Review Article

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Documentation and Interpretation of Injury Patterns in Assault Cases in a Digital Era

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Abstract

Injuries following assault are a major medico-legal and public health problem across the globe, especially in low to middle income countries that has high burden of violence as one of its social wrongs. An accurate documentation and interpretation of injury patterns is essential for lawful procedures, victim protection and medico-legal decisions. This article compiles available research concerning standardized documentation process, interpretation models and innovative techniques for forensic injury assessment. Literature was selected after conducting searches that included keywords such as “assault”, “injuries”, “forensic documentation”, “injury pattern interpretation”, “violence-related trauma”, “digital forensic imaging” and “medico-legal evaluation” and the sources of information included PubMed, Scopus and Google Scholar. Results suggest that the adoption of structured proforma, digital photography and three-dimensional (3D) imaging significantly improve objectivity and evidentiary fidelity. Analysis of injuries, including bruises, abrasions, lacerations, and fractures can be used to reconstruct the events surrounding a particular attack, as well as testing alternate theories of mechanism force and intent. Nonetheless documentation practices are not uniform between regions because of resource constraints, lack of training, absence of consensus on medico-legal procedures. Integration of cyber forensics, AI-aided pattern recognition and international guideline harmonization are found to be potential future directions of development. The review summarizes that detailed recording of injuries and cross-disciplinary interpretation is the foundation of proper forensic practice and judicial accuracy in assault cases.

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Introduction

Violence and injury are one of the greatest worldwide public health and medicolegal problems of the 21st century. Interpersonal violence, such as domestic, sexual, and community assault causes millions of injuries annually which must be forensically documented for judicial action and evidence-based epidemiologic surveillance. Each year about 1.3 million people die from injury and tens of millions more are injured that require medical care and the generation of a record, as estimated by the World Health Organization (WHO).[1] In forensic aspects, all cases of assault are inherently bivalent with concerns both medical (need to treat) and legal (duty to diagnose injuries correctly). Medicolegal documentation of injury acts as a link between medicine and the law. The aim is preserved for a courts' review and interpretation in the future. It consists of standard identification features such as written descriptions, anatomical drawings, scaled photographs, and more recently digital and three-dimensional (3D) visualization. The size, shape, color and placement of each entry wound provide its own piece of evidence. For instance, patterned abrasions may be attributed to tool or weapon use; the dispersion of bruises can reflect holding, control, or sequential striking tasks; while defensive wounds indicate protective actions.[2] Interpretation of injury profiles is as important. Forensic scientists use morphologic character appearance, force direction and wound site to create a picture of how the injury was made. This explanation can differentiate between accidental injury self-induced lesions or inflicted violence. As forensic medicine has developed, the

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"reading" of the "language" of injuries is now at the heart of medicolegal investigation.[3,4] The use of cutting-edge forensic tools has raised documentation standards in the developed countries. Digital photography, 3D surface scanning, UV photography and machine learning algorithms applied to wound pattern recognition improved the objectivity and reproducibility of forensic evidence.[5] In developed countries such as high-income nations, these technologies are now readily available in emergency departments and forensic laboratories. In countries like Bangladesh, however, the process remains heavily reliant on narrative history taking, hand notes and sketches with no means of validation through photographs. Such constraints undermine the probative value of medico-legal reports and may influence court decisions.[6,7] The value of ensuring sound documentation is never more critical than when a patient has been assaulted, if they are the victim of domestic violence or suffer injury while in custody. When it comes to causation and the identification of responsibility, courts rely heavily on forensic evidence. The lack of a photo, an unclear description or no map on how the injury occurred can be between conviction and acquittal. Thereby, documentation is not only a professional duty but also constitutional and ethical obligation of the examining physician.[8] The importance of thorough and standardized documentation of injuries in assault cases cannot be overstated. Accurate documentation serves several interrelated purposes, e.g., clinical management of injuries and monitoring of healing, any legal adjudication through the medico-legal report (MLR) as substantial evidence, forensic interpretation of injury patterns reconstructing the mechanism and intent behind and aggregated data from assault cases inform policy-making, resource allocation, and violence prevention strategies.[9,10]

Precision is important in the field of medicolegal investigations (also in forensic medicine). Misinterpretation can result even from slight variations in measurement, terminology, or injury sequence. For instance, simply using the term "laceration" instead of "incised wound" may concretely influence the interpretation of what type of weapon was used. Likewise, lack of time-stamping on images can also result in questions about their authenticity and chain of custody.[11] These concerns emphasize the importance of forensic standardization in terminology and methods. In LMICs, the problem is exacerbated by a lack of forensic resources and insufficient training. Within South Asia, reported rates of photo-documentation in assault cases range from 40 to 50%, with less than one third meeting international evidentiary standards for quality.[12] Moreover, medicolegal personnel in rural and district hospitals function specifically without training for forensic service or with digital facilities, leading to differential skill of the posed reports.[13] Hence, this subject is also relevant with the increasing judicial recognition of scientific evidence. Contemporary courts want hard evidence, and now they want it digital. In Bangladesh, for example, under the Evidence Act and the Penal Code, digital files such as forensic images are considered to be admissible items so long as authenticity can be preserved.[14] However, this shift highlights the imperative to digitize and standardize medico-legal documentation. Over and above individual cases, reliable records are of importance to research, epidemiology and prevention. Injury surveillance systems require uniform data to determine the demographic risk factors, patterns of trauma by geographic regions and social determinants of violence. Gendered violence for example presents unique injury profiles such as facial bruising, upper limb defensive wounds and soft tissue

contusions that can assist with the identification of serial victims of acts of abuse.[15] Thus, forensic documentation serves not only to assist justice but also to act as a humanitarian function telling us when and where action for protection is needed.[16] Therefore, this review was proposed to comprehensively examine recent global and regional developments in the documentation and interpretation of injury patterns in assault cases and consolidate current evidence on prospects and challenges in the documentation and interpretation related processes.

Methods

This review encompasses literature from forensic medicine, casualty surgery, emergency medicine, and legal studies. The literature for this review was identified through a structured search of three major databases – PubMed, Scopus and Google Scholar – done between July and December 2025. Search terms combined Boolean operators and Medical Subject Headings (MeSH) related to the topic, including "*Assault injuries*," "*forensic documentation*," "*injury pattern interpretation*," "*violence-related trauma*," "*digital forensic imaging*," and "*medico-legal evaluation*." Our inclusion criteria were: i) peer-reviewed articles published in English; ii) studies addressing documentation or interpretation of injuries related to assault or violence; iii) research involving adult or adolescent population; and iv) forensic, clinical, or multidisciplinary focus. Exclusion criteria included i) case reports or commentaries without methodological detail; and ii) articles not related to human assault/injuries (e.g., animal studies).

The initial search yielded 248 articles; after removing duplicates and scrutiny (following title, abstract, and full-text screening), 32 articles finally met our inclusion criteria. Data extracted from selected studies included author, year, study design, country, sample size, documentation method, main findings, and conclusions. Additional references were drawn from international forensic guidelines such as those of the World Health Organization (WHO), INTERPOL, Forensic Science Regulator (FSR) and Faculty of Forensic and Legal Medicine of UK, and Directorate General of Health Services (DGHS), under Ministry of Health and Family Welfare, Bangladesh, to contextualize practices and recommendations.

Results

Forensic documentation operates at the intersection of medical observation, legal accountability, and ethical responsibility. The process begins at the moment a victim presents to a healthcare facility. Clinicians are legally obligated to document all injuries meticulously whether or not the patient initially expresses intent to pursue legal action. In many jurisdictions, including Bangladesh, failure to document injuries in potential assault cases can amount to professional negligence.[16] In Bangladesh, the documentation process generally follows a structured pathway including i) clinical examination or systematic inspection of the body, recording all external and visible injuries; ii) descriptive notation using medico-legal terminology to record the type (abrasion, laceration, contusion), size, shape, and anatomical location of each injury; iii) photographic evidence, e.g., high-resolution images with scale markers, date, and case identification (particularly in rural and district hospitals). However, in advanced facilities some other processes follow: iv) injury mapping through using body charts or software to represent injury distribution visually; v) interpretation through correlation of injuries with the alleged mechanism (e.g., blunt, sharp, or firearm injury) and circumstances and vi) preparation of a medicolegal report following institutional or national guidelines.[14]

Injury interpretation requires not only technical expertise but also contextual reasoning. For example, parallel linear bruises may indicate rod-like weapon strikes, while crescentic abrasions could suggest bite marks. Similarly, the location and orientation of wounds can distinguish between self-inflicted injuries (typically accessible body parts with uniform direction) and assault injuries (random distribution and variable direction).[17] Advances in forensic science have refined these interpretive frameworks. Machine learning algorithms can now assist in wound classification and differentiation between accidental and intentional injuries based on image datasets. Evidence demonstrated the feasibility of convolutional neural networks in recognizing patterned bruises and predicting weapon characteristics with up to 85% accuracy.[18] However, ethical and legal acceptance of AI-generated interpretations remains an evolving debate.

Documentation Techniques and Standards Overview: The documentation of injuries in assault cases is the cornerstone of forensic examination. It ensures accurate, objective, and reproducible representation of clinical findings for use in both medical and legal contexts. The methods for documentation range from manual written descriptions to high-resolution digital imaging and computer-assisted mapping. Recent global forensic trends emphasize structured documentation frameworks over narrative, unstandardized reporting. Evidence showed that the implementation of standardized proforma in emergency and forensic units increased documentation completeness by 38% compared to unstructured methods.[19] Similarly, the World Health Organization's Injury Surveillance Guidelines recommended integration of anatomical diagrams and photographic records in every medico-legal examination.[20]

Methods and Practices: In Bangladesh and other South Asian countries, medico-legal documentation traditionally relies on written narratives and hand-drawn body charts. However, several pilot initiatives have introduced digital documentation systems, such as tablet-based forms and mobile apps with integrated photograph upload features.[21] Evidence showed that digital formats minimize human error, improve legibility, and support faster judicial retrieval and facilities adopting structured proforma reported a 30–45% reduction in inter-observer variability. The inclusion of photographs increased the likelihood of legal acceptance of the medico-legal report by 60%.[22] Guidelines and policy recommendations taken into our considerations for this review work are given in the Table-I.

Table-I: Guidelines and policy recommendations

Source	Year	Key Recommendations	Implementation Impact
World Health Organization (WHO) – Injury Surveillance Guidelines[20]	2001	Standardized documentation formats, digital injury mapping, gender-sensitive consent protocols	Improved global consistency
INTERPOL guidelines[23]	2021	Photographic scale inclusion; secure data storage	Enhanced evidence reliability
Forensic Science Regulator (FSR), UK[24]	2023	Capacity building in digital forensic practice including AI integration	Enhance professional competence and investigative procedure
Faculty of forensic and Legal Medicine, UK[25]	2024	Integration of 3D imaging in court presentations	Facilitated judicial comprehension
Directorate General of Health Services (DGHS), Bangladesh[26]	2017	Mandatory written and photographic documentation(if available) in all assault/injury cases	Improved regional standardization

Discussion

We gathered evidence from global studies published between January 2022 and December 2024 concerning the documentation and interpretation of injury patterns in assault cases. This synthesis integrates empirical findings, theoretical frameworks, and policy perspectives to critically evaluate current forensic practices and propose future directions.

The findings of this review collectively emphasize that standardized, structured, and technology-assisted documentation significantly improves the reliability and medico-legal utility of assault injury reports. Across reviewed studies, facilities implementing digital documentation systems demonstrated better evidence quality, reduced inter-observer variability, and higher rates of judicial acceptance compared to traditional handwritten formats.[27,28] The adoption of structured proformas, endorsed by different organizations such as the WHO and INTERPOL, ensures consistency and comprehensiveness of recorded data.[20,23] The key advantage of structured templates lies in their ability to minimize omissions an issue frequently observed in manual narrative records.[24] Moreover, digital imaging and 3D reconstruction techniques have improved accuracy in representing age estimation, wound morphology and dimensions, allowing forensic experts to visualize age of the victim and injury depth, direction, and spatial relationship to anatomical landmarks.[29,30] Interpretation frameworks are increasingly guided by biomechanical principles and supported by digital analytics; the integration of artificial intelligence (AI) and machine learning algorithms has demonstrated substantial potential for automated recognition of injury types, pattern detection, and weapon classification.[31,32] Furthermore, the review highlights the critical role of professional training. Continuous education in forensic documentation practices leads to improved terminology usage, higher report completeness, and enhanced interdisciplinary collaboration between healthcare and legal professionals.[20,24,25] In a developing country like Bangladesh, training programme supported by the Directorate General of Health Services (DGHS) has begun bridging gaps between forensic medicine and judicial requirements.[26]

In essence, the synthesis confirms three principal trends:

1) Documentation quality directly influences legal outcomes and evidentiary reliability;
2) Digital transformation is redefining forensic accuracy and accessibility; and
3) Training and intersectoral collaboration remain indispensable to sustainable improvement.

While the global literature demonstrates remarkable technological progress, significant disparities persist between high-income and low- to middle-income countries (LMICs). In technologically advanced regions, forensic units routinely employ integrated electronic medico-legal systems (eMLS), digital injury databases, different medic-legal software and photogrammetry tools.[33-36] In contrast, facilities in LMICs often rely on limited resources, manual recordkeeping, and inconsistent medico-legal oversight. However, the increased use of digital and photographic records raises privacy and data security concerns. In regions with inadequate legal frameworks, victims' images may risk unauthorized dissemination or misuse. Consent protocols remain inconsistently applied particularly in cases of sexual or domestic violence highlighting the need for clearer ethical guidelines.[37,38] Furthermore, the strength of forensic interpretation remains contingent on human expertise. Although AI tools show promise, they

cannot yet replace the clinical reasoning and contextual understanding possessed by experienced forensic pathologists. A critical gap lies in interdisciplinary integration. The best outcomes arise from collaboration between physicians, forensic scientists, law enforcement, and judiciary personnel.[39-42]

Implications and Recommendations

The findings of this review have broad implications for forensic medicine, healthcare policy, and judicial practice in the country. We advocate a paradigm shift from ad hoc documentation towards integrated, system-based medico-legal recordkeeping supported by national policies, training, and technology.

Implementation of Standardized Documentation Systems: All healthcare and forensic facilities should adopt structured medicolegal proformas that include injury diagrams, measurement scales, and photographic records. Such systems enhance objectivity, minimize omissions, and facilitate cross-case comparisons. Digital documentation platforms should be prioritized where feasible, with secure cloud storage and audit trails to ensure data authenticity.

Integration of Technological Innovations: Institutions should progressively incorporate 3D imaging, UV/IR photography, and AI-assisted wound analysis into routine practice. These tools, when ethically deployed, can substantially improve the precision and interpretive validity of forensic reports. Collaboration between forensic scientists, data engineers, and clinicians will be essential to create user-friendly, secure, and validated forensic software.

Strengthening Training and Capacity Building: Continuous medical education (CME), simulation-based learning, and interdisciplinary workshops must be mandated for physicians involved in medico-legal examination. Emphasis should be placed on injury classification, digital documentation, ethical principles, and courtroom communication.

Policy and Legal Reform: Governments and judicial authorities should establish clear legislation governing the admissibility of digital and AI-derived evidence, chain-of-custody management, and confidentiality safeguards. Besides, Directorate General of Health Services (DGHS) may oversee the centralized databases for forensic documentation to ensure consistency and accountability across institutions.

Future Research Directions: Future research should focus on developing validated scoring systems for documentation quality, evaluating the impact of digital systems on conviction rates, and exploring victim-centered perspectives to ensure that documentation practices remain compassionate as well as scientifically sound.

Conclusion

To conclude, accurate documentation and interpretation of injury patterns are the linchpins of forensic justice. Poorly described or incomplete injury records frequently result in judicial delays or acquittals, while well-structured and comprehensively documented reports significantly increase evidence credibility and reliability as well as conviction rates. When executed with scientific precision, ethical sensitivity, and technological support, they transform medicine into a powerful instrument of truth. The evolving integration of digital forensics, standardized protocols, and AI-assisted analysis holds immense promise for the future. However, these advancements must remain guided by human judgment, compassion, and integrity ensuring that every recorded injury speaks with clarity, credibility, and conscience in the pursuit of justice. Progress in this

domain requires sustained institutional investment, transdisciplinary collaboration, and ongoing research innovation. By embracing technology and ethical best practices, forensic medicine can evolve from reactive documentation to proactive justice facilitation, ensuring that every recorded injury becomes a scientifically sound testimony of truth.

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