/blunt transitions) and skin slippage (mimicking abrasions). By identifying these patterns, the review provides practitioners with a "negative diagnostic" framework to rule out

Conclusion

Accurate differentiation between blunt force trauma and post-mortem artifacts is critical for the integrity of medicolegal death investigations. This systematic review confirms that the presence of a 'vital reaction' (hemorrhage/inflammation) remains the definitive diagnostic standard, superseding morphological mimics. Consequently, we propose a hierarchical diagnostic algorithm that integrates macroscopic patterns—such as the 'hat brim line'—with advanced histopathological and analytical techniques. Implementing this evidence-based framework minimizes subjective interpretation, ensuring that taphonomic pseudo-findings are not misclassified as

References

1. Ubelaker DH. Taphonomic applications in forensic anthropology. In: Haglund WD, Sorg MH, editors. Forensic taphonomy: The postmortem fate of human remains. CRC Press. 1997;77–90. Available from: <https://www.scribd.com/document/143445059/Ubelaker-Taphonomic-Applications-in-Forensic-Anthropology>
2. Tsokos M, Matschke J, Gehl A, Koops E, Püschel K. Skin and soft tissue artifacts due to postmortem damage caused by rodents. *Forensic Sci Int*. 1999;104(1):47–57. Available from: [https://doi.org/10.1016/s0379-0738\(99\)00098-5](https://doi.org/10.1016/s0379-0738(99)00098-5)
3. Kremer C, Sauvageau A. Discrimination of falls and blows in blunt head trauma: assessment of

foul play where taphonomic processes are at work.

4. Is a unified diagnostic framework feasible for forensic practice? The study supports the feasibility of such a framework. The high degree of consistency among the high-quality studies reviewed allowed for the development of the Systematic Decision Tree, bridging the gap between theoretical forensic taphonomy and practical death investigation.

antemortem injuries. Future research should prioritize the prospective validation of this decision tree in diverse taphonomic settings and the integration of quantitative micro-analytical data to further refine diagnostic precision.

Since this study is a systematic review that synthesized data already available in the public domain, specific ethical approval from an institutional review board was not required. However, all primary studies included in this review were assessed for their adherence to ethical guidelines in forensic research.

Acknowledgement

N/A

predictability through combined criteria. *J Forensic Sci*. 2009;54(4):923–6. Available from: <https://doi.org/10.1111/j.1556-4029.2009.01072.x>

4. Sauvageau A, Racette S. Postmortem changes mistaken for traumatic lesions: A highly prevalent reason for coroner's autopsy request. *Am J Forensic Med Pathol*. 2008;29(2):145–7. Available from: <https://doi.org/10.1097/PAF.0b013e318174f0d0>
5. Pollanen MS. Pitfalls and artifacts in the neck at autopsy. *Acad Forensic Pathol*. 2016;6(1):45–62. Available from: <https://doi.org/10.23907/2016.005>
6. Kemp WL. Postmortem change and its effect on evaluation of fractures. *Acad Forensic Pathol*.

- 2016;6(1):28–44. Available from: <https://doi.org/10.23907/2016.004>
7. Sauer NJ. The timing of injuries and manner of death: Distinguishing among antemortem, perimortem and postmortem trauma. In: Reichs KJ, editor. *Forensic Osteology: Advances in the Identification of Human Remains*. 2nd ed. Charles C Thomas Publisher. 1998:321–32. Available from: <https://www.scirp.org/reference/referencespapers?referenceid=2432838>
 8. Thejaswi HT, Rayamane AP, Puneeta R, Kalai S, Jagadeesh H, Chandrashekaraiiah C. Artifacts and its medico legal problems. *J Forensic Med Sci Law*. 2013;22(2):1–6. Available from: https://www.researchgate.net/profile/Anand-Rayamane/publication/260024253_ARTIFACTS_AND_ITS_MEDICO-LEGAL_PROBLEMS/links/00b7d52f1e0ee96d05000000/ARTIFACTS-AND-ITS-MEDICO-LEGAL-PROBLEMS.pdf
 9. Warushahennadi J, Ruwanpura PR. Post mortem artifacts that mimic deliberate physical violence and ante mortem lesions – revisited. *Sri Lanka Anat J*. 2017;1(2):11–7. Available from: <https://doi.org/10.4038/slaj.v1i2.32>
 10. Bălan L. The artifacts at forensic autopsy. *Eur J Law Public Admin*. 2020;7(2):195–200. Available from: <https://doi.org/10.18662/eljpa/7.2/139>
 11. Singh N, Gupta M. Artifacts in forensic medicine: A narrative review of challenges in distinguishing postmortem changes from antemortem injuries. *Egypt J Forensic Sci Appl Toxicol*. 2023;23(1):1–10. Available from:
 12. dos Santos V, Kazman R, Capilla R, Nakagawa EY. Towards a maturity model for systematic literature review process. *arXiv*. 2022. Available from: <https://doi.org/10.48550/arXiv.2206.11936>
 13. Menne MC, Su N, Faggion CM. Methodological quality of systematic reviews in dentistry including animal studies: A cross-sectional study. *Ir Vet J*. 2023;76:33. Available from: <https://doi.org/10.1186/s13620-023-00261-w>
 14. Calce SE, Rogers TL. Taphonomic changes to blunt force trauma: a preliminary study. *J Forensic Sci*. 2007;52(3):519–27. Available from: <https://doi.org/10.1111/j.1556-4029.2007.00405.x>
 15. Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf MC, et al. Searching for and selecting studies. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd ed. Wiley; 2022. p. 67–108. Available from: <https://doi.org/10.1002/9781119536604.ch4>
 16. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. Available from: <https://doi.org/10.1136/bmj.n71>
 17. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. *Cochrane handbook for systematic reviews of interventions (Version 6.4)*. Cochrane; 2022. Available from: <https://doi.org/10.1002/9781119536604>
 18. Aromataris E, Munn Z, editors. *JBI manual for evidence synthesis*. Joanna Briggs Institute; 2020. Available from: <https://doi.org/10.46658/IBIMES-20-01>
 19. Wheatley BP. Perimortem or postmortem bone fractures? An experimental study of fracture patterns in deer femora. *J Forensic Sci*. 2008;53(1):69–72. Available from: <https://doi.org/10.1111/j.1556-4029.2008.00593.x>
 20. Moraitis K, Spiliopoulou C. Identification and differential diagnosis of perimortem blunt force trauma in tubular long bones. *Forensic Sci Med Pathol*. 2006;2(4):221–9. Available from: <https://doi.org/10.1385/FSMP:2:4:221>
 21. Ribeiro P, Jordana X, Scheirs S, et al. Distinction between perimortem and postmortem fractures in human cranial bone. *Int J Legal Med*. 2020;134:1765–74. Available from: <https://doi.org/10.1007/s00414-020-02356-3>
 22. Winter-Buchwalder M, Schwab N, Galtés I, Ortega-Sánchez M, Scheirs S, Jordana X. <https://www.nepjol.info/index.php/IJOSH>

- Microcracking pattern in fractured bones: New approach for distinguishing between peri- and postmortem fractures. *Int J Legal Med.* 2024;138(1):35–42. Available from: <https://doi.org/10.1007/s00414-022-02875-1>
23. Yu K, Wang G, Cai W, Wu D, Wei X, Zhang K, et al. Identification of antemortem, perimortem and postmortem fractures by FTIR spectroscopy based on a rabbit tibial fracture model. *Spectrochim Acta A Mol Biomol Spectrosc.* 2020;239:118535. Available from: <https://doi.org/10.1016/j.saa.2020.118535>
24. Obertová Z, Leipner A, Messina C, Vanzulli A, Fliss B, Cattaneo C, Sconfienza LM. Postmortem imaging of perimortem skeletal trauma. *Forensic Sci Int.* 2019;302:109921. Available from: <https://doi.org/10.1016/j.forsciint.2019.109921>
25. Delia A, Seligardi M, Di Paolo M, Spinetti I, Bortolini S, Bugelli V. Scanning Electron Microscopy with Energy Dispersive Spectrometry as part of an integrated multidisciplinary approach in a complex cadaver case. *Leg Med.* 2026;80:102775. Available from: <https://doi.org/10.1016/j.legalmed.2026.102775>
26. Moghaddam N, Campana L, Abegg C, Vilarino R, Volland C, Dedouit F, et al. Hidden lesions: a case of burnt remains. *Forensic Sci Res.* 2023;8(3):1–6. Available from: <https://doi.org/10.1093/fsr/owad019>
27. De Donno A, Campobasso CP, Santoro V, Leonardi S, Tafuri S, Introna F. Bodies in sequestered and non-sequestered aquatic environments: a comparative taphonomic study using decompositional scoring system. *Sci Justice.* 2014;54(6):439–46. Available from: <https://doi.org/10.1016/j.scijus.2014.10.003>
28. Indra L, Lösch S, Errickson D, Finaughty D. Forensic experiments on animal scavenging: A systematic literature review on what we have and what we need. *Forensic Sci Int.* 2023;353:111862. Available from: <https://doi.org/10.1016/j.forsciint.2023.111862>
29. Farantos G, Christofilea O, Dounias G. Hospital occupational health and safety services and accidents in Greek hospitals: A case study in a Greek health region. *Multidiscip Rev.* 2026;9(3):e2026119. Available from: <https://doi.org/10.31893/multirev.2026119>
30. Farantos G, Ntounias C, Tsantiris S, Farantos I, Damikouka I. Decision making methods in political economy of health policy in crises: A systematic review for hospitals. *Multidiscip Rev.* 2026;9(8):e2026373. Available from: <https://doi.org/10.31893/multirev.2026373>