Rom J Leg Med [33] 128-134 [2025]
DOI: 10.4323/rjlm.2025.128

FORENSIC MANAGEMENT OF MASS FATALITY OCCURRING IN DISASTER CONDITIONS

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Abstract: Mass fatality incidents (MFIs) - whether resulting from natural disasters, pandemics, or human-made catastrophes - pose unique challenges to forensic systems, requiring swift, coordinated, and multidisciplinary interventions. We explore the forensic management of mass fatalities, with a focus on internationally recognized protocols, such as the Interpol Disaster Victim Identification (DVI) model, and the role of particular forensic subspecialties such as pathology, odontology, anthropology, radiology, and genetics. Drawing from recent literature and the local experience in Sibiu County, Romania, our paper highlights the operational difficulties generated by MFIs such as overcrowded morgues, limited protective equipment, and logistical strain on identification procedures. The integration of advanced techniques, like DNA profiling and anthropological analysis, is essential but often constrained by logistical and legislative gaps, and needs increased investment in state-of-the-art forensic infrastructure. The analysis of the existing emergency plans underscores the pressing need for updated, more rigorous national legislation and well-defined local protocols, in order to ensure efficient professional outcomes and also ethical and dignified handling of victims in large-scale fatality events.

Keywords: mass fatalities, disaster medicine, identification, forensic medicine, COVID-19 pandemic, emergency response.

INTRODUCTION

Multiple fatality incidents (MFIs) challenge the very core of forensic practice, demanding precision and coordination under extreme pressure. Whether caused by natural disasters, traffic events, acts of terrorism, or global pandemics, these events require forensic pathologists to balance scientific rigor with humanitarian urgency. The management of mass fatalities demands robust multidisciplinary coordination, planning, and ethical sensitivity. This paper analyzes the essential characteristics of a comprehensive forensic response to mass fatality incidents.

MULTIPLE FATALITY INCIDENTS

Mass fatality can be defined as a sudden, violent, and unexpected event resulting in a large number of casualties that requires substantial resources to manage effectively (1). It is characterized by a death toll that exceeds the local capacity to process human remains (2), thus necessitating an urgent, coordinated, and multidisciplinary response (3). From a temporal perspective, the high number of deaths must occur within a short time frame, overwhelming the existing governmental resources and straining logistical capabilities (4). Quantitatively, mass fatality incidents are typically defined as involving ten or more deaths, with up to 100 or more individuals injured or affected, and in certain situations, may require international assistance (1).

Mass fatality incidents can take various forms. Most commonly, they are the result of natural disasters, catastrophic events caused by natural processes that lead to significant loss of life, extensive property damage, and severe disruption to daily life. These events are often defined by their sudden onset, intensity, and their capacity to overwhelm local resources and emergency response systems. Examples

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include tsunamis (3), earthquakes (5), hurricanes, typhoons, tornadoes (6), and bushfires (1). Other mass fatalities are human-made, most frequently caused by large-scale transportation accidents such as ferry disasters, aircraft crashes, and train or motor vehicle collisions (1). In addition to accidents, human-made mass fatality events may arise from terrorist acts or conflict-related incidents. Terrorist-related fatalities can result from bombings (5), mass shootings (6), or targeted attacks such as the 9/11 events (7). Conflict-related mass fatalities may occur in war zones (5) or involve acts like serial killings (1). A particularly tragic form of conflict- or crisis-induced mass fatality is seen in the mass drownings of migrants attempting to cross borders by sea, often driven by armed conflict or economic desperation (5).

The COVID-19 pandemic has been widely recognized as a global mass fatality event, overwhelming mortuary capacities and straining public health systems across countries. Unlike sudden disasters, COVID-19 created a prolonged crisis where local resources proved insufficient to manage the sheer volume of deceased individuals. In cities like New York and Detroit, temporary morgues, refrigerated trailers, and even mass graves were employed to cope with the rising death toll (8).

ROLE OF FORENSIC MEDICINE

In the context of natural or man-made catastrophes, disaster medicine plays a crucial role. Whenever these events lead to MFIs, forensic medicine is automatically involved, playing a vital complementary role in managing these multiple deaths, especially with regard to the complex task of victim identification.

Catastrophic events such as terrorist attacks, tsunamis, wildfires, plane crashes, and other large-scale accidents often result in numerous casualties, many of whom are severely disfigured, decomposed, or fragmented. In such situations, traditional identification methods become inadequate or entirely unfeasible, making the use of specialized forensic techniques not only essential but often the only reliable means of establishing identity. At the core of forensic response to mass fatalities is the process of Disaster Victim Identification (DVI), a standardized, multi-phase procedure endorsed by international organizations such as Interpol. This framework is designed to ensure consistency, accuracy, and dignity in the identification of victims. Forensic medicine plays an integral role in DVI by drawing on multiple scientific disciplines, including forensic pathology, odontology, anthropology, radiology, and genetic analysis through DNA profiling. Each of these subspecialties contributes uniquely, with their relevance determined by the condition of the remains and the specific circumstances surrounding the disaster (9).

DNA profiling is one of the most frequently employed techniques in victim identification, particularly useful in cases where bodies are fragmented or extensively decomposed. Studies have documented the use of DNA analysis across a wide range of incidents, including the 9/11 terrorist attack and several large-scale natural disasters, with thousands of victims identified through genetic matching (3,10-12). During the investigation of the 9/11 attacks, DNA analysis played a central role, successfully identifying 877 victims (11). In India, the Centre for DNA Fingerprinting and Diagnostics (CDFD) was highlighted as a key institution in conducting DNA profiling for disaster victim identification efforts (10). However, the method has limitations; following the Southeast Asian tsunami, DNA analysis accounted for only 1.3% of victim identifications, proving less effective than other techniques in that context (3). Challenges such as sample degradation and logistical constraints, particularly in remote or resource-limited settings, can hinder the effectiveness of DNA-based identification. These issues are especially evident when remains are severely compromised or when forensic infrastructure is lacking. In many cases, DNA evidence is used in combination with anthropological analysis to improve identification accuracy (12). In some situations, forensic odontology serves as an alternative or complementary method to DNA analysis. Based on dental records and morphological features, this technique has demonstrated high reliability, especially when dental structures remain intact despite trauma or exposure to fire. Forensic odontology was widely cited in the literature, including in cases from East Asian tsunamis and the bushfires in Victoria, Australia (3,10,12-14).

Forensic anthropology has emerged as a key component and primary method in the identification of victims during mass fatality incidents. Anthropological analysis has played a critical role across a range of disaster scenarios, including both terrorist attacks (11) and natural disasters (13). Core applications of the discipline include skeletal examinations to determine age, sex, ancestry, and stature, as well as trauma analysis to differentiate between pre-, peri-, and postmortem injuries (14).

Frequently integrated into multidisciplinary teams, forensic anthropologists have collaborated closely with pathologists, odontologists, and DNA specialists to support comprehensive identification efforts (10). Within operational frameworks, anthropologists are recognized as essential members of Disaster Victim Identification (DVI) teams (10), contributing not only to identification but also to life history reconstruction (12). The effectiveness of anthropological methods has been especially notable when used in conjunction with DNA profiling and dental records (14). Nevertheless, challenges persist, particularly when dealing with highly compromised remains (15) or operating in difficult terrain and resource-limited environments (10). Even in such contexts, anthropological expertise has proven indispensable, especially in complex identification scenarios involving international response efforts (13). With its systematic and adaptable approach, forensic anthropology remains a cornerstone of mass fatality response, particularly when conventional methods are limited or unavailable.

Radiological technique, particularly computed tomography (CT) scanning, represents a significant but less commonly reported forensic method compared to DNA or dental analysis. A notable innovation in the field was documented by Rutty et al., 2007 (16), who reported the first use of mobile multi-detector computed tomography (MDCT) scanning in a mass fatality incident, demonstrating impressive efficiency with imaging times of approximately 15 minutes per body and analysis taking about 1 hour per case (16). In Australia, CT scanning played a pivotal role in victim identification processes following bushfire disasters (13). The integration of radiological expertise within multi-disciplinary teams was evident, with radiologists included as key members of Disaster Victim Identification (DVI) teams (10).

The execution of these identification techniques is orchestrated within multi-disciplinary teams composed of pathologists, odontologists, anthropologists, radiologists, and molecular biologists. These experts collaborate very often under challenging field conditions, with limited resources or in extreme environments but also by time constraints, in order to ensure that identification efforts are scientifically sound and ethically managed. In many instances, forensic teams must operate in mobile or makeshift facilities, sometimes imaging or scanning bodies within as little as 15 minutes or conducting investigations that span several months, as, for example, the case following the 2004 tsunami in Southeast Asia (3).

Forensic medicine also contributes to broader operational aspects of mass fatality incidents. This includes establishing standardized operating procedures, managing the secure collection and storage of ante-mortem and post-mortem data, ensuring quality control in laboratory processes, and overseeing the chain of custody for evidence. When international cooperation is required, as in multi-national disasters, Interpol protocols help to harmonize procedures across different jurisdictions. Interpol provides global leadership in victim identification through its DVI Guide, regular training programs, and field support via specialized response teams. The protocol is structured into four phases. Scene Examination involves systematically recovering and documenting all human remains and personal effects, with careful attention to preserving evidence and maintaining dignity. In Post-Mortem Data Collection, forensic experts, including pathologists, odontologists, anthropologists, and DNA specialists, gather identifying information from the remains using standardized methods and forms. Ante-Mortem Data Collection follows, involving interviews with families, collection of medical and dental records, and DNA reference samples from relatives or personal items. The final phase, Reconciliation, matches post-mortem and ante-mortem data using primary identifiers such as fingerprints, dental records, and DNA profiles. Only when a 100% match is confirmed is the identification finalized and families are notified (9).

OTHER CONTRIBUTIONS OF FORENSIC MEDICINE IN DISASTER CONTEXT

In the context of mass fatality incidents, autopsy procedures are strategically adapted to ensure efficiency, accuracy, and respect for the deceased, despite overwhelming operational demands. The primary objective is rapid identification, which often requires streamlining standard forensic protocols while preserving the integrity of medico-legal investigations (9). To cope with the high volume of cases, autopsy teams typically operate in continuous shifts, and procedures are simplified where possible to expedite processing. Techniques such as en bloc or en masse organ removal as Rokitansky method are favored for their efficiency in internal examinations, while in certain cases, minimally invasive methods may be employed, especially when resources are limited or when minimal disruption of remains is preferable (17). DNA sampling is prioritized early in the process,

using materials such as blood, bone marrow, or tissue, often collected onto FTA cards for easy storage and rapid analysis. These genetic profiles are essential for both identification and establishing cause of death (18). At the disaster scene, the establishment of secure perimeters and well-organized staging areas ensures proper evidence management and facilitates systematic body processing (19). Ancillary investigations, including toxicological analysis and histopathological examination, further contribute to determining precise causes of death and uncovering contributing factors such as intoxication or pre-existing conditions. Throughout the process, meticulous documentation, including photographic records and strict adherence to chain-of-custody protocols, is maintained to ensure forensic credibility and legal validity (17).

Cultural and religious beliefs can influence decisions regarding autopsies, burial timelines, and mourning rituals, making cultural competence a critical component of any forensic response (20). Communities around the world observe diverse death-related customs, ranging from how the body is handled and who participates in mourning, to specific ceremonies and timeframes for burial. Religious doctrines often emphasize the sanctity and integrity of the body, with some prohibiting invasive procedures or requiring immediate burial, which may conflict with standard medico-legal practices (21). In such cases, understanding afterlife beliefs and mourning customs helps professionals communicate with sensitivity and minimize distress among bereaved families. Effective dialogue between authorities and relatives is essential to ensure respect for these values while maintaining forensic and legal standards (22). Whenever possible, forensic teams should consider alternative procedures, such as non-invasive or minimally invasive autopsies, to reconcile religious concerns with investigative needs. Additionally, the incorporation of cultural sensitivity training for forensic personnel enhances the ability to navigate complex social dynamics during large-scale emergencies.

The psychological impact of mass fatality events on forensic medicine professionals is profound and often underestimated. Prolonged exposure to such circumstances places them at heightened risk for a spectrum of mental health challenges, including burnout, secondary traumatic stress, and compassion fatigue. Secondary traumatic stress can arise from witnessing the suffering of victims and grieving families, evoking symptoms that mirror those of direct trauma survivors. Over time, compassion fatigue may erode the professionals' ability to empathize, leading to emotional detachment. In more severe cases, individuals may develop post-traumatic stress disorder (PTSD), alongside anxiety or depressive disorders. Addressing these challenges requires a systemic commitment to mental health support, peer counseling, and institutional recognition of the negative emotional impact of mass fatality events on forensic medicine workers (23).

NATIONAL REGULATIONS

In Romania, The Red Plan („Planul Roșu") represents a vital component of the national emergency response system, specifically designed for managing collective accidents and disasters involving multiple victims. Rather than a standalone piece of legislation, it is a procedural framework grounded in key legal instruments, most notably Law no. 95/2006 on Health Reform, particularly Title IV, which establishes the National System of Emergency Medical Assistance and Qualified First Aid. This legal foundation is complemented by joint ministerial orders, such as Order no. 2021/691/2008, which defines the operational aspects of the plan, and Order no. 1168/203/2010, which outlines its structure and execution at county and municipal levels. The core objective of The Red Plan is to ensure a rapid, coordinated, and efficient response when major incidents occur, mobilizing ambulances, SMURD units, firefighters, police, forensic medicine and other emergency structures. The plan delineates roles, facilitates inter-agency coordination, and prioritizes immediate medical intervention, triage, and transport of casualties to specialized hospitals. It also provides mechanisms for requesting additional support from other counties or international partners if local capacities are overwhelmed. Activation typically occurs at the request of the County Inspectorate for Emergency Situations (ISU) addressed to the county's Prefect, although some emergency circumstances allow direct activation by the ISU chief. Once triggered, all public emergency medical services are placed under unified command to streamline operations (24).

FORENSIC RESPONSE TO THE 2014 MILITARY HELICOPTER CRASH IN SIBIU COUNTY, ROMANIA

On November 21st, 2014, a military helicopter (IAR-330 PUMA) from the 71st Air Base crashed in a remote area located between Stejăriș and Mălâncrav

in Sibiu County, Romania. The aircraft carried ten military personnel, of whom eight lost their lives, while two survived. The incident represented a complex Mass Fatality Incident (MFI), requiring rapid interinstitutional coordination between the Ministry of National Defence (MApN), Emergency Services Inspectorate (ISU) - including firefighter units, County Police (IPJ), and the Forensic Department of Sibiu County (SJML Sibiu). Due to the intense fire that followed the crash, most remains were severely burned and fragmented, posing significant challenges for identification. The forensic team collected muscle tissue and blood samples for DNA and blood group analysis, and also conducted a preliminary identification, based on personal identifiers such as military equipment, wedding rings, helmets, and mobile phones. This air traffic event emphasized the critical importance of established protocols for DNA sampling, labeling, and preservation, and also of the adherence to the chain of custody, documenting trauma, and ensuring ethical handling of remains under media and institutional pressure. It is worth noting that subsequent DNA analysis - ordered by the Military District Attorney - confirmed our preliminary (primary) identification findings. Causes of death included primary burn shock and carbon monoxide poisoning, with carboxyhemoglobin levels up to 47%.

FORENSIC CHALLENGES DURING THE COVID-19 PANDEMIC IN SIBIU COUNTY, ROMANIA

The COVID-19 pandemic presented an unprecedented public health crisis that also deeply impacted forensic medical activity. In Sibiu County, as in many other regions, the early stages of the pandemic were marked by a lack of standardized protocols, limited access to personal protective equipment (PPE), and uncertainty regarding the safety of autopsies on SARS-CoV-2 infected individuals. Both the forensic and the pathology departments of the Clinical Emergency Hospital of Sibiu County faced a significant increase in the number of deaths, particularly in the first four waves, which required a rapid adaptation of procedures to ensure both staff safety and the integrity of medico-legal investigations. The peak of the fourth wave of COVID-19 infections in Romania (autumn of 2021), driven by the highly aggressive Delta variant, brought a dramatic surge in mortality, with approximately 600 deaths reported daily nationwide and 10-15 deaths per day in Sibiu County. By this point, medical personnel had already endured two previous significant waves, the Beta and earlier Delta variants, during the winter of 2020 and spring of 2021, each resulting in around 200 deaths per day across the country. The fourth wave, however, posed unprecedented challenges: severe shortages of protective equipment, overcrowded morgues, the use of improvised refrigerated containers to store the deceased, and an increased need for autopsies. Staff faced immense physical and emotional strain, further aggravated by the lack of essential resources such as stretchers and adequate facilities for storing bodies (25). SARS-CoV-2 positive patients arrived in body bags, often stacked in shipping containers without stretchers, and their identities had to be confirmed before being transported directly to cemeteries in sealed coffins. Protective barriers, disinfection routines, and modified workflows were implemented despite logistical constraints. The situation highlighted the urgent need for national-level guidance and reinforced the role of forensic institutions in balancing scientific rigor with public health responsibilities. It also underscored the psychological and ethical strain on personnel working under prolonged exposure to risk and emotional burden.

DISCUSSIONS

The forensic management of mass fatality incidents necessitates a structured, interdisciplinary, and highly adaptive approach. As evidenced in both historical and recent disasters, including the COVID-19 pandemic, the ability of forensic systems to respond effectively is directly influenced by pre-existing preparedness plans, resource availability, and inter-agency coordination.

Preparedness remains a recurrent theme across all reviewed sources. A survey of U.S. medical examiner and coroner offices revealed widespread deficits in training, resources, and formal mass fatality plans, with only a minority having access to portable morgues or recent DVI exercises (26). Similarly, burn mass casualty incidents in Europe have prompted calls for a continent-wide coordinated forensic response system (27).

The existing national framework in Romania - The Red Plan („Planul Roșu") - serves as critical infrastructure for mobilizing emergency resources during crises. The effectiveness of such a plan is based on inter-agency coordination, predefined roles, and clear communication strategies. Nevertheless, a

thorough analysis of this plan leads to the conclusion that there is a need for further detailing of the roles played by each of the involved institutions (including the role of the forensic units).

Forensic institutions must not only deliver scientifically sound identifications but also uphold ethical standards and public trust through transparency, empathy, and respect for the deceased (28).

In sum, the evolving landscape of mass fatality response requires forensic systems that are not only scientifically robust but also ethically grounded and operationally resilient. Continuous investment in training, infrastructure, and interdisciplinary collaboration is essential in order to meet the complex demands of future disasters. Also, the need of a national well-developed legislation is crucial for an optimal response in case of disasters with mass fatalities in Romania.

In conclusion, the forensic management of mass fatalities demands not only scientific accuracy and multidisciplinary coordination but also a solid legislative and infrastructural foundation. As demonstrated in both international and Romanian contexts, including the COVID-19 pandemic and major transportation accidents, the absence of clear, updated national protocols can delay response efforts and compromise identification processes. The integration of disciplines such as forensic pathology, anthropology, odontology, and radiology must be supported by adequate investment in state-of-the-art equipment - such as mobile CT scanners, DNA processing labs, and temporary morgue units.

First and foremost, though, in Romania, although frameworks like The Red Plan provide a starting point for coordinated response, there remains an urgent need to reinforce and detail the legal and procedural infrastructure specific to mass fatality incidents. National legislation should more clearly define responsibilities (including those of the forensic units), establish minimum operational standards, and ensure forensic institutions are equipped and trained to respond efficiently and ethically. Preparing for future mass fatality events requires not only scientific excellence but also political will and strategic investment in both people and technology.

Conflict of interest

The authors declare that they have no conflict of interest.

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