Prehospital Pain Management in Mass Casualty Scenarios: A Scoping Review

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Abbreviations

AID - Autoinjector Device
ALS - Advanced Life Support
AMP - Advanced Medical Presidium
BLS - Basic Life Support
CINAHL - Cumulative Index to Nursing and Allied Health Literature
DMAT - Disaster Medical Assistance Team
DMS - Defence Medical Services
EMBASE - Excerpta Medica Database
EMS - Emergency Medical Services
EMT - Emergency Medical Technician
FEMA - Federal Emergency Management Agency
FST - Field Forward Surgical Team
HPCSA - Health Professions Council of Southern Africa
ICU - Intensive Care Unit
IM - Intramuscular
IN - Intranasal
IO - Intraosseous
IV - Intravenous
LAST - Local Anaesthetic Systemic Toxicity
MCS - Mass Casualty Scenario
MED - Morphine Equivalent Dose
MEDLINE - Medical Literature Analysis and Retrieval System Online
MIMMS - Major Incident Medical Management and Support
NEMSIS - National Emergency Medical Services Information System
NSAID - Non-Steroidal Anti-Inflammatory Drug
OTFC - Oral Transmucosal Fentanyl Citrate
PRISMA-ScR - Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
PTSD - Post-Traumatic Stress Disorder
SAMU - Service d'Aide Médicale Urgente
SST - Sublingual Sufentanil Tablet
START - Simple Triage and Rapid Treatment
TBI - Traumatic Brain Injury
TBSA - Total Body Surface Area
TCCC - Tactical Combat Casualty Care
TIVA - Total Intravenous Anesthesia
v-NRS - verbal Numerical Rating Scale
WHO - World Health Organization

Part A: Literature Review: Prehospital Pain Management in Mass Casualty Scenarios

1. Introduction

1.1 Context and background

Pain management in mass casualty scenarios (MCS) is one of the most challenging aspects of prehospital emergency care, yet it remains notably understudied and under-resourced. A mass casualty scenario (also referred to as a mass casualty incident) is defined as: “an event which generates more patients at one time than locally available resources can manage using routine procedures or resulting in a number of victims large enough to disrupt the normal course of emergency and health care services and would require additional non-routine assistance.” (1) Recent studies show a significant gap between optimal pain management practices and what is achievable in austere conditions during MCSs, with practitioners frequently failing to reach therapeutic dosage levels (2,3). This disparity becomes is concerning considering that inadequate pain management is inhumane and linked to increased morbidity and mortality among casualties (4,5). Furthermore, these challenges persist despite growing recognition of pain as the "fifth vital sign" and efforts to elevate its importance alongside airway, breathing, and circulation (ABCs) in emergency care protocols (6–8).

Evidence from local studies indicates a lack of prehospital pain management guidelines in the South African setting with recent movements by Health Professions Council of Southern Africa (HPCSA) seeking to address these gaps by incorporating structured pain management into standard emergency response frameworks via the implementation of Clinical Practice Guidelines (9,10). However, the adoption of these protocols is inconsistent, and their implementation is further hampered in resource-constrained environments (11). The complexity of MCSs, combined with prolonged rescue and evacuation times, extreme traumatic injuries, and other compounding factors such as intrinsic resource constraints, hinders adequate pain control (12). The literature highlights notable similarities between MCS and combat theatres, as both become austere environments due to inadequate supplies, lack of equipment, and qualified prehospital personnel’s limitations (12).

Recent events in South Africa underscore these challenges. The catastrophic Boksburg explosion in December 2022 resulted in 41 fatalities, with eight immediate deaths occurring during the blast and

other patients succumbing to their injuries after hospitalisation (13). This incident, followed by another mass casualty fire later in 2023 that claimed 78 lives, left many patients suffering unnecessarily from painful injuries (14). Events such as these highlight the urgent need for clear, predefined, and definitive protocols for pain management in MCSs.

A review of the major theoretical resource used for instructing those attending MCS, the Major Incident Medical Management and Support (MIMMS) manual references pain management only approximately seven times, highlighting the relative neglect of this critical aspect of care (3,15). This oversight is particularly concerning given that inadequate pain management can lead to immediate suffering and long-term complications, including chronic pain syndromes and post-traumatic stress disorders (16).Significant progress has been made in developing analgesic options, including pharmacological and non-pharmacological modalities, even in the context of MCS (16–19). These advancements demonstrate that effective pain management is achievable and there is no reason that an appropriate modality or intervention cannot be selected for the patients.

To better understand and address these challenges, a review of current practices, protocols, and evidence was undertaken. This literature review aims to examine the state of prehospital pain management in MCS, identify current best practices, and highlight areas requiring further research and protocol development.

1.2 Significance of the problem

Researchers have established that pain management in MCS represents a critical yet frequently overlooked aspect of prehospital emergency care, with significant implications for both immediate patient outcomes and long-term public health consequences (3,16). The inadequate treatment of pain during MCSs represents a humanitarian concern and poses substantial clinical challenges that can impact patient recovery trajectories and healthcare resource utilisation.

Recent studies show that the absence of standardised protocols for pain management in MCSs has led to substantial variability in care delivery, with evidence suggesting that pain is undertreated in up to 70% of mass casualty victims(16,20). This systematic undertreatment occurs despite growing evidence that early and effective pain management can significantly reduce both short-term morbidity and the development of chronic pain syndromes.

Advanced pain management techniques are now available in prehospital settings, but it is unclear how these should be used in MCS settings. One perspective suggests that resource limitations and the chaos inherent in MCS preclude anything beyond basic analgesic interventions (2). Conversely, emerging evidence contends that newer technologies, such as portable ultrasound-guided regional anaesthesia, could provide effective solutions even in austere conditions (21).

The significance of this problem extends beyond immediate patient care to encompass broader public health and economic implications. Inadequately managed acute pain prolongs individual recovery periods and also leads to long-term physical and psychological sequelae, such as chronic pain syndromes and post-traumatic stress disorder (PTSD), both of which require substantial healthcare resources (8,16). The economic burden includes increased direct costs, such as extended hospital stays and the need for specialised care, and indirect costs, such as lost productivity and long-term disability (22).

Poor initial pain management also reduces the effectiveness of subsequent interventions, leading to a compounding effect on healthcare resource utilisation. For example, studies show that chronic pain conditions significantly increase the likelihood of repeated hospital admissions and reliance on opioid prescriptions, further straining already limited resources (22,23). During disaster recovery phases, these compounded effects exacerbate healthcare system overload, delaying recovery for both disaster victims and routine patients (17).

1.3 The Boksburg explosion case example

The Boksburg tanker explosion of December 2022 provides a compelling case study that illustrates the complex challenges of pain management in MCSs. Researchers have found that practitioner-to-patient ratios significantly influence the quality of care in MCSs (24). Earlier studies show that effective pain management in MCSs requires adequate personnel and the appropriate skill mix and clear protocols (25).

Boksburg explosion from the perspective of a first responder, a personal account by C Morris.

The Boksburg explosion occurred on December 24, 2022, in Gauteng, South Africa, when a gas tanker was trapped under a low bridge near the Tambo Memorial Hospital. The subsequent explosion of the gas tanker caused significant destruction, resulting in 41 fatalities and over 70 injuries, including severe burns and trauma. The incident overwhelmed local emergency services and exposed critical gaps in disaster preparedness, particularly in pain management and resource allocation during MCSs. First-hand accounts from advanced life support practitioners who responded to the incident exposed critical systemic challenges that impact the delivery of effective pain management. In the Boksburg incident, the initial ratio of patients to practitioners authorised to administer analgesia exceeded an estimated 8:1, creating a substantial care delivery gap. While lower-qualified practitioners were available to assist, their limited scope of practice regarding analgesic administration - particularly concerning high-risk medications such as ketamine and fentanyl - created a bottleneck in pain management efforts. The incident was significantly complicated by the multiple competing priorities inherent in MCSs. The simultaneous demands of establishing effective command and control structures while implementing mass casualty triage protocols created substantial operational challenges. Scene safety management required constant attention, particularly given the ongoing hazards presented by the compromised fuel tanker. Furthermore, the necessity to coordinate multiple emergency response agencies added another layer of complexity to the already challenging environment. These concurrent demands created a situation where responders had to constantly balance immediate patient care needs against broader operational and safety considerations, potentially impacting the delivery of consistent pain management protocols. The Boksburg incident highlighted that having personnel present does not necessarily translate to effective pain management capacity. The complexity of drawing up and administering potentially dangerous analgesics such as ketamine and fentanyl required direct supervision by advanced life support practitioners, who were simultaneously managing multiple critical tasks.

Advocates claim that triage systems do not effectively prioritise pain management in MCSs (26), and studies indicate that pain management often becomes deprioritized when immediate life threats and scene safety concerns dominate the response environment (2,16,27). This observation aligns with findings from international studies documenting similar challenges in balancing immediate life-saving interventions with pain management in MCSs (16,27).

1.4 Purpose of the Review

The primary purpose of this review is to map and evaluate existing evidence regarding prehospital pain management strategies in MCSs, addressing a critical gap in current emergency medical practice. Recent studies show that despite advances in emergency medicine, pain management protocols for MCSs remain poorly defined and inconsistently implemented (2,28). This scoping review aims to identify and analyse existing literature on prehospital pain management strategies in MCS. This scoping review evaluates current practices across key domains including pharmacological interventions, non-pharmacological approaches, pain assessment methodologies, and resource limitations in austere environments.

Through examination of current evidence, this review seeks to identify significant knowledge gaps to inform future research directions, policy development, clinical practice guidelines, and educational curriculum development for emergency medical services personnel. This approach will provide an evidence-based foundation for improving pain management practices and patient outcomes in MCSs.

1.5 Methodology of Literature Review

A review of the available literature on pain management in MCSs was undertaken. The aim was to identify relevant studies, reports, and grey literature that address the key themes and challenges in this field.

The search was conducted across multiple electronic databases, including PubMed, MEDLINE, EMBASE, CINAHL, and the Cochrane Database of Systematic Reviews. These databases were chosen to provide a diverse range of perspectives, from clinical research to systematic reviews and allied health literature. Additionally, grey literature was explored through resources such as MedNar, OpenSIGLE, NTIS, and WorldWideScience.org, as well as conference proceedings, lectures, and presentations. Google Scholar was also searched to broaden the scope and capture any overlooked publications.

Search terms included combinations of keywords such as "mass casualty incidents," "pain management," "disaster medicine," "prehospital care," and "analgesia." Boolean operators (AND, OR) were utilised to refine results and ensure relevance. The search was limited to literature published from the year 2005 onward to focus on recent advancements and challenges in the field, until 31 October 2024.

Example of the search string used in Scopus:

TITLE-ABS-KEY("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND TITLE-ABS-KEY("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion)

2. Pain Management in Disaster and Mass Casualty Settings

2.1 Historical Perspective

The evolution of pain management in disaster and mass casualty settings has been shaped by both military medicine and civilian disaster response experiences. Many current practices trace their origins to battlefield medicine, where the necessity for rapid, effective pain control under austere conditions drove innovation in analgesic approaches (12,21).

Prior to the 1990s, pain management in MCSs was often viewed as a secondary consideration, with immediate life-saving interventions taking precedence (2). The development of structured triage systems, such as Simple Triage and Rapid Treatment (START), initially focused primarily on identifying immediate life threats, with pain management notably absent from early protocols (29).

The military experience in various conflicts has significantly influenced civilian mass casualty pain management, with innovations such as the combat wound medication pack and the introduction of battlefield analgesics like oral transmucosal fentanyl citrate (OTFC) being adapted for civilian use (30). These developments represent significant advances in providing rapid, effective analgesia in austere conditions.

The historical neglect of pain management in disaster planning and response protocols may reflect the necessary prioritisation of limited resources in MCSs (3). Conversely, other evidence suggests that inadequate pain management leads to poorer outcomes and increased morbidity (16). This historical oversight has contributed to current deficiencies in mass casualty pain management protocols and requires systematic correction.

The 2009 L'Aquila earthquake marked a significant turning point in pain management in natural disaster, as it led to one of the first comprehensive studies of the topic. Researchers documented both the challenges and opportunities for improving pain management in MCSs, providing valuable insights that continue to influence current practices (16).

2.2 Current Challenges

Researchers have found that pain management in MCSs face multiple intersecting challenges that complicate care delivery and impact patient outcomes. These challenges include resource limitations, personnel constraints, and systemic barriers that collectively impede effective pain control (3).

One of the most significant challenges is the mismatch between casualty numbers and qualified personnel authorised to administer analgesics (24). The practitioner-to-patient ratio often exceeds sustainable levels in MCSs (20). This disparity is particularly problematic when managing high-risk analgesics such as ketamine and fentanyl, which require advanced practitioner oversight.

Although modern emergency medical services may be well-equipped for routine emergencies, MCSs can quickly overwhelm standard operating procedures and available resources (17,31,32). Resource limitations present a significant challenge, manifesting as insufficient stockpiles of analgesic medications, limited availability of delivery devices and monitoring equipment, inadequate access to alternative pain management modalities, and restricted availability of advanced life support practitioners (28).

Operational constraints further complicate pain management efforts through complex triage decisions involving pain management prioritization, difficulties in pain assessment during chaos and time pressure, communication barriers between providers and patients, and environmental challenges affecting medication administration. These operational issues are compounded by system-level challenges including the lack of standardized protocols for mass casualty pain management, limited integration of pain management into disaster response frameworks, insufficient training in mass casualty analgesia, and regulatory restrictions on medication administration by intermediate-level practitioners (11).

Non-pharmacological pain management strategies in MCSs could provide possible alternatives when analgesic medications are limited, however, their implementation may require time and resources or training that may be scarce in mass casualty settings (33–35).

2.3 The Neglected "Fifth Vital Sign"

Despite pain being recognised as the "fifth vital sign," its assessment and management in MCSs remains notably neglected in disaster response protocols and training (17). This oversight is particularly concerning given that pain is reported as one of the most prevalent symptoms in MCSs, with studies documenting pain prevalence rates of up to 34.6% among patients attending Advanced Medical Presidiums following disasters (16).

Recent studies show that healthcare providers are often unprepared to adequately assess and treat acute pain in disaster settings (17,24,32). This unpreparedness stems from both cultural and material factors, including insufficient training in disaster pain management and the limited availability of assessment tools appropriate for MCSs (3,9,10). The situation is further complicated by the frequent shortage of opioids and other analgesics in disaster settings, forcing providers to adapt their assessment and treatment approaches (20).

Although pain should be prioritised in disaster responses, according to the literature it is often overshadowed by immediate life-threatening concerns (17,25). This de-prioritisation occurs despite evidence suggesting that inadequate pain treatment can lead to both immediate suffering and long-term physical and psychological consequences (28).

One controversial issue is the integration of pain assessment into mass casualty triage protocols. Some researchers argue that incorporating pain assessment could delay critical interventions in time-sensitive situations (2). Other scholars suggest that early pain assessment and management can significantly impact patient outcomes and resource utilisation (12). A synthesis of the evidence suggests that simplified pain assessment tools specifically designed for MCSs could bridge this gap without compromising triage efficiency.

2.4 Impact on Patient Outcomes

Inadequate pain management in MCSs can have profound immediate and long-term consequences for patient outcomes. Studies following the L'Aquila earthquake documented that 58.8% of patients reported severe pain (verbal Numerical Rating Scale 7-10), with initial pain scores averaging 7.59 ± 1.3, highlighting the significant burden of uncontrolled pain in disaster scenarios (16).

Pain syndromes following MCSs often display a biphasic pattern, with both acute and chronic manifestations that can persist well beyond the initial incident (17). The relationship between stress and pain in disaster settings creates a potential vicious cycle, where inadequate pain control exacerbates psychological trauma, which in turn can amplify pain perception (32).

Although multimodal analgesia approaches are effective in managing pain, many studies demonstrate a shortage of strong opioids and other analgesics in disaster settings which limits treatment options (16,17,34). In mass casualty burn incidents, for instance, studies have shown that the average daily morphine equivalent doses range from 24.6 to 52.5 mg, with peak requirements occurring on day 8 post-burn (34). This highlights the sustained nature of analgesic requirements following mass casualty events.

The relationship between acute pain management and long-term recovery outcomes remains a subject of ongoing debate in emergency medicine literature. It is suggested that adequate pain control can significantly improve immediate outcomes and reduce morbidity (12). However, resource constraints in MCSs often make optimal pain management impossible (3).

3. Types of Mass Casualty Scenarios and Associated Pain Profiles

Different types of MCSs present unique challenges and pain profiles requiring distinct management approaches. Pain management demands are likely to vary significantly based on incident type, mechanism of injury, resource availability, and environmental conditions, necessitating tailored approaches to care delivery.

3.1 Natural Disasters

Natural disasters create complex pain management scenarios characterised by a high prevalence of crush injuries, orthopaedic trauma, and widespread infrastructure disruption affecting healthcare delivery. The L'Aquila earthquake experience documented pain prevalence reaching 34.6% among casualties, with 58.8% reporting severe pain (verbal Numerical Rating Scale 7-10) (16). This high prevalence of severe pain, combined with infrastructure disruption and extended periods of required pain management, created substantial challenges for healthcare providers (16,17). The psychological impact of natural disasters further complicates pain management, creating a potential cycle of increased pain perception and psychological distress (17).

3.2 Industrial Accidents

Although industrial accidents follow somewhat predictable patterns, these incidents often present unique pain management challenges such as chemical burns requiring specialised approaches, multiple trauma patterns from explosions or structural collapses, and a high incidence of inhalation injuries affecting treatment options (28,36,37). Similarly, building collapse scenarios, such as those documented in Bangladesh, demonstrate the need for adaptable pain management strategies capable of addressing multiple injury patterns simultaneously (28). Victims often suffer from crush injuries, fractures, and compartment syndrome, necessitating the use of multimodal analgesia, including opioids, ketamine, and nerve blocks (16).

3.3 Mass Gathering Incidents

Mass gathering incidents, such as concerts, sports events, or religious pilgrimages, create unique challenges for pain management due to high casualty volumes, diverse injury patterns, and limited access to emergency medical services. Injuries often range from minor contusions to severe trauma, such as fractures or head injuries caused by stampedes or collapses. Some researchers argue for comprehensive pain management resources at major events (3). With other evidence suggests that basic analgesic protocols may be more practical given resource constraints (20).

3.4 Terrorist Incidents

Terrorist incidents create particularly challenging pain management scenarios through multiple trauma patterns from explosive devices, the high incidence of penetrating injuries, and significant psychological trauma complicating pain management. Studies of combat casualty care have significantly influenced pain management approaches in terrorist incidents, particularly regarding the use of rapid-acting analgesics and novel delivery systems (30). Scene safety concerns and the need for rapid evacuation often compromise optimal pain control in these scenarios.

3.5 Transportation

Transportation-related MCSs present specific challenges through complex extrication requirements potentially delaying pain management, multiple trauma patterns requiring different analgesic approaches, and hazardous conditions affecting care delivery (38). The geographic spread of casualties in these incidents often complicates resource allocation, while the need for simultaneous pain management during extended extrications creates additional complexity (38).

Across all MCS types, several common elements emerge regarding pain management. Resource limitations consistently affect care delivery through shortages of qualified personnel, the limited availability of analgesic medications, and restricted access to monitoring equipment. Operational challenges include the need for rapid triage decisions, communication difficulties affecting pain assessment, and environmental factors complicating care delivery. Clinical considerations span multiple simultaneous casualties requiring pain management, complex injury patterns requiring different analgesic approaches, and psychological factors influencing pain perception.

Studies across different MCS types consistently emphasise the need for adaptable pain management protocols, enhanced provider training in mass casualty pain management, and integration of psychological support. The development of resource-appropriate analgesic strategies and improved pain assessment tools for MCSs remains crucial for advancing care in these challenging environments (2,3,16,20,28). The complexity of pain management in MCSs underscores the importance of continued research and protocol development to address these multifaceted challenges effectively.

4. Prehospital Pain Management Resources and Limitations

A comprehensive analysis of the National Emergency Medical Services Information System (NEMSIS) database, examining nearly 20 million EMS activations in the USA, revealed critical gaps in prehospital pain management during MCSs (20). Despite pain being reported as the primary symptom in 38.9% of MCS activations, only 26.9% of cases received any medication, with analgesics being administered in just 3.2% of cases (20). When medications were administered, fentanyl emerged as the dominant narcotic (6.7% of all medications), followed by morphine sulphate (4.0%), suggesting a relatively narrow range of analgesic options being utilised even in relatively well resourced and trained settings in MCSs (24).

There are disparities in pain management capabilities across different service levels, with Advanced Life Support and Air Medical Transport services demonstrating substantially higher medication administration rates (34.5% and 58.9% respectively) compared to Basic Life Support services (8.7%) (24). This variation appears to reflect both scope of practice limitations and resource constraints rather than differences in clinical need.

The shortage of opioids and other analgesics in disaster settings creates significant treatment limitations, while the lack of monitoring equipment and delivery devices further constraining pain management options (17). Studies following natural disasters consistently document that healthcare providers are often materially unprepared to manage acute pain effectively in these settings (16,17).

The adequacy of current training programs in preparing healthcare providers for mass casualty pain management is a pressing issue. Existing emergency medical training may provide sufficient foundational knowledge for pain management (29). However, studies document significant gaps in provider preparedness, particularly regarding paediatric-specific pain management in disasters, with 42% of Disaster Medical Assistance Teams in the USA lacking paediatric pain management in their curriculum (29). Specialised training in mass casualty pain management, including scenario-based exercises, should be integrated into standard emergency medical education (17,29,39). Logistical challenges further complicate pain management efforts through complex supply chain disruptions, difficulties in medication storage and preservation during disasters, and challenges in maintaining appropriate documentation and tracking systems. The L'Aquila earthquake experience demonstrated that finding, loading, unloading, and preserving drugs during disasters presents significant operational challenges that directly impact pain management capabilities (16).

Burn MCSs provide additional insights into resource planning challenges, with opioid requirements that can vary significantly, with average daily morphine equivalent doses ranging from 24.6 to 52.5 mg, peaking at day 8 post-burn (34). This variability complicates stockpile planning and resource allocation, particularly in extended mass casualty responses.

The integration of newer technologies, such as portable ultrasound units for regional anaesthesia, presents both opportunities and challenges. While these technologies could enhance pain management capabilities, their implementation requires additional training, maintenance, and resource allocation that may strain already limited disaster response resources (21,40). Furthermore, the lack of standardized protocols for implementing advanced pain management techniques in MCS creates uncertainty regarding optimal resource allocation.

The combined impact of these limitations creates a complex challenge for EMS attempting to deliver effective pain management in MCSs. Success requires addressing the immediate resource needs and developing sustainable solutions for training, logistics, and personnel deployment that can function effectively under the extreme pressures of MCSs (2,3,16,20).

5. Pain Management Options in Mass Casualty Settings

Effective pain management in MCSs requires a multi-modal approach incorporating both pharmacological and non-pharmacological interventions (12,41,42). Studies analysing emergency medical services during mass-casualty incidents show that opioid analgesics remain the primary pharmacological interventions, with fentanyl being the most common narcotic analgesic (6.7% of all medications), followed by morphine sulphate (4.0%) during MCS activations (20,43).

5.1 Opiates

Opioid selection patterns varies significantly across different MCSs (24,25,34,43). The Operation HERRICK event demonstrated that opioids could be administered safely to a large number of casualties (43). Operation HERRICK was a UK military operation in Afghanistan that ran from 2006 to November 2014 (44). During this period, the UK Defence Medical Services (DMS) operated a field hospital in Afghanistan that treated 7,800 UK service personnel and civilians (44). Operation Herrick was a catalyst for major improvements in battlefield medicine for the UK.

The introduction of novel delivery systems, such as oral transmucosal fentanyl citrate (OTFC) and sublingual sufentanil tablets, provided new options for rapid analgesia in austere environments (43). The study examined 5,801 casualties who received opioid analgesia during the seven-year conflict period, with 46.2% receiving prehospital pain management (43). Notably, the complication rate requiring naloxone administration was remarkably low at 0.24% (14 patients), demonstrating the safety of opioid use in battlefield conditions (43). The study also documented the successful implementation of oral transmucosal fentanyl citrate (OTFC) in 258 episodes across 249 casualties, primarily during evacuation phases, with no recorded instances requiring naloxone intervention (43). These findings have significant implications for mass casualty pain management protocols, suggesting that opioid analgesia can be safely administered in austere environments when proper protocols are followed.

5.2 Ketamine

While some studies highlight ketamine's critical role in mass casualty pain management, its use remains limited, reported as only 0.3% of all medications administered during MCSs (20). However, the Kashmir earthquake experience demonstrated ketamine's particular value in resource-limited settings, allowing simultaneous management of up to five patients while maintaining effectiveness without sophisticated monitoring equipment (32).

Ketamine is discussed as a crucial analgesic option in Wedmore and Butler's (39) analysis of battlefield pain management, particularly for casualties experiencing moderate-to-severe pain with compromised haemodynamic or respiratory status. The medication's unique properties make it especially valuable in austere environments - it maintains airway reflexes and haemodynamic stability while providing effective analgesia with a remarkably high therapeutic index. For analgesia, the authors recommend sub-dissociative dosing at 0.3-0.5 mg/kg via multiple possible routes (IV/IM/IN/IO), with initial doses of 20mg IV/IO or 50mg IM/IN that can be repeated in boluses at 20-30 minute intervals as needed (39). The paper notably addresses and largely dismisses historical concerns about ketamine's effects on intracranial pressure in head injury patients. While side effects exist - including rare instances of laryngospasm (0.3%), transient apnoea with rapid IV administration (0.8%), emesis (5-15%), and emergence phenomenon - the overall safety profile remains impressive (39). Most relevant for MCS is that ketamine's characteristics allow for simultaneous management of multiple patients with minimal monitoring requirements, making it particularly valuable in resource-constrained environments (39). Wedmore and Butler's (39) comprehensive evidence synthesis has not only shaped modern military medicine protocols but also offers valuable insights for civilian mass casualty response, especially in austere conditions where advanced monitoring capabilities may be unavailable.

Bebarta et al.'s (19) 2020 study examines the safety and outcomes of prehospital ketamine administration in combat casualties with traumatic brain injury (TBI), addressing a critical knowledge gap in military emergency medicine. The post-hoc sub-analysis of the larger Life Saving Intervention study analysed data from 160 combat casualties with suspected TBI treated in Afghanistan between November 2009 and March 2014 (19). The study aimed to assess whether ketamine, which has historically been controversial for TBI patients due to concerns about increasing intracranial pressure, could be safely used as an analgesic in this population (19).

The research compared three groups of casualties: those who received ketamine (29%, n=46), those who received other analgesics (28%, n=45), and those who received no analgesics (43%, n=69) (19). Despite the ketamine group having more severe injuries and requiring more life-saving interventions, they showed similar outcomes to the other groups in terms of vital signs at admission, mortality rates, and hospital/ICU stay duration. Most subjects were 26-year-old males with explosion-related injuries (66%) and a median injury severity score of 12 (19). The findings demonstrated that combat casualties with suspected TBI who received prehospital ketamine had comparable outcomes to those who

received other or no analgesics, suggesting that ketamine can be safely administered in the prehospital combat setting even to patients with potential brain injuries (19).

5.3 Regional Anaesthesia

The introduction of affordable mobile ultrasound units and their inclusion in clinical practice guidelines for paramedic-level qualifications and above could facilitate newer and better pathways to multimodal analgesia. Ultrasound-guided peripheral nerve blocks, frequently utilised in emergency departments due to their relative speed and ease of performance, represent one potential solution that remains underutilised in prehospital settings (21).

Lippert et al.'s (21) 2020 research paper examines the potential role of ultrasound-guided nerve blocks for pain management in mass casualty and disaster settings. The authors particularly focus on four specific nerve blocks - femoral, popliteal, forearm, and interscalene - that could be rapidly taught to emergency physicians who already possess basic ultrasound skills (21).

The study synthesises evidence from both combat and civilian disaster experiences to demonstrate that ultrasound-guided nerve blocks can provide effective regional anesthesia for 4-14 hours without requiring advanced monitoring or risking systemic effects (21). Drawing from earlier research in emergency departments and military settings, the authors present a compelling case for integrating these techniques into disaster response protocols, particularly given that extremity injuries constitute the majority of trauma cases in mass casualty events (21). The paper provides detailed consideration of implementation challenges, including provider training requirements, equipment needs, documentation issues in austere conditions, and the management of potential complications like local anaesthetic systemic toxicity (LAST), whilst offering practical solutions and guidelines for each challenge identified (21).

The implementation of regional anaesthesia techniques in MCSs remains a subject of scholarly debate (21,27). Proponents point to compelling evidence from the 2010 Haiti earthquake, where practitioners successfully performed 536 regional nerve blocks under austere conditions, demonstrating the feasibility of these techniques in resource-limited settings (27). However, other studies highlight limitations including the need for skilled practitioners and potential complications like LAST that may limit widespread adoption (21,27,42). The literature indicates that implementation success depends heavily on provider expertise, available resources, and operational conditions as it provides excellent, extended pain control while conserving scarce systemic analgesic resources (21,27).

5.4 Autoinjector Technology

The advancement of autoinjector technology presents promising solutions for mass casualty pain management. These devices enable rapid drug administration comparable to intravenous delivery while requiring minimal training and resources (46). However, their higher cost and limited shelf life must be balanced against their operational advantages in MCSs.

Vijayaraghavan's (46) 2020 study provides a comprehensive review of autoinjector devices (AIDs) for rapid drug and antidote administration in emergency and MCSs. This review addresses a critical need in disaster medicine: the ability to quickly and effectively administer life-saving medications in situations where medical expertise may be limited or unavailable (46). The author examines the evolution and current state of AID technology, emphasising their particular value in scenarios requiring immediate drug administration alongside other first aid measures at the incident site (46).

The review synthesises evidence from a wide range of clinical and preclinical studies, examining AIDs across multiple applications including pain management. The study demonstrates that AIDs provide several key advantages: they enable rapid drug delivery across a large muscle area, can be used effectively by individuals without medical training, and typically cause less pain than traditional injections (46). The author particularly emphasises the versatility of modern AIDs, documenting their successful use with buprenorphine for pain relief (46).

Resource-appropriate solutions have become increasingly important as experience with MCSs grows. The burn mass casualty experience demonstrates that analgesic requirements can be substantial and sustained, with daily morphine equivalent doses reaching up to 52.5 mg and peak requirements occurring into the second week post-burn (34).

An evaluation of the current research consistently emphasises the importance of developing flexible protocols that can be scaled according to incident size, available resources, and provider capabilities (2,42).

6. Case Studies in Mass Casualty Pain Management

Literature specifically around pain management in MCS is thin, yet the following studies describe incidents in detail, specifically around analgesia. These incidents are reviewed and will give substance to the following sections.

6.1 L'Aquila Earthquake Experience

The 2009 L'Aquila earthquake provided crucial insights into pain management during natural disasters. Angeletti et al.'s study documented 958 patients attending Advanced Medical Presidiums (AMPs) in tent camps during the first five weeks following the earthquake, with pain prevalence reaching 34.6% among casualties and 58.8% of these patients reporting severe pain (v-NRS 7-10) (16).

The L'Aquila response faced several significant challenges through limited availability of strong opioids and other analgesics in the disaster setting, with complex pain syndromes showing a biphasic pattern over five weeks (16). The significant influence of psychological factors on pain perception, combined with resource constraints, necessitated the continuous adaptation of treatment strategies throughout the response period.

Findings from the L'Aquila experience indicate the need for significant adaptation of conventional analgesic approaches (41). The implemented multimodal analgesia strategy combined NSAIDs (diclofenac, ketorolac, nimesulide, ibuprofen, aspirin), paracetamol, weak and strong opioids, and local anaesthetics. This approach proved effective, with average pain scores decreasing from 7.59 ± 1.3 to 3.54 ± 1.2 after initial treatment, and further improving to 2.78 ± 0.8 after second administration (16).

The L'Aquila experience offers valuable lessons for disaster preparedness and response planning. The successful implementation of multimodal analgesia despite severe resource constraints demonstrates the importance of flexible pain management protocols that can be adapted to austere conditions (41). However, the high prevalence of severe pain and difficulties in maintaining adequate analgesic supplies underscore the critical need to integrate pain management more systematically into disaster planning. This includes establishing reliable supply chains for essential analgesics, particularly strong opioids, developing standardized protocols for pain assessment and treatment in field conditions, and ensuring healthcare providers are trained in both pharmacological and non-pharmacological pain management techniques suitable for disaster settings (41). The biphasic pattern of pain syndromes observed also highlights the importance of maintaining pain management capabilities throughout both the acute and recovery phases of disaster response.

6.2 Burn Mass Casualty Planning

Recent studies examining burn MCSs provide valuable insights into resource planning and protocol development. Leazer et al. (34) studied, 141 acute burn survivors with burns covering ≤30% total body surface area (TBSA), and their study offers critical data for mass casualty planning. Their findings demonstrate the complex relationship between burn severity, patient age, and analgesic requirements, providing crucial guidance for resource allocation in MCSs (34).

The approach to analgesic administration in burn MCSs remains a subject of debate within emergency medicine. Proponents of traditional methods emphasise opioids are the cornerstone of burn pain management, with studies demonstrating a direct correlation between analgesic requirements and burn severity. Conversely, emerging research highlights the necessity of opioid-sparing strategies in resource-limited mass casualty environments (34). A synthesis of the available evidence supports implementing a structured approach that strategically combines both opioid and non-opioid interventions, thereby optimising resource utilisation while maintaining effective pain control. This balanced strategy allows for scalable pain management protocols that can adapt to varying resource availability while preserving the core principles of burn pain management.

The burn mass casualty experience reveals that opioid requirements peak at day 8 post-burn, averaging 52.5 mg morphine equivalent doses (MED), with TBSA positively correlating with opioid requirements (1.5 unit increase in MED per 1% TBSA). Age demonstrates a negative correlation with opioid requirements (0.5 unit decrease in MED per year of age) (34). These findings provide crucial guidance for protocol development and resource planning in MCSs.

Protocol development for burn MCSs must address both immediate and sustained pain management needs. The research demonstrates the importance of considering initial pain control strategies during the acute phase while planning for sustained analgesic requirements during the recovery phase. Resource allocation planning must account for casualty numbers and burn severity, while integrating multimodal analgesic approaches to optimize available resources.

Both case studies emphasise the necessity of flexible, adaptable pain management protocols and the importance of stockpiling appropriate analgesic medications. The integration of psychological support in pain management emerges as a crucial component, particularly in extended disaster responses. Ongoing staff training and protocol development remain essential for maintaining effective pain management capabilities in MCSs.

7. Knowledge Gaps and Future Directions

Researchers have found significant gaps in current evidence regarding pain management in MCSs. Studies analysing prehospital documentation of injury-related pain assessment reveal that only 15% of casualties receive documented prehospital analgesic administration, with merely 7% having documented pain assessments (47). This profound lack of documentation reflects broader systemic gaps in pain management protocols and implementation.

The retrospective nature of most mass casualty research, combined with the chaos inherent in disaster response, creates significant barriers to data collection and analysis. Documentation from the DMATs reveals substantial gaps in paediatric pain management protocols, with 42% of teams lacking paediatric pain management in their curriculum and 37.8% missing essential paediatric medications from their equipment (29).

Military pain management protocols may be adaptable to civilian scenarios, yet evidence highlights potential barriers exist in translating battlefield medicine to civilian practice. The Operation HERRICK experience demonstrates that while opioid analgesia can be safely administered in austere environments, the military setting may not fully represent civilian MCSs (43).

The literature reveals differing perspectives on advanced pain management techniques in mass casualty settings. Studies from field hospitals have documented successful implementation of regional anesthesia and advanced analgesic delivery systems (42). For example, Missair et al. demonstrated successful completion of 536 regional nerve blocks during the Haiti earthquake response (48). However, other researchers emphasise resource and training constraints as significant barriers to implementation. Khayata and Bourque highlight that limited equipment availability and provider training requirements may restrict the feasibility of advanced techniques in many MCSs (49). This tension between potential benefits and practical limitations remains a significant theme in the current literature. The evidence supports adopting a graduated implementation of advanced pain management techniques, where interventions are strategically matched to provider competencies and resource availability. This approach offers a pragmatic framework that can adapt to varying operational conditions and requirements while maintaining clinical effectiveness.

Protocol development opportunities exist in several key areas. The success of ketamine-based anaesthesia in building collapse scenarios suggests opportunities for expanding the role of ketamine

in mass casualty pain management (28). Similarly, the emergence of novel delivery systems like autoinjectors presents opportunities for improving analgesic administration in austere environments (46).

Training implications extend beyond individual practitioner skills to encompass system-level preparedness. The L'Aquila earthquake experience highlights the critical need for healthcare providers to receive systematic training in disaster pain management, including psychological aspects of pain control and resource-appropriate analgesic strategies (16). Furthermore, the burn mass casualty experience demonstrates the importance of developing protocols that account for sustained analgesic requirements and resource utilisation patterns (34).

Future research needs include prospective studies of pain management interventions in MCSs, development and validation of mass casualty-specific pain assessment tools, and evaluation of novel analgesic delivery systems. The integration of psychological support into pain management protocols and the role of non-pharmacological interventions in resource-limited settings require particular attention. Additionally, research should focus on developing evidence-based guidelines for scaling pain management responses according to incident size and available resources.

The path forward requires addressing these knowledge gaps through systematic research while simultaneously developing practical solutions for current challenges. Success will require collaboration between military and civilian healthcare systems, integration of lessons learned from diverse mass casualty experiences, and development of flexible protocols that can adapt to varying resource levels and operational contexts.

8. Conclusion

Pain management in MCSs represents a critical yet frequently overlooked aspect of disaster response. Analysis of available literature indicates systematic undertreatment of pain in MCSs, with studies showing analgesic administration in only 3.2% of MCS activations, despite pain being reported in 38.9% of cases (20).

Successful mass casualty pain management requires a multi-faceted approach incorporating pharmacological and non-pharmacological interventions. The experience from field hospitals demonstrates that ketamine and regional anaesthesia techniques can maximise resource utilisation,

allowing simultaneous management of multiple patients in austere conditions (28). Furthermore, novel delivery systems such as oral transmucosal fentanyl citrate and autoinjectors offer promising solutions for rapid analgesia administration in challenging environments (45).

Although standard pain management protocols can be adapted for MCSs, significant modifications are necessary to address resource limitations and operational constraints (24,25). The L'Aquila earthquake experience demonstrated that healthcare providers are often materially and culturally unprepared for pain management in disaster settings, highlighting the need for specialised training and protocols (16). The optimal balance between comprehensive pain management and operational efficiency in MCSs remains a subject of critical debate in emergency medicine. Proponents of aggressive pain management emphasise that suboptimal analgesia contributes to increased morbidity and adverse long-term outcomes, with studies demonstrating correlations between inadequate acute pain control and the development of chronic pain syndromes (17). On the other hand, resource limitations and immediate life threats often force prioritisation of other interventions (2). The integration of empirical findings suggests that incorporating structured pain management protocols within established triage and treatment frameworks, coupled with stratified analgesic approaches calibrated to resource availability, offers the most viable solution to this challenge. Analysis of current research supports developing scalable interventions that can be systematically implemented within existing operational frameworks, while maintaining flexibility to adapt to resource constraints.

The implications for practice are substantial and multifaceted. Healthcare systems must develop scalable pain management protocols that can adapt to varying casualty volumes and resource levels. The burn mass casualty experience provides valuable guidance for resource planning, demonstrating predictable patterns in analgesic requirements that can inform stockpiling and distribution strategies (34). Training programs must expand to include mass casualty-specific pain management techniques, particularly regarding resource-appropriate analgesic strategies and psychological support integration.

Future research directions should focus on addressing current evidence gaps through prospective studies of pain management interventions in MCSs. Priority areas include validating mass casualty-specific pain assessment tools, evaluating novel analgesic delivery systems, and develop evidence-based guidelines for scaling pain management responses. Research must also address the integration of psychological support into pain management protocols and the role of non-pharmacological interventions in resource-limited settings.

Success in improving mass casualty pain management will require sustained commitment to protocol development, provider training, and resource allocation. The evidence suggests that investment in these areas can significantly improve patient outcomes while optimizing resource utilisation in challenging operational environments. As MCSs continue to occur with ever increasing frequency and severity, the developing and implementing effective pain management strategies is increasingly critical for emergency medical services both locally and internationally.

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Prehospital Pain Management in Mass Casualty Scenarios: A Scoping Review

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Keywords

Analgesia, ketamine, prehospital, disaster, mass casualty, pain

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Abstract

Background:

Effective pain management in mass casualty scenarios (MCS) is critical due to the high prevalence of severe pain and its association with increased morbidity. MCS, defined as incidents where patient care needs exceed available resources, pose unique challenges for prehospital care providers. This scoping review aims to synthesize existing evidence on prehospital pain management strategies, identify gaps, and inform future research and policy development.

Methods:

Following PRISMA-ScR guidelines, a comprehensive literature search was conducted across major medical databases (PubMed/MEDLINE, EMBASE, CINAHL, Scopus, and Web of Science) and grey literature repositories, covering studies published from 2005 to 2024. Inclusion criteria encompassed English-language studies addressing prehospital pain management in MCS, reporting on pain assessment, pharmacological/non-pharmacological interventions, or resource limitations. Excluded were hospital-based studies and non-evidence-based publications. Data were charted and synthesized into thematic categories.

Results:

The review included 22 studies, highlighting significant gaps in standardised pain management protocols and documentation. Key findings revealed underutilisation of analgesics, with only 3.2% of MCS cases receiving pain medication. Ketamine and regional anaesthesia emerged as viable options, particularly in resource-limited settings, while novel delivery systems like autoinjectors showed promise. Major barriers included resource shortages, provider training gaps, and limited integration of pain management in triage systems.

Conclusion:

Prehospital pain management in MCS requires scalable, evidence-based protocols emphasising early analgesic administration, particularly ketamine and multimodal strategies. Systemic barriers, including inadequate training and documentation, hinder effective implementation. Addressing these gaps through improved training, simplified protocols, and better resource planning can enhance patient outcomes and disaster response capabilities. Future research should prioritise paediatric care and standardised outcome measures to further refine pain management in diverse MCS contexts.

African Relevance

- Resource-optimized pain protocols using ketamine could improve mass casualty care in settings with limited advanced life support capacity
- Implementation of simplified documentation systems could enhance pain management in austere African emergency care environments
- Regional anesthesia techniques offer cost-effective solutions for prolonged mass casualty events where opioid supplies may be limited

Prehospital Pain Management in Mass Casualty Scenarios: A Scoping Review

1. Introduction

Pain management in mass casualty scenarios (MCS) presents a unique challenge for prehospital emergency care providers. MCS occur when patient care needs exceed the resources and capabilities of the local healthcare system to provide standard care (1). Recent studies show a significant gap between optimal pain management practices and what is achievable during MCS (2,3). The complexity of these scenarios, combined with prolonged rescue and evacuation times, extreme traumatic injuries, and resource limitations, often results in suboptimal pain control that likely increases both morbidity and mortality (4).

The prevalence of pain in MCSs is substantial, with pain being a primary symptom in many MCS activations Most MCS patients report severe pain (5,6). This widespread prevalence of severe pain, combined with documented shortages of analgesic medications and limited availability of qualified personnel, should create a categorical imperative to address pain management in MCSs.

Despite the critical nature of pain management in MCS, there is an absence of systematic algorithms and evidence-based guidelines specifically addressing this aspect of care. Healthcare providers frequently struggle to achieve therapeutic dosage levels, and despite technologies like portable ultrasound and regional anesthesia these are under-utilized (7,8). However, these technologies remain underutilized in MCS settings due to training requirements, equipment availability, and the time constraints inherent in mass casualty response. Inadequate pain management is not only inhumane but may lead to adverse long-term physical and psychological outcomes for survivors (4,9). This review will map and synthesize the current evidence regarding prehospital pain management strategies in MCS, to identify knowledge gaps to inform future research directions, policy development, clinical practice guidelines, and educational curriculum development for emergency medical services personnel. This approach will provide an evidence-based foundation for improving pain management practices and patient outcomes in MCS.

2. Methods

A scoping review was conducted following the PRISMA-ScR guidelines and framework of Arksey and O'Malley (10-12). The search included studies published from 2005 onwards to encompass developments in prehospital care protocols and the emergence of new analgesic strategies

Eligible studies encompassed English language publications that specifically focused on prehospital pain management in MCS; and considered primary research articles, systematic reviews, and pertinent grey literature, including technical reports, dissertations, and practice guidelines. Only studies with full-text availability were included, and studies needed to report on at least one of the following elements: pain assessment methodologies, pharmacological treatment adherence patterns, or effectiveness measures of pain relief interventions in MCS. Exclusion criteria were studies that exclusively examined hospital-based pain management, publications that did not specifically address pain management in MCS contexts, and studies focusing solely on individual trauma cases. Conference abstracts without accompanying full-text publications, as well as opinion pieces and editorials were excluded to maintain the evidence-based nature of the review.

A comprehensive literature search was conducted across major medical databases (PubMed/MEDLINE, EMBASE, CINAHL, Scopus, and Web of Science) from 2005 through October 2024. Grey literature repositories (MedNar, OpenSIGLE) and institutional websites (WHO, FEMA, Red Cross) and key emergency medicine and disaster management journals were hand-searched, and content experts were consulted to identify unpublished materials. The search was conducted across multiple search interfaces, using the following search terms: "Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment" AND "mass casualty incident" OR "mass casualty event" OR “mass casualty scenario” OR “disaster” OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion.

A two-stage screening process was implemented following the PRISMA-ScR guidelines: Stage 1: Title and abstract screening by two independent reviewers (PH,CM) with any conflicts resolved through discussion between the reviewers, with provision for a third reviewer to arbitrate if consensus could not be achieved. Stage 2: Full-text review of all potentially eligible articles was performed by the same two reviewers against the established inclusion criteria, documenting specific reasons for any exclusions. As with the initial screening, any disagreements between reviewers were resolved through collaborative discussion. A data extraction matrix was developed and refined in Microsoft Excel with

four key domains: publication characteristics, study details, clinical parameters, and applicability assessment. Quality assurance was maintained through comparison of extracted data between reviewers, with any discrepancies resolved through discussion. Missing data was noted as "not reported" rather than left blank to ensure transparency in reporting.

3. Results

3.1 Study Selection

The screening process identified 22 relevant studies (Fig 1). Table 1 summarizes the key data for the 22 papers.

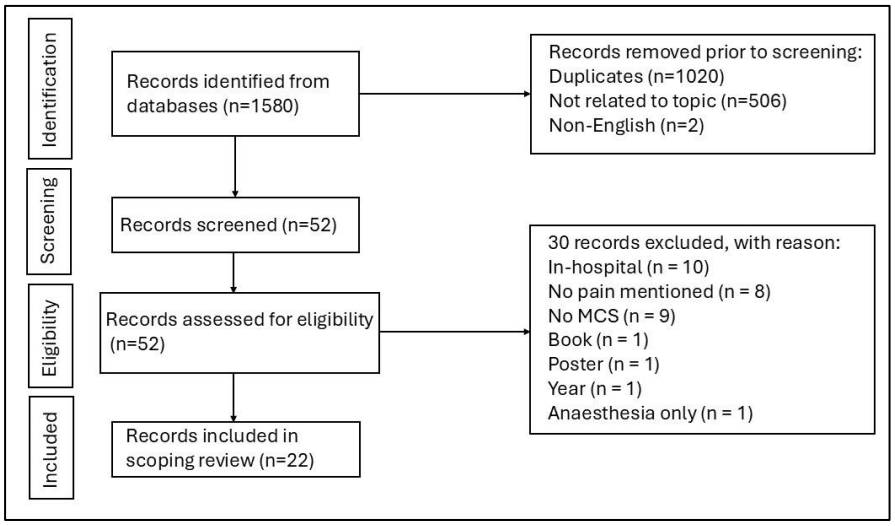

Figure 1. PRISMA flow diagram showing record selection and screening process

MCS - mass casualty scenarios

Table 1. Summary table of included studies

Author, Year	Title	Analgesic interventions	Key findings
Angeletti C et al., 2012 (6)	Pain after Earthquake	NSAIDs (diclofenac, ketorolac, nimesulide, ibuprofen, aspirin) Paracetamol Weak opioids Strong opioids Combination therapies Local anaesthetics	1. 34.6% pain prevalence in AMPs, 58.8% reporting severe pain (v-NRS 7-10) 2. Biphasic pain patterns over 5 weeks 3. Multimodal analgesia effective 4. Psychological factors influenced pain perception 5. Limited by opioid shortages 6. v-NRS implementation improved assessment/management
Baker DJ, et al., 2007 (13)	Multiple Casualty Incidents: The Prehospital Role of the Anesthesiologist in Europe	Morphine, mixed opioids, nonopioids, regional anesthesia, general anesthesia	1. Anesthesiologists crucial in European prehospital MCS care, especially in French SAMU system 2. On-site stabilization with advanced airway/anesthesia beneficial in MCSs 3. Terrorist incidents demonstrated value of anaesthesiologist-inclusive teams 4. Coordinated response plans (French 'red'/'white' plans) essential for MCS management 5. Integrated prehospital anesthesia services improve MCS outcomes
Bebarta VS, et al., 2020 (14)	Prehospital Use of Ketamine in the Combat Setting: A Sub-Analysis of Patients With Head Injuries Evaluated in the Prospective Life Saving Intervention Study	Ketamine Other analgesics No analgesics	1. Ketamine showed similar outcomes to other/no analgesics in TBI patients 2. Despite treating more severe injuries, ketamine group had comparable vital signs and outcomes 3. No difference in mortality, ICU/ventilator days, or hospital stay 4. Ketamine demonstrated safety in TBI patients 5. Viable analgesic option for MCSs involving TBI
Black IH, McManus J, 2009 (3)	Pain Management in Current Combat Operations	Opioids NSAIDs (meloxicam) Acetaminophen Ketamine Regional anesthesia techniques Multimodal analgesia approaches	1. Point-of-injury pain management critical 2. Multimodal analgesia effective in combat settings 3. OTFC suitable for austere environments 4. Regional anesthesia valuable for combat casualties 5. Ketamine emerging as key combat analgesic 6. Pain relief must balance with cognitive function 7. Active research in battlefield analgesic development
Carenzo L, et al., 2022 (15)	Pre-hospital oral transmucosal fentanyl citrate for trauma analgesia	Oral transmucosal fentanyl citrate (OTFC) lozenge	1. OTFC is an effective and safe analgesic option for pre-hospital trauma care 2. It can be administered rapidly without need for IV access 3. Useful for both penetrating and blunt trauma patients 4. Lower dose (400µg) may offer improved safety profile compared to military settings 5. OTFC could be a valuable tool in mass casualty incidents where rapid analgesia is needed
de Valence T, Suppan L, 2023 (16)	Time to Reconsider Analgesia in Mass Casualty Incidents	OTFC, sublingual sufentanil, inhaled methoxyflurane, ketamine	Argues for early analgesia in all types of MCSs
El Sayed M, et al., 2016 (17)	Description of Medication Administration by Emergency Medical Services during Mass-casualty Incidents in the United States	opioids, ketamine, ketorolac, nitrous oxide, regional	1. MCS medication administration: 26.9% of activations received medications 2. Low analgesic use: only 3.2% received pain medications 3. Service level variations: • Air Medical: highest rate (58.9% overall, 31.1% narcotics) • Significant variation between service levels 4. Medication patterns:

			• Oxygen most common (16.3%) • Fentanyl leading analgesic, followed by morphine • Ketamine: 0.3% of medications, <0.1% of MCSs • Regional anesthesia used but frequencies unspecified 5. Medication hierarchy 6. Findings valuable for MCS stockpile planning
Gebhard RE, et al., 2020 (18)	Anesthesia and Pain Management in Field Hospitals	Inhalation anesthesia Total Intravenous Anesthesia (TIVA) Regional anesthesia techniques Ketamine Opioids Multimodal analgesia	1. TIVA and regional techniques preferred: portable and effective in austere settings 2. Ketamine valuable for both analgesia and anesthesia 3. Multimodal approaches effective while minimizing side effects 4. Success requires adaptation to resource/environmental limitations 5. Technique selection based on: •Patient condition •Available resources •Provider expertise
Gerhardt RT, et al., 2016 (19)	Analysis of Prehospital Documentation of Injury-Related Pain Assessment and Analgesic Administration on the Contemporary Battlefield	opioids Ketorolac	• 15% received documented prehospital analgesia • 7% had prehospital pain assessment • 56% had hospital arrival pain assessment • 5% had both pre/hospital assessments • Modest documentation improvement over time • Pain assessment/management remain key improvement targets • Recommended expansion of prehospital analgesic options
Guetti C., et al., 2013 (20)	Pain and Natural Disaster	Opioids, Nonopioid compounds	1. Healthcare providers unprepared for disaster pain management 2. Opioid shortages common in disasters 3. Lack of MCS pain guidelines 4. Poor pain control leads to long-term physical/psychological impacts 5. Stress-pain cycle compounds issues 6. Staff training inadequate 7. Pain requires prioritization in disaster response
Khayata I, Bourque J, 2012 (21)	Mobile anesthesia: Ready, set, pack, and go	Inhalation anesthesia. Total Intravenous Anesthesia (TIVA). Regional anesthesia. Ketamine-based anesthesia.	1. TIVA/regional techniques preferred - portable and effective 2. Ketamine valuable for analgesia/anesthesia in field hospitals 3. Multimodal analgesia effective, minimizes side effects 4. Success requires adaptation to resource limitations 5. Technique selection based on patient, resources, provider expertise 6. Portable medic bags contain essential supplies
Kim SY, et al., 2022 (22)	The Newest Battlefield Opioid, Sublingual Sufentanil: A Proposal to Refine Opioid Usage in the U.S. Military	Sublingual Sufentanil Tablets (SSTs, Dsuvia). Opioids	1. SSTs advantageous over battlefield opioids - easier administration/safer profile 2. Sublingual delivery beneficial in austere/MCS environments 3. May reduce overall opioid use and addiction risk vs IV opioids 4. More research needed on SST effectiveness/safety 5. Requires proper protocols to prevent misuse
Leazer ST, et al., 2020 (23)	Analgesic use in contemporary burn practice: Applications to burn mass casualty incident planning	Opioids acetaminophen Adjuncts	1. Peak opioid need: 52.5 mg MED at day 8 post-burn 2. TBSA correlation: +1.5 MED units per 1% TBSA 3. Age correlation: -0.5 MED units per year 4. Multimodal analgesia commonly used 5. Results useful for MCS burn opioid planning

Lewis P, et al., 2018 (24)	Opioid analgesia on the battlefield: a retrospective review of data from Operation HERRICK	opioids	1. 5,801 casualties received opioids safely with low complications 2. Morphine/fentanyl primary analgesics via multiple routes 3. Intranasal fentanyl effective, especially in paediatrics 4. Opioids proven safe/effective in high-stress environments 5. Multiple analgesic options needed for MCSs
Mace SE, Bern AI, 2007 (25)	Needs assessment: are Disaster Medical Assistance Teams up for the challenge of a pediatric disaster?		1.Significant deficiencies in pediatric-specific curriculum (16-45% missing topics). 2. Substantial gaps in paediatric equipment (16-62% missing items). 3. Only 63% included paediatric patients in disaster drills. 4. Only 33% had pediatric protocols beyond triage. 5. 35.1% were paediatric emergency medicine specialists.
Missair A, et al., 2010 (26)	Surgery under Extreme Conditions in the Aftermath of the 2010 Haiti Earthquake: The Importance of Regional Anesthesia	Regional , ketamine, Local anaesthetics, general anaesthesia	Regional anesthesia crucial in resource-limited MCS settings; allows multiple simultaneous surgeries
Mulvey JM, et al., 2006 (27)	Earthquake Injuries and the Use of Ketamine for Surgical Procedures: The Kashmir Experience	ketamine	1. Ketamine safe/effective in MCS - allowed 5 patients treated simultaneously 2. Injury profile: 78.4% limb injuries, 50.3% fractures 3. Minimal complications: 3.3% vomiting (mainly young children), no hallucinations 4. Surgery possible without oxygen/advanced monitoring 5. Recommended for disaster surgery, especially resource-limited settings
Murshed H,et al., 2014 (28)	Mass Casualty in A Building Collapse: Techniques of Anaesthesia in Mass Casualty Management	Total Intravenous Anesthesia (TIVA) with ketamine, Regional , General anesthesia (rarely used)	1. Ketamine/regional techniques enabled 5 simultaneous patients 2. Successfully managed mass casualties with limited resources 3. Minimal general anesthesia use due to constraints
Schauer SG, et al., 2017 (29)	Prehospital Interventions During Mass-Casualty Events in Afghanistan: A Case Analysis	Oral transmucosal fentanyl citrate (OTFC), ketamine, opioids, acetaminophen	1. Common interventions: tourniquets (19.6%), pressure dressings (18.8%), pain meds (15.2%) 2. OTFC most common analgesic 3. Explosives primary injury cause, 97% survival rate 4. Combat vs civilian differences: less IV fluids, no spinal immobilization 5. Alternative analgesic routes used (intranasal, transmucosal) 6. Ketamine effective for pain control 7. Pain management significant in prehospital MCS care
Lippert SC, et al., 2013 (7)	Pain Control in Disaster Settings: A Role for Ultrasound-Guided Nerve Blocks	Ultrasound-guided nerve blocks, Multimodal approach including opioids, NSAIDs, N-methyl-D-aspartate receptor antagonists	1. Ultrasound-guided nerve blocks offer effective regional pain control without systemic effects 2. Emergency physicians can be rapidly trained in these techniques 3. Blocks can provide 4-14 hours of pain relief 4. Technique is particularly valuable in resource-limited settings 5. Serves as a viable alternative to opioid-based pain management
Vijayaraghavan R, 2020 (30)	Autoinjector device for rapid administration of drugs and antidotes in emergency situations and in mass casualty management	opioid, ketamine	1. Autoinjectors enable rapid drug delivery in emergencies 2. Can deliver various analgesics including opioids/ketamine 3. Self-administration capable - crucial for MCSs 4. Delivery effectiveness comparable to IV administration 5. Good safety profile demonstrated 6. Increases patient treatment capacity in MCSs 7. Requires proper training/protocols

Wedmore IS, Butler FK Jr, 2017 (31)	Battlefield Analgesia in Tactical Combat Casualty Care	opioid, ketamine	1. TCCC adaptable to civilian MCS 2. Early analgesia emphasized 3. Suitable for wilderness medicine 4. Applicable to broader mass casualty settings

AMP - Advanced Medical Presidium, ICU - Intensive Care Unit, IV – Intravenous, MCS - Mass Casualty Scenario, MED - Morphine Equivalent Dose, NSAIDs - Non-Steroidal Anti-Inflammatory Drugs, OTFC - Oral Transmucosal Fentanyl Citrate, SST - Sublingual Sufentanil Tablet, TBI - Traumatic Brain Injury, TBSA - Total Body Surface Area, TCCC - Tactical Combat Casualty Care, TIVA - Total Intravenous Anesthesia, v-NRS - verbal Numerical Rating Scale

3.2 Study Characteristics

Papers discussed MCS operations across the globe, as well as general papers discussing pain management with authorship largely from the USA (Table 2).

Table 2. Geographic distribution of country where studies conducted (n=22)

Country	**Number of Studies**	**Percentage (%)**
General/Not specified	9	40.9
United States	4	18.2
Afghanistan	3	13.6
Italy	1	4.5
France	1	4.5
United Kingdom	1	4.5
Haiti	1	4.5
Pakistan	1	4.5
Bangladesh	1	4.5

3.3 Study designs

The distribution of study designs shows a predominance of narrative reviews/commentaries (n=6, 27.3%), followed by retrospective studies including cohort, case control, and cross-sectional designs (n=5, 22.7%). Descriptive studies and review articles each represented 13.6% (n=3) of the sample. Observational studies, including both retrospective and cohort designs, accounted for 9.1% (n=2) of papers. The remaining studies consisted of single examples (4.5% each) of a book chapter, survey-based research, and opinion piece.

3.4 Types of mass casualty events

A graphical distribution of the various mass casualty scenario types is displayed in Figure 2. Understanding these different MCS types is essential as each presents distinct pain management challenges requiring tailored approaches.

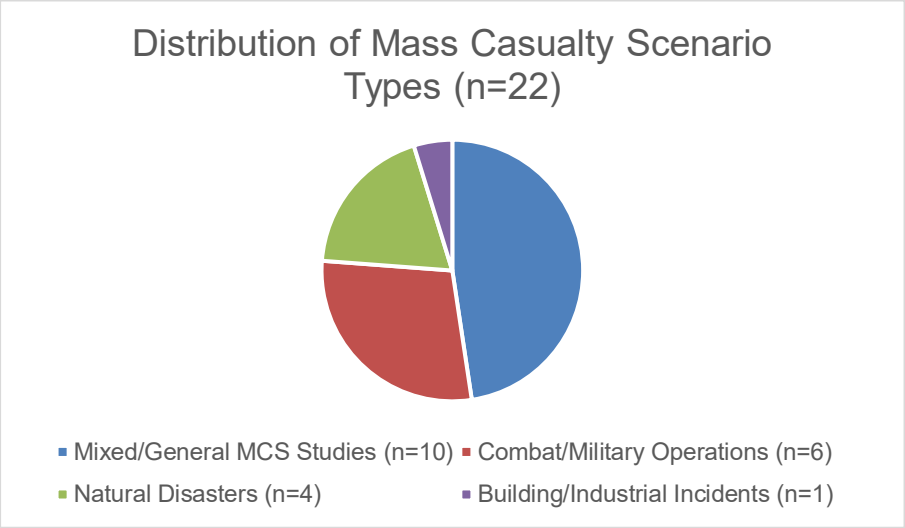

Figure 2. Mass Casualty Scenario Types

3.5 Provider and scene characteristics

The care setting significantly influenced pain management delivery, with most studies focusing on either immediate scene response (immediate on-site care) or field hospital (temporary medical facility) environments (Table 4). Scene response was predominantly provided by paramedics or combat medics with limited documentation of interventions (13), while field hospitals showed more structured pain management approaches delivered by a wider range of providers, including anesthesiologists and emergency physicians (26,27). Regional anaesthesia techniques were primarily documented in field hospital settings under the supervision of anaesthesiologists (26,28). Study populations across the reviewed literature encompassed both military and civilian casualties, with sample sizes ranging from 41 to 8,913 patients (17). While military studies concentrated on combatants and local civilians in conflict zones, civilian research examined natural disaster victims, industrial accident casualties, and burn patients. Notably, only one study specifically addressed paediatric considerations, revealing a significant gap in the literature regarding pain management for special populations (25).

Table 4 describes the different levels of care and available analgesic options for each respective service level.

Table 3. Provider Characteristics and Service Levels in Mass Casualty Settings

Service Level	Provider Types	Medication Administration Rate	Key Characteristics
Air Medical Transport	- Advanced providers - Specialized medical teams	58.9% (17)	- Highest rate of medication administration - Advanced monitoring capabilities - Specialized equipment access
Advanced Life Support	- Emergency physicians - Paramedics – Anaesthesiologists (26,27)	34.5% (17)	- Structured pain management protocols - Regional anesthesia capabilities (7,26) - Advanced intervention options
Basic Life Support	- EMTs - Combat Medical Technicians (24) - First responders	8.7% (17)	- Limited medication administration options - Focus on immediate life threats - Limited documentation of interventions (13)

3.6 Pain Assessment

Pain assessment practices in MCS remain notably understudied and poorly documented. Analysis of prehospital documentation from combat settings revealed that only 7% of casualties had documented pain assessments, despite pain being a significant factor in combat injuries (19). In civilian MCS, studies show pain assessment is often deprioritized during initial triage. An analysis of nearly 20 million EMS activations found that while pain was reported as the primary symptom in 38.9% of MCS activations, formal pain assessments were rarely documented (17). The L'Aquila earthquake experience provided detailed accounts of systematic pain assessment, using the standardised verbal Numerical Rating Scale (v-NRS) to document that 58.8% of patients reported severe pain (v-NRS 7-10), with initial pain scores averaging 7.59 ± 1.3 improving to 3.54 ± 1.2 after initial treatment, with further improvement to 2.78 ± 0.8 after a second administration (6). While the outcomes data demonstrates successful pain management, the specific operational protocols or systems enabling their thorough assessment and documentation practices remain unclear. Their sustained five-week documentation period allowed identification of important temporal patterns in pain manifestation, including this biphasic pattern of pain syndromes, highlighting the value of systematic long-term pain assessment in disaster response, if their protocols were included a more comprehensive data analysis may have been possible. Notably, major triage systems such as START (Simple Triage and Rapid Treatment) do not incorporate pain assessment as a primary consideration, focusing instead on immediate life threats (13).

Studies examining pain management in MCS identified significant psychological components affecting pain perception and management. There is a complex interaction between psychological trauma and pain perception, with psychological distress amplifying pain experiences among survivors (6). Inadequate pain control exacerbates psychological trauma, which in turn amplifies pain perception (20).

3.7 Pain Management

Analysis of pain management interventions revealed three primary categories: pharmacological interventions, regional anesthesia techniques, and novel delivery systems. Pharmacological approaches predominantly featured opioids. In El Sayed et al.'s (17) comprehensive analysis of nearly 20 million EMS activations in the United States, fentanyl was documented as the most commonly reported analgesic (6.7% of all medications in MCS activations), followed by morphine sulphate (4.0%). The Operation HERRICK study, examining combat casualty care in Afghanistan, demonstrated multiple delivery methods for fentanyl including intravenous administration, oral transmucosal formulations, and intranasal applications (24). In the same operational context, morphine was utilized through multiple routes including intravenous, intramuscular, and auto-injector delivery systems (24).

Ketamine emerged as a significant alternative, particularly valued in austere environments, with efficacy in managing up to five patients simultaneously during the Kashmir earthquake response (27). Ketamine was administered in sub-dissociative doses for analgesia, which are significantly lower than the doses used for procedural sedation or induction. The analgesic doses were repeated at regular intervals when needed to maintain pain control (27).

Regional anesthesia techniques, including ultrasound-guided nerve blocks, showed promising results in MCS (32). Missair et al. (26) reported successful completion of 536 regional nerve blocks during earthquake response efforts (26). Ultrasound-guided peripheral nerve blocks focused particularly on femoral, popliteal, forearm, and interscalene techniques (32), utilizing ropivacaine (0.35%-0.5%) and mepivacaine (1.5%) (26,32). Implementation of regional techniques often occurred alongside systemic analgesia as part of multimodal protocols.

Novel delivery systems included autoinjector technology and oral transmucosal fentanyl citrate (OTFC). Autoinjector technology facilitated rapid administration of various analgesics including morphine, fentanyl, and ketamine (30). Autoinjector devices (AIDs) are specialized drug delivery systems designed for both self-administration by patients and use by medical personnel in emergency

situations. These devices feature a pre-filled drug cartridge with a retracted needle that deliver medications subcutaneously or intramuscularly with minimal training. Key advantages include rapid drug administration, comparable absorption to intravenous delivery, reduced pain compared to traditional injections, and particular utility in MCS where speed and ease of use are crucial (30). Analysis of Operation HERRICK, a military engagement in Afghanistan, demonstrated successful implementation of OTFC in 258 episodes across 249 casualties, with no recorded instances requiring naloxone reversal (24). Methoxyflurane although not currently FDA-approved in the United States, is widely used in metered dose inhalers throughout Australian EMS systems (19). The L'Aquila earthquake experience demonstrated successful implementation of multimodal analgesia, combining NSAIDs, opioids, and local anaesthetics despite resource constraints, with average pain scores decreasing from 7.59 ± 1.3 to 3.54 ± 1.2 after initial treatment (6). Multimodal protocols typically combined NSAIDs (including diclofenac, ketorolac, nimesulide, ibuprofen, and aspirin), paracetamol, weak and strong opioids, or local anaesthetics (6). Non-pharmacological approaches, though less extensively documented, included positioning, splinting, and psychological support measures.

3.8 Pain Patterns and Temporal Evolution

Analysis of pain manifestation across MCS revealed important temporal patterns. The L'Aquila earthquake experience documented that pain syndromes often displayed a biphasic pattern over the five-week observation period, with distinct acute and chronic phases requiring different management approaches (6). This temporal evolution was particularly evident in burn mass casualty research, predictable patterns in analgesic requirements were demonstrated (23). Analysis also revealed quantifiable relationships between injury characteristics and analgesic requirements, showing that total body surface area (TBSA) positively correlated with opioid requirements (1.5 unit increase in morphine equivalent dose per 1% TBSA), while age demonstrated a negative correlation (0.5 unit decrease in morphine equivalent dose per year of age) (23).

3.9 Challenges to Successful MCS Pain Management

The following table synthesizes the major challenges identified in implementing effective pain management during MCS. Drawing from the studies across diverse settings, it presents key findings alongside their operational impacts, highlighting the interconnected nature of resource, competency, safety, and documentation challenges in MCS pain management.

Table 4. Key Findings and Implementation Impact

Challenge Category	Key Findings	Implementation Impact
Resource Availability	• Unsustainable practitioner-to-patient ratios • Significant disparity between ALS (34.5%) and BLS (8.7%) medication administration rates (17) • Difficulties in drug logistics (finding, loading, unloading, preserving) (6)	• Limited ability to deliver timely pain management (17) • Inequitable access to pain control based on service level (17) • Disrupted supply chain affecting continuous care (6)
Provider Competency	• High percentage of DMATS lack paediatric pain management training (25) • Advanced techniques require specific expertise (32) • Regional anesthesia skills can be rapidly acquired (32)	• Suboptimal care for special populations (25) • Limited utilization of advanced pain control options(32) • Potential for rapid skill enhancement with proper training (32)
Safety Monitoring	• Operation HERRICK showed low complication rates (24) • Need for effective monitoring systems in resource-limited settings(32) • Protocols must be adaptable to austere conditions (18)	• Demonstrated safety of protocol-driven pain management (24) • Risk of inadequate patient monitoring (32) • Required adaptation of standard monitoring practices (18)
Documentation	• Only 15% of casualties receive documented analgesic administration (19) • Need for simplified documentation systems (19) • Systems must be adaptable to mass casualty conditions (13,18)	• Compromised continuity of care (19) • Difficulty tracking medication administration (19) • Challenges in quality improvement efforts (13)

ALS - Advanced Life Support, BLS - Basic Life Support, DMAT - Disaster Medical Assistance Team.

Analysis of pain management effectiveness revealed varying outcomes across incident types. The L'Aquila earthquake documented significant improvement in pain scores after initial and second treatments(6), while military studies showed mixed results with 49.1% of patients improving but 23.5% reporting worsening pain (19). Adverse events were notably rare when protocols were followed, with Operation HERRICK reporting only 0.24% of cases requiring naloxone despite widespread opioid use (24).

It is important to note that military-derived protocols may require significant adaptation for civilian use. Military settings typically have different command structures, younger and fitter patient populations, and unique logistical capabilities that may not translate directly to civilian MCS response.

Resource utilization analysis revealed significant underutilization of pain management, with finding showing that only 26.9% of MCS cases received medication and just 3.2% of those received analgesics (17). El Sayed et al.'s (17) analysis revealed that even when resources were theoretically available, implementation barriers such as overwhelming provider-to-patient ratios and complex triage demands often prevented effective delivery. While success factors included standardized protocols, adequate provider training, and flexible delivery systems, these elements were frequently compromised by the chaos and resource limitations inherent in MCSs (13,31). Regional anesthesia, though proven viable even in austere conditions with one study documenting 536 successful nerve blocks during earthquake response, faced significant implementation challenges including equipment availability, provider expertise requirements, and monitoring capabilities (26,32).

Explicit information about pain management protocols was limited, except for military protocols for battlefield analgesia, which included specific guidelines for oral transmucosal fentanyl citrate (OTFC) administration (24). The L'Aquila earthquake response described a structured multimodal analgesic approach, though this appeared to be developed during the response rather than pre-existing (6). US EMS revealed significant practice variability, with Advanced Life Support (ALS) services more likely to have standardized protocols than Basic Life Support (BLS) units, though specific numbers were not reported (17). Disaster Medical Assistance Teams (DMAT) showed a lack of any structured protocols for paediatric pain management (25).

4. Discussion

This synthesis of the evidence reveals fundamental challenges in mass casualty pain management that extend beyond simple resource limitations. The systematic undertreatment of pain, known as

oligoanalgesia, manifests distinctly in MCS, creating unique challenges that differ from routine emergency care (20,33). While pain is a primary presentation in many MCS activations, a minority received analgesics and this disparity between pain prevalence and treatment represents a critical gap in emergency care delivery.(17).

Although MCS occur globally, research documentation remains unevenly distributed with many general/non-location-specific studies (40.9%) suggesting more theoretical and broad-based approaches rather than context-specific analyses. Studies from high-income countries and conflict zones are better represented, while research from many regions frequently affected by MCS is limited. This pattern may affect our understanding of pain management challenges in diverse healthcare settings and resource contexts. Studies are dominated by retrospective analyses and narrative reviews, pointing to the challenges in conducting prospective research in MCS, which necessitates careful consideration of the available evidence (13,16). The preponderance of military-derived evidence (30.4% of studies) raises important questions about the generalizability of current protocols to civilian contexts (24), where organizational structures and resource availability differ significantly (20,34).

Our findings suggest a disconnect between technological capability and operational feasibility of analgesic options and delivery methods. The successful implementation of innovative drugs and drug delivery systems in MCS demonstrates the potential (13), however, the limited adoption of such advances indicates broader systemic barriers to implementation that must be addressed through comprehensive system redesign (29,34).There are clear messages around long-established analgesic strategies from non-MCS practice that can and should be used in MCS settings – these include the generous use of opioids that have proven safe, ketamine as an increasingly viable first option, and early field use of regional anaesthesia.. Khayata and Bourque (21) highlighted significant implementation barriers, including equipment availability and provider training requirements. This tension between potential benefits and practical limitations suggests these techniques might be better positioned as targeted interventions for specific scenarios where resources and expertise allow, rather than as standard protocol elements.

Documentation gaps were identified across studies, particularly in resource-limited settings, suggesting a need for fundamental changes in how we approach pain assessment in MCSs (19,34). Rather than attempting to implement comprehensive, but impractical pain assessment protocols in MCS, efforts might be better directed toward developing simplified systems that capture essential

information while remaining feasible under extreme conditions. The gaps in standardized protocols for MCS pain management point to a disconnect between emergency medicine knowledge and disaster response frameworks (16). While military experiences demonstrate the feasibility of systematic pain management in austere conditions, the challenge lies in translating these successes to civilian contexts (24).

Resource constraints in mass casualty pain management reflect deeper systemic issues rather than simple shortages. The L'Aquila earthquake experience challenges conventional assumptions by demonstrating that even sophisticated healthcare systems struggle with pain management during MCS (6). Healthcare system sophistication alone does not guarantee effective disaster response, particularly regarding pain management. The evidence indicates that success depends more on having adaptable protocols and simplified operational procedures than on baseline resource levels.

There is a strong relationship between psychological trauma and pain perception in MCS, and integrated physical and psychological approaches, rather than purely pharmacological solutions, may be more effective for pain management in these scenarios (6,20).

The systematic gaps in paediatric pain management preparedness highlight a critical weakness in current disaster response frameworks (25). Rather than viewing this as simply a training deficit, it represents a broader challenge in how healthcare systems adapt specialized care protocols to mass casualty conditions.

These findings point to several key recommendations for improving mass casualty pain management. First, there is a need for simplified protocols that emphasize early analgesic administration, particularly focusing on agents like ketamine that offer favourable risk-benefit profiles in austere conditions (14,27).Second, pain management considerations should be integrated into existing triage systems, addressing the current oversight noted in major incident management frameworks (16). Finally, there is a clear need for standardized documentation tools specifically designed for mass casualty contexts, along with provider training that focuses on rapid pain assessment and management decision-making (25,35).Successful approaches to MCS pain management requires moving beyond traditional frameworks to develop more flexible, integrated systems that can adapt to evolving circumstances while maintaining effectiveness across different resource settings (13,16). This may involve rethinking basic assumptions about healthcare delivery hierarchies, pain management protocols, and the integration of physical and psychological care in disaster response.

4.1 Strengths and Limitations

We performed a rigorous search encompassing both military and civilian experiences of different MCS types, allowing for valuable cross-contextual analysis. This review faces several methodological constraints: predominantly retrospective studies and case series limit evidence strength, while English-language restriction may exclude valuable insights from non-English speaking regions. Publication bias likely favours successful interventions, presenting an optimistic view of pain management strategies. The translation of military findings to civilian settings presents challenges. This scoping review did not include formal quality appraisal or risk of bias assessment of included studies, which may affect the interpretation of findings.

Beyond the limitations of the review methodology, we found a research scarcity on paediatric populations (25) and special patient groups limits the comprehensiveness of recommendations for these populations. The near-absence of paediatric-specific pain management protocols represents a critical vulnerability in MCS response, particularly given children's unique pharmacological needs and communication challenges.These limitations underscore the need for improved research methodologies with standardized documentation practices and consistent outcome measures, while acknowledging the inherent challenges of conducting research in mass casualty settings. This review did not extensively explore ethical dimensions of pain management in MCS, including triage prioritization dilemmas, consent issues in unconscious patients, and cultural factors affecting pain expression and treatment acceptance. These warrant future investigation. This review included a substantial proportion of military-derived evidence (30.4% of studies), which may limit generalizability to civilian contexts where organizational structures, resource availability, and patient demographics differ significantly.

5. Conclusions

Effective pain management options do exist for MCS, yet there are significant barriers to implementation. There is a pressing need to develop and implement standardized, scalable protocols that can adapt to varying resource levels while maintaining clinical effectiveness. Implementation should focus on multimodal and novel analgesia strategies that can be scaled according to resource availability, with protocols prioritizing ketamine as a first-line agent given its demonstrated safety profile and ability to manage multiple patients with minimal monitoring. Resource planning should follow the predictable patterns in analgesic requirements, particularly focusing on extended incident durations where requirements peak several days post-event. Comprehensive provider training programs which emphasizing both pharmacological and practical approaches are needed. Further

research should focus on paediatric pain management and standardized outcome measures, perhaps using military experience as a foundation for civilian MCS response systems.

Dissemination of results

Results of this study were shared with key role players in South African Disaster Response Systems, and will be presented at various conferences.

Author contributions: CRediT

- CM: Conceptualisation, Data curation, Investigation, Methodology, Resources, Software, Visualisation, Writing – original draft. PH: Data curation, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – review and editing.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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Supplementary Material for Article: Summary of Included Studies

Author, Year	Title	Country of MCS	Methods	Incident type	Sample (number patients where applicable)	Analgesic interventions	Key findings
Angeletti C et al., 2012	Pain after Earthquake	Italy	Observational retrospective study	earthquake	958	NSAIDs (diclofenac, ketorolac, nimesulide, ibuprofen, aspirin) Paracetamol Weak opioids Strong opioids Combination therapies Local anaesthetics	1. Pain prevalence was 34.6% among patients attending AMPs 2. 58.8% of pain patients reported severe pain (v-NRS 7-10) 3. Pain syndromes showed a biphasic pattern over the five weeks 4. Multimodal analgesia approach was effective in managing pain 5. Psychological factors significantly influenced pain perception 6. Shortage of strong opioids was a major limitation in pain management 7. Use of v-NRS as a vital parameter improved pain assessment and management,
Baker DJ, et al., 2007	Multiple Casualty Incidents: The Prehospital Role of the Anesthesiologist in Europe	France	Narrative review			Morphine, mixed opioids, nonopioids, regional anesthesia, general anesthesia	1. Anesthesiologists play a crucial role in prehospital care during MCSs in some European countries, particularly France 2. The French SAMU system integrates anesthesiologists into prehospital emergency medical services 3. On-site stabilization, including advanced airway management and anesthesia, can be beneficial in certain MCS 4. Recent terrorist attacks in Europe have highlighted the value of on-site medical teams that include anesthesiologists 5. Coordinated emergency response plans (e.g., French 'red' and 'white' plans) are crucial for effective management of MCSs
Bebarta VS, et al., 2020	Prehospital Use of Ketamine in the Combat Setting: A Sub-Analysis of Patients With Head Injuries Evaluated in the Prospective Life Saving Intervention Study	Afghanistan	observational cohort study	combat	160	Ketamine Other analgesics No analgesics	1. Combat casualties with suspected TBI who received prehospital ketamine had similar outcomes to those who received other analgesics or no analgesics 2. Ketamine group had more severe injuries but similar vital signs at admission and disposition at discharge 3. No significant differences in mortality, ICU days, ventilator days, or hospital days between groups 4. Prehospital use of ketamine appears safe in patients with suspected TBI 5. Ketamine may be considered as an analgesic option in MCS involving TBI
Black IH, McManus J, 2009	Pain Management in Current Combat Operations	general	Review article	combat		Opioids NSAIDs (meloxicam) Acetaminophen Ketamine Regional anesthesia techniques Multimodal analgesia approaches	1. Early pain management at the point of injury is crucial 2. Multimodal analgesia approaches are effective in combat settings 3. Novel analgesic delivery methods (e.g., OTFC) can be useful in austere environments 4. Regional anesthesia techniques are valuable for pain management in combat casualties 5. Ketamine is emerging as an important analgesic option in combat settings 6. Balancing pain relief with maintained cognitive function is important in combat scenarios 7. Ongoing research is focused on developing new analgesic options for battlefield use
Carenzo L, et al., 2022	Pre-hospital oral transmucosal fentanyl citrate for trauma analgesia	United Kingdom	Retrospective cohort study	trauma MCS		Oral transmucosal fentanyl citrate (OTFC) lozenge	1. OTFC is an effective and safe analgesic option for pre-hospital trauma care 2. It can be administered rapidly without need for IV access 3. Useful for both penetrating and blunt trauma patients 4. Lower dose (400 µg) may offer improved safety profile compared to military settings 5. OTFC could be a valuable tool in mass casualty incidents where rapid analgesia is needed

de Valence T, Suppan L, 2023	Time to Reconsider Analgesia in Mass Casualty Incidents	general	Narrative review			OTFC, sublingual sufentanil, inhaled methoxyflurane, ketamine	Argues for early analgesia in all types of MCSs
El Sayed M, et al., 2016	Description of Medication Administration by Emergency Medical Services during Mass-casualty Incidents in the United States	United States	Retrospective cross-sectional study	prehospital	26	opioids, ketamine, ketorolac, nitrous oxide, regional	1. 26.9% of MCS activations had at least one medication administered 2. Oxygen was the most common medication (16.3% of activations) 3. Analgesics (mainly narcotics) were administered in 3.2% of activations 4. Medication administration rates varied significantly by EMS service level 5. Air Medical Transport had the highest rate of medication administration (58.9% of activations) 6. Types of medications used reflect focus on trauma management and limited on-scene interventions 7. Findings can help EMS agencies plan medication stockpiles for MCSs 8. Fentanyl was the most commonly administered analgesic, followed by morphine sulfate 9. Narcotic pain medications were administered in 3.2% of MCS activations, ranking as the fourth most common medication group after oxygen, crystalloids, and 'unknown' 10. Air Medical Transport activations had the highest rate of pain medication administration (31.1% for narcotics) 11. Ketamine was reported as a sedative, used in 0.3% of all medications and less than 0.1% of MCS activations 12. Regional anesthesia techniques (nerve blocks) were reported as being used, but specific types and frequencies were not provided
Gebhard RE, et al., 2020	Anesthesia and Pain Management in Field Hospitals	United States	Book Chapter	field hospitals		Inhalation anesthesia Total Intravenous Anesthesia (TIVA) Regional anesthesia techniques Ketamine Opioids Multimodal analgesia	1. TIVA and regional anesthesia techniques are preferred in austere environments due to their portability and effectiveness 2. Ketamine is a valuable agent for both analgesia and anesthesia in field hospitals 3. Multimodal analgesia approaches can provide effective pain management while minimizing side effects 4. Adapting to limited resources and environmental challenges is crucial for successful anesthesia and pain management in field hospitals 5. The choice of anaesthetic technique should consider the patient's condition, available resources, and provider expertise
Gerhardt RT, et al., 2016	Analysis of Prehospital Documentation of Injury-Related Pain Assessment and Analgesic Administration on the Contemporary Battlefield	combat various	Retrospective cohort study	combat	8,913	opioids Ketorolac	1. Only 15% of casualties had documented prehospital analgesic administration 2. Only 7% had documented prehospital pain assessment 3. 56% had documented pain assessment upon hospital arrival 4. 5% had both prehospital and hospital pain assessments documented 5. Time-series analysis showed modest improvements in documentation over time 6. Prehospital pain assessment, management, and documentation remain primary targets for performance improvement 7. Expansion of the prehospital battlefield analgesic formulary is recommended
Guetti C., et al., 2013	Pain and Natural Disaster	general	Opinion Piece	earthquake		Opioids, Nonopioid compounds	1. Healthcare providers are often unprepared to adequately treat acute pain in disaster settings 2. Opioids are frequently unavailable or in short supply during natural disasters 3. There is a lack of guidelines for pain management in MCSs 4. Inadequate pain treatment can lead to long-term physical and psychological consequences 5. The relationship between stress and pain in disaster settings creates a potential vicious cycle 6. There is a need for better training of medical and nursing staff in disaster pain management 7. Pain should be considered a priority in disaster response, not just a secondary concern
Khayata I, Bourque J, 2012	Mobile anesthesia: Ready, set, pack, and go	general	Review article			Inhalation anesthesia. Total Intravenous Anesthesia (TIVA). Regional anesthesia. Ketamine-based anesthesia.	1. TIVA and regional anesthesia techniques are preferred in austere environments due to their portability and effectiveness 2. Ketamine is a valuable agent for both analgesia and anesthesia in field hospitals 3. Multimodal analgesia approaches can provide effective pain management while minimizing side effects 4. Adapting to limited resources and environmental challenges is crucial for successful anesthesia and pain management in field hospitals 5. The choice of anaesthetic technique should consider the patient's condition, available resources, and provider expertise

							6. Anesthesia configured medic bags can be used to contain essential supplies in a portable manner 7. Field Forward Surgical Teams (FSTs) provide a model for organizing mobile surgical and anesthesia capabilities
Kim SY, et al., 2022	The Newest Battlefield Opioid, Sublingual Sufentanil: A Proposal to Refine Opioid Usage in the U.S. Military	general	Review article	combat		Sublingual Sufentanil Tablets (SSTs, Dsuvia). Opioids	1. SSTs offer potential advantages over previous battlefield opioids in terms of ease of administration and safety profile 2. The sublingual delivery system may be particularly beneficial in austere environments or MCS 3. SSTs may reduce overall opioid use and the risk of addiction compared to IV opioids 4. Further research is needed to fully evaluate the effectiveness and safety of SSTs in battlefield and mass casualty settings 5. Proper protocols and controls are necessary to prevent misuse and ensure appropriate administration
Leazer ST, et al., 2020	Analgesic use in contemporary burn practice: Applications to burn mass casualty incident planning	United States	Retrospective cohort study	burns	141	Opioids acetaminophen Adjuncts	1. Opioid requirements peaked at day 8 post-burn with an average of 52.5 mg MED 2. TBSA positively correlated with opioid requirements (1.5 unit increase in MED per 1% TBSA) 3. Age negatively correlated with opioid requirements (0.5 unit decrease in MED per year of age) 4. Multimodal analgesia approach was commonly used, including non-opioid analgesics and adjunct medications 5. Study provides a basis for estimating opioid needs in burn MCSs
Lewis P, et al., 2018	Opioid analgesia on the battlefield: a retrospective review of data from Operation HERRICK	Afghanistan	Retrospective case control study	combat	5,801	opioids	1. Opioid analgesia was administered safely to 5,801 casualties with a very low complication rate 2. Morphine and fentanyl were the primary analgesics used, with various routes of administration 3. Intranasal fentanyl was found to be effective and well-tolerated, especially in paediatric patients 4. The study supports the safety and efficacy of opioid analgesia in challenging, high-stress environments 5. Results suggest the need for multiple analgesic options in MCS
Mace SE, Bern AI, 2007	Needs assessment: are Disaster Medical Assistance Teams up for the challenge of a paediatric disaster?	United States	Survey-based needs assessment	disaster teams	38		Significant deficiencies in paediatric-specific curriculum (16-45% missing topics). Substantial gaps in paediatric equipment (16-62% missing items). Only 63% included paediatric patients in disaster drills. Only 33% had paediatric protocols beyond triage. 74.2% of DMAT physicians were emergency medicine specialists. 35.1% were paediatric emergency medicine specialists.
Missair A, et al., 2010	Surgery under Extreme Conditions in the Aftermath of the 2010 Haiti Earthquake: The Importance of Regional Anesthesia	Haiti	Descriptive study	earthquake	>1000	Regional , ketamine, Local anaesthetics, general anesthesia	Regional anesthesia crucial in resource-limited MCS settings; allows multiple simultaneous surgeries
Mulvey JM, et al., 2006	Earthquake Injuries and the Use of Ketamine for Surgical Procedures: The Kashmir Experience	Pakistan	Descriptive study	earthquake	149	ketamine	1. Ketamine anesthesia was safe and effective in this mass casualty setting 2. 78.4% of patients had upper or lower limb injuries 3. 50.3% of patients had fractures, mainly closed 4. Vomiting occurred in 3.3% of patients, mainly in children under 5 5. No patients experienced hallucinations 6. Up to five patients could be anesthetized simultaneously 7. The technique allowed for surgery without oxygen or advanced monitoring 8. The authors recommend encouraging ketamine use in disaster area surgery, particularly in under-resourced settings
Murshed H,et al., 2014	Mass Casualty in A Building Collapse: Techniques of	Bangladesh	Descriptive study	building collapse	155	Total Intravenous Anesthesia (TIVA) with ketamine,	Ketamine and regional techniques maximized resource use; up to 5 patients managed simultaneously. Successful management of a large number of

	Anaesthesia in Mass Casualty Management					Regional , General anesthesia (rarely used)	casualties with limited resources and personnel. Minimal use of general anesthesia due to resource constraints
Schauer SG, et al., 2017	Prehospital Interventions During Mass-Casualty Events in Afghanistan: A Case Analysis	Afghanistan	Retrospective cohort study	combat	50	Oral transmucosal fentanyl citrate (OTFC), ketamine, opioids, acetaminophen	1. Tourniquet placement (19.6%) and pressure dressings (18.8%) were the most common interventions 2. Pain medication administration (15.2%) was the third most common intervention 3. OTFC was the most commonly used analgesic 4. Explosives were the most common cause of injuries 5. 97% of patients with available discharge data survived 6. Interventions differed significantly from civilian mass casualty events (e.g., less IV fluid administration, no spinal immobilization) 7. Alternative routes of administration (intranasal, oral transmucosal) were utilized for analgesia 8. Ketamine was used effectively for pain management 9. Pain management was a significant component of prehospital care in mass-casualty events
Lippert SC, et al., 2013	Pain Control in Disaster Settings: A Role for Ultrasound-Guided Nerve Blocks	general	Narrative review			Ultrasound-guided nerve blocks, Multimodal approach including opioids, NSAIDs, N-methyl-D-aspartate receptor antagonists	1. Ultrasound-guided nerve blocks offer effective regional pain control without systemic effects 2. Emergency physicians can be rapidly trained in these techniques 3. Blocks can provide 4-14 hours of pain relief 4. Technique is particularly valuable in resource-limited settings 5. Serves as a viable alternative to opioid-based pain management
Vijayaraghavan R, 2020	Autoinjector device for rapid administration of drugs and antidotes in emergency situations and in mass casualty management	general	Review article			opioid, ketamine	1. Autoinjectors provide rapid and effective drug delivery in emergency situations 2. Various analgesic medications can be administered via autoinjectors, including opioids and ketamine 3. Autoinjectors allow for self-administration, which can be crucial in mass casualty events 4. The effectiveness of drug delivery via autoinjectors is comparable to intravenous administration 5. Autoinjectors have shown good safety profiles in various studies 6. The use of autoinjectors can significantly increase the number of patients treated in MCS 7. Proper training and protocols are necessary for the effective use of autoinjectors in emergency situations
Wedmore IS, Butler FK Jr, 2017	Battlefield Analgesia in Tactical Combat Casualty Care	general	Narrative review			opioid, ketamine	TCCC approach adaptable to civilian scenarios; early analgesia crucial. Authors suggest approach is suitable for wilderness medicine; potential for other MCS

Appendices

1. Proposal as submitted to HREC

UNIVERSITY OF CAPE TOWN

NAME:	**Christopher Vivian Morris**
STUDENT NUMBER:	**MRRCHR024**
SUBMISSION:	**Research Proposal**
PROGRAMME:	**MPhil Emergency Medicine**
COURSE:	**Minor Dissertation (FCE16060W)**
TITLE:	**Prehospital Pain Management in Mass Casualty Scenarios: A Scoping Review**
WORDS:	**2574**

I, Christopher Morris, declare that this proposal is based on original work (except where indicated).

I hereby declare the following:

1. I am aware that plagiarism (the use of another's work without their permission and/or without acknowledging the original source) is wrong.
2. I know plagiarism is a serious form of academic dishonesty.
3. I have used the Vancouver convention for citation and referencing. Each contribution to, and quotation in, this proposal from the work(s) of other people has been attributed and has been cited and referenced.
4. Any section taken from an internet source has been referenced to that source.
5. Where I have used the exact words of others, I have indicated this using quotation marks (i.e.,"") followed by the reference number and the page number where the quotation came from.
6. This proposal is my own work and is in my own words (except where I have attributed it to others).

7. I have not and shall not allow anyone to copy my work with the intention of passing it off as her or his own work.
8. I acknowledge that copying someone else's assignment or essay, or part of it, is wrong, and declare that this is my own work.

Name and Surname: Christopher Morris Date: 08 April 2024

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Introduction to the Study

Prehospital pain management is a critical aspect of emergency medical services (EMS) care, particularly in mass casualty scenarios (MCS). Effective pain management can improve patient outcomes and reduce the risk of long-term complications. However, there is a lack of consensus on the best practices for prehospital pain management in MCS. This scoping review aims to identify and synthesize the available literature on prehospital pain management in
MCS. The review will follow the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines to ensure a comprehensive and transparent search process. The findings of this review will inform the development of evidence-based guidelines for prehospital pain management in MCS and contribute to improving patient outcomes in emergency medical care.

Background

MCS are intuitively difficult to predict and there are numerous limitations regarding medical research at the time of incidents like this (to compare different types of interventions), we are thus left to review data retrospectively, in this case, through a scoping review. There is a gap in the knowledge when it comes to understanding pain management in emergent situations, specifically during MCS (1). Pain management is only referenced around seven times in the Major Incident Medical Management and Support manual (2). Due to prolonged rescue and evacuation times, extreme traumatic injuries and other compounding factors it may be difficult to control a patient's pain adequately (3). It must be kept in mind that inadequate pain management is inhumane and may increase mortality and morbidity(4).

There are a wide variety of possible mechanisms for mass casualty scenarios, from mass gatherings to man-made disasters, natural disasters and infectious disease outbreaks (5–7). Man-made disasters may encompass events such as terrorist attacks and explosions to chemical spills, each of which may present a differing pain profile that requires attention on the clinical level and an understanding of the pathophysiological process that may occur in the presenting patients (8). Specifically, explosions may result in massive musculoskeletal and visceral pain, requiring different pain management strategies to burns (6,7). Mass gatherings may result in stampedes and the resultant crushing, musculoskeletal trauma and fractures would also necessitate an alternative approach to analgesia when dealing with multiple patients (9). Natural disasters would also differ in terms of mechanism, although there is a commonality between the various mechanisms such burns due to fire and musculoskeletal, crush injuries due to earthquakes or landslides (7). Pain due to infectious diseases present an entirely different modality of analgesic considerations, a consideration in this instance could be opioid based (10).

There is a gap in the knowledge when it comes to understanding pain management in emergent situations, specifically during MCS (1). With practitioners frequently failing to reach anything near therapeutic dosage levels (1). The introduction of affordable mobile ultrasound units onto the market and onto the clinical practice guidelines for paramedic level qualifications and above could facilitate newer and better pathways to multimodal analgesia. Ultrasound guided peripheral nerve blocks are frequently utilized in emergency departments due their relative speed and ease to perform (11). There is no reason why such procedures should not be performed by adequately trained and competent prehospital emergency care providers. With immediate relief from acute pain

in the prehospital environment there should also be a decrease in long term effects of pain (12). There are no systematic algorithms for pain management, let alone for pain management in an MCS (12). There are also no valid or up to date modern guidelines that deal with the specific treatment of pain in MCSs.

All healthcare providers that provide a first responder type function in disasters should be systematically trained to deal with the issue of pain during disasters (13). The similarities between MCS and combat theatres should not be overlooked as both become austere environments due inadequate supplies, lack of equipment and limitations on qualified prehospital personnel, additionally, pain is one of the most frequent conditions for which military operators seek medical treatment (3).

Research Question

What are the current prehospital pain management practices for mass casualty patients, both locally and internationally?

Objectives

The objectives for this proposed study are as follows:

1. to summarise and describe the existing body of published literature on prehospital pain management strategies implemented in mass casualty scenarios (MCS); and
2. to identify gaps in knowledge and guide future research directions and policy development in this critical area.

These objectives are designed to provide a comprehensive understanding of the current evidence on prehospital pain management in MCS, informing best practices and guiding future research and policy development in this area. The scoping review will follow the PRISMA-ScR guidelines.

Methodology

A scoping review can be a valuable tool for understanding the current state of knowledge and identifying gaps in research on prehospital pain management in MCS. This process was chosen to explore prehospital pain management in MCS because it will:

1. provide a comprehensive overview of the existing literature in prehospital pain management in MCS and offer a broad understanding of the current landscape of research;
2. identify knowledge gaps and expose areas where further research is needed to improve pain management in these critical situations;
3. offer a comprehensive picture of the various strategies and considerations for pain management in mass casualties gained from different approaches and perspectives;
4. inform future research and practice by providing valuable insights for researchers and healthcare professionals to guide the development of evidence-based protocols and best practices; and
5. allow for a relatively quick and efficient research timeframe as scoping reviews are typically completed in a shorter time frame compared to systematic reviews, thus allowing for timely dissemination of findings.

However, it is important to be aware of the limitations and consider the need for further research to draw definitive conclusions about the most effective pain management strategies in these complex situations.

The limitations of a scoping review for prehospital pain management in MCS, include the following:

- limitations to assess the effectiveness of interventions as scoping reviews do not assess the quality or effectiveness of individual studies, making it difficult to draw definitive conclusions about the best pain management practices;
- MCS can involve diverse patient populations and settings, leading to variability in study designs and methodologies, which can be challenging to synthesise;
- scoping reviews prioritise mapping the existing research rather than providing a critical appraisal of individual studies, limiting the ability to assess the overall quality of the evidence; and
- similar to any research method, scoping reviews can be susceptible to bias in the selection of studies and interpretation of findings.

- Only English literature will be included.

This scoping review will follow the PRISMA-ScR guidelines which includes 20 essential reporting items and two optional items to ensure that the review is transparent and reproducible, and conducts a systematic search of relevant databases. A search strategy has been developed using keywords for Scopus and Ebsco searches with the assistance of the university's librarian. The search will be limited to English-language articles published from 2010 onwards.

Inclusion criteria

1. Studies that focus on prehospital pain management in MCS.
2. Studies that report on pain assessment, pharmacological treatment adherence, or the effectiveness of pain relief therapy in mass casualty incidents.
3. Studies that are published in English and are available in full-text format.

Exclusion criteria

The exclusion criteria will be:

1. Studies that focus on hospital-based pain management.
2. Studies that do not report on pain management in MCS.
3. Studies that are not published in English or are not available in full-text format.

The data extraction and charting process will be conducted using a standardized data extraction form, and the results will be synthesized using descriptive statistics and narrative summaries.

Sources

Data sources will include electronic databases such as Primo, MEDLINE via PubMed, and other recognised journals. Additionally, a search of grey literature such as lectures, conference proceedings,

blogs, podcasts, and institutional websites would also be appropriate. Data sources such as titles, abstracts and full-text documents need to be screened with the full text documents requiring analysis.

Search strategies

The sampling strategy would be to conduct a comprehensive search of electronic databases such as MEDLINE via PubMed, Primo and recognised journals, and including grey literature such as conference proceedings and lectures or presentations to identify all relevant literature due to the limited availability of data on the subject. Additional databases to be included are as follows:

1. PubMed (https://pubmed.ncbi.nlm.nih.gov/)
2. MEDLINE (https://medlineplus.gov/)
3. EMBASE (https://www.elsevier.com/products/embase)
4. CINAHL([EBSCO Information Services cinahl com]) : CINAHL is a database of nursing and allied health literature. It is a good resource for finding research on emergency nursing and other aspects of prehospital care.
5. Cochrane Database of Systematic Reviews (https://www.cochranelibrary.com/) This is a good resource for finding high-quality evidence on the effectiveness of different treatments for emergency medicine conditions.

Inclusion of the above databases will extend the resource base and maximise search results.

Grey literature databases such as MedNar, OpenSIGLE, NTIS and WorldWideScience.org may also be accessed and searched.

A two-stage screening process with clear inclusion and exclusion criteria will be employed to identify relevant articles for this scoping review.

Stage 1: Title and Abstract Screening

1. Duplicate Removal: All retrieved citations will be uploaded to reference management software (e.g., Mendeley, EndNote) to identify and remove duplicates.

2. Independent Review: Two reviewers will independently screen titles and abstracts of all remaining citations based on pre-defined inclusion and exclusion criteria (outlined below). Discrepancies will be resolved through discussion or by consulting a third reviewer.

Inclusion and exclusion criteria

Studies focusing on prehospital pain management interventions in MCS.

- Studies including any type of research design (e.g., randomized controlled trials, observational studies, case reports, etc.).
- Studies published in English in the past (however many years, adjust timeframe as needed).

Exclusion Criteria

- Studies solely focused on definitive pre-hospital care or pain management after patient transport.

- Studies on non-human subjects (e.g., animal studies).
- Reviews, editorials, letters, and conference abstracts (unless full text provides relevant data).
- will be clearly defined based on keywords and index terms and a combination of both to ensure that the relevant literature is identified, and nothing is missed.

Stage 2: Full-Text Review

1. Full-Text Retrieval: Full text will be retrieved for all articles deemed potentially relevant based on the title and abstract screening.

2. Full-Text Assessment: Both reviewers will independently assess the full text of retrieved articles against the same inclusion and exclusion criteria used in stage 1. Discrepancies will be resolved as described above.

A preliminary search strategy has been developed, showcased in Appendix 1.

Data Extraction

Once the final set of articles is identified, a standardised data extraction form will be used to collect relevant information from each study, such as:

- Study design
- MCS type
- Pain management interventions used
- Outcomes measured (e.g., pain scores, patient satisfaction, medication used) • Key findings

This data will be used to map the existing literature on prehospital pain management in MCS and achieve the research objectives of the scoping review.

Data analysis

For a scoping review the data analysis plan is known as data extraction or “charting the data” with an aim to create a descriptive summary of the results that address this scoping review’s objective and answers the research question. The type of data will be information based on the research question.

The extracted data from included articles will undergo descriptive content analysis to identify major topics through an “inductive-dominant approach”(14). This analysis will involve carefully reviewing the data to identify recurring themes, concepts, and patterns. The researcher will work to code the data and reach consensus on the key findings with the supervisor (14).

An inductive-dominant approach to data analysis is ideal for scoping reviews due to its exploratory nature, flexibility, and ability to handle diverse data types. It allows themes and patterns to emerge directly from the data, providing a comprehensive understanding and accommodating the breadth of information typically found in scoping reviews. This method supports theory development and aligns well with the iterative process of integrating new information as the review progresses, making it well-suited for identifying key concepts and research gaps.

Due to this scoping review being performed by a single researcher, it may not be possible to ensure consistency and rigor in the data analysis process by double-coding a subset of articles (14). Any potential bias or errors in the analysis that emerge will be minimized by discussion between the supervisor and the principal investigator (14).

Reporting Results

The results of the descriptive content analysis will be reported in a discussion format, with a supporting summary table (14). This approach will allow for a rich, narrative description of the key findings while also providing a concise tabular summary of the included studies and their characteristics (14).

The findings will be organized and presented in relation to the research question and sub questions (14). This will ensure that the results are directly relevant to the objectives of the scoping review and provide a clear and coherent answer to the overarching research question.

The discussion will highlight the types of literature that exist concerning prehospital pain management in MCS's, the key findings from these studies, and any notable knowledge gaps or limitations in the current body of evidence. This will help to identify areas for future research and inform the development of strategies for integrating pain management in MCS's.

Editor's services

An editor's services will be retained to ensure the submission is free from language errors and of an acceptable standard prior to submission. The costs of the editor will be covered by the candidate and an editor's certificate will be provided prior to submission.

Data management

Data will be stored in a secure cloud location and backup on multiple external solid state storage devices; major versions will be emailed to the candidate's cloud email address as additional backup and storage in case of data loss or corruption.

Ethical considerations

The researcher will seek exemption from UCT's Ethics Committee as this is a scoping review of existing literature and does not involve the collection of data from human subjects, it is not required to obtain ethics committee clearance. The focus of the research is solely on analysing and synthesising published studies and therefore does not raise any ethical concerns related to participant safety, privacy, or informed consent.

However, the researcher will disclose any potential conflicts of interest that might bias the study's findings or influence its objectives. Ethical considerations will also extend to accurate representation and interpretation of findings. A balanced and transparent presentation of the findings is essential to maintain ethical integrity.

Budget

ITEM	COST

Proposal	Nil (IT based)
Ethics Approval	Nil (University of Cape Town)
Study Design	Nil (IT based)
Methodology	Nil (IT based/Data)
Data analysis	Nil (Self, IT based)
Editors certificate	R0.25/word – estimated 5000 words = R1250
Stationary	R1500
Assorted/misc. costs	R500
TOTAL	**R3250**

Costs shall be met by the student.

Timeline

PHASE	**TIMELINE/PROGRESS**	**PROJECTED DATES**
Proposal fine tuning with supervisor	Resubmission	June 2024
Ethics Approval	To gain exemption	July 2024
Study Design	Completed	April 2024
Methodology Implementation	6 weeks	July/August 2024
Data analysis – Write up and design	12 weeks	September-November 2024
Study submission	4 weeks	December 2024
Total	6 months	

Conclusion

This scoping review will provide a systematic overview of the current evidence on prehospital pain management in MCS, informing best practices and guiding future research and policy development in this area. The results will also help to identify knowledge gaps and inform the development of educational programs and training materials for healthcare providers.

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APPENDIX:

Search Strategies

Scopus:

- (TITLE-ABS-KEY (("mass casualty" OR "mass casualties"))) AND (TITLE-ABS-KEY (("pain control" OR "pain management")))
- TITLE-ABS-KEY (("pain control" OR "pain management"))
- TITLE-ABS-KEY (("mass casualty" OR "mass casualties"))

Ebsco:

	Christopher – Ebsco – 25 Aug 2023			
S3	S1 AND S2	http://ezproxy.uct.ac.za/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=awn&db=cin20&db=cmedm&db=psyh&bquery=((%26quot%3bpain+control%26quot%3b+OR+%26quot%3bpain+management%26quot%3b))+AND+((%26quot%3bmass+casualty%26quot%3b+OR+%26quot%3bmass+casualties%26quot%3b))&type=0&searchMode=Standard&site=ehost-live	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - Africa-Wide Information;CINAHL;MEDLINE;APA PsycInfo	21
S2	("mass casualty" OR "mass casualties")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - Africa-Wide Information;CINAHL;MEDLINE;APA PsycInfo	8,106

S1	("pain control" OR "pain management")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	Interface - EBSCOhost Research Databases Search Screen - Basic Search Database - Africa-Wide Information;CINAHL;MEDLINE;APA PsycInfo	165,134

Updated Search Strategies

An updated search using Google Scholar was performed on the 8th April 2024, this yielded 1580 results using the search string: "pain management" and "mass casualty". A number of new papers have been added to the literature from 2022 and 2023; this increases the feasibility of the scoping review. Additional search terms laid out below will improve the yield on usable literature. As per revision, updated search terms will include:

Strategy 1: Comprehensive Search Including All Mass Casualty Scenarios

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion))

Strategy 2: Pharmacological Pain Management Across Scenarios

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND (analgesics OR opioids OR NSAIDs OR "local anesthetics" OR "pain medications"))

Strategy 3: Non-Pharmacological Interventions Across Scenarios

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND ("non-pharmacological" OR "psychological support" OR "physical therapy" OR "multimodal analgesia"))

Strategy 4: Prehospital and Emergency Medical Response

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND ("prehospital care" OR "emergency medical services" OR "EMS" OR "first responders" OR "paramedics" OR "field hospitals"))

Strategy 5: Military and Field Medicine

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND ("military medicine" OR "field medicine" OR "combat casualty care"))

Strategy 6: Specific Populations in Mass Casualty Scenarios

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND (adults OR children OR "vulnerable populations"))

Database-Specific Search Strategy Adaptations PubMed/MEDLINE

("Pain Management"[Mesh] OR "Analgesia"[Mesh] OR "Analgesics"[Mesh]) AND ("Disasters"[Mesh] OR "Mass Casualty Incidents"[Mesh] OR "Emergency Medicine"[Mesh] OR "Building Collapse"[Mesh] OR "Fires"[Mesh] OR "Earthquakes"[Mesh] OR "Transportation Accidents"[Mesh] OR "Terrorism"[Mesh] OR "Explosions"[Mesh])

CINAHL

("Pain Management" OR "Pain Relief" OR "Analgesia" OR "Analgesics") AND ("Disasters" OR "Mass Casualty Incidents" OR "Emergency Response" OR "Building Collapse" OR "Fires" OR "Earthquakes" OR "Bus Accidents" OR "Train Accidents" OR "Aviation Accidents" OR "Terrorist Attacks" OR "Explosions")

Scopus

TITLE-ABS-KEY("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND TITLE-ABS-KEY("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion)

Grey Literature and Additional Sources Google Scholar

"Pain management" AND ("mass casualty" OR disaster OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion)

Organizational Reports and Guidelines

- Search websites and repositories of organizations such as WHO, FEMA, Red Cross, and others using similar combinations of the above search terms.

Boolean Logic Variations

1. Use **AND** to combine major concepts.
2. Use **OR** to include synonyms and related terms.
3. Use **NOT** to exclude irrelevant results (e.g., "NOT animal" to exclude animal studies).

Example Combining Boolean Logic

(("Pain management" OR "pain relief" OR analgesia OR "pain control" OR "pain treatment") AND ("mass casualty incident" OR "mass casualty event" OR disaster OR "major incident" OR emergency OR catastrophe OR "multiple casualties" OR "building collapse" OR fire OR earthquake OR "natural disaster" OR "bus accident" OR "train accident" OR "aviation accident" OR "terrorist attack" OR explosion) AND ("prehospital care" OR "emergency medical services" OR "EMS" OR "first responders" OR "paramedics" OR "field hospitals")) NOT ("animal study")

PubMed/MEDLINE

Justification:

1. **Comprehensive Coverage:** PubMed/MEDLINE is a premier database for biomedical literature, covering a wide range of medical disciplines including emergency medicine, pain management, and disaster response.
2. **High-Quality Sources:** It includes peer-reviewed articles from reputable journals, ensuring access to high-quality and clinically relevant research.
3. **MeSH Terms:** The use of Medical Subject Headings (MeSH) allows for precise and consistent search results, enhancing the retrieval of relevant studies.
4. **Extensive Reach:** Widely used by researchers, clinicians, and healthcare professionals, making it a crucial resource for any medical literature review.

Scopus

Justification:

1. **Broad Multidisciplinary Coverage:** Scopus covers a vast array of disciplines including medicine, health sciences, social sciences, and more, providing a comprehensive view of research related to MCS and pain management.
2. **Citation Tracking:** It offers advanced citation tracking and analysis tools, allowing for assessment of the impact and relevance of studies.
3. **Extensive Abstract and Indexing:** Scopus indexes not only journal articles but also conference papers, books, and patents, providing a broader spectrum of information.

Web of Science Justification:

1. **High-Quality Content:** Web of Science includes high-impact journals and peer reviewed conference proceedings, ensuring access to rigorous and well-regarded research.
2. **Multidisciplinary Database:** It covers multiple disciplines including science, social science, and humanities, which is beneficial for exploring the broader impacts of mass casualty incidents and pain management.
3. **Citation Analysis Tools:** Similar to Scopus, Web of Science provides robust tools for citation analysis, helping to identify key studies and emerging trends.

CINAHL (Cumulative Index to Nursing and Allied Health Literature) Justification:

1. **Specialized Coverage:** CINAHL is focused on nursing and allied health literature, which is essential for understanding the practical aspects of pain management in prehospital and emergency settings.
2. **Relevance to Practice:** It includes studies on clinical practices, patient care, and health services research, which are directly relevant to managing pain in MCS.
3. **Diverse Content Types:** The database includes a variety of content such as research articles, evidence-based care sheets, and continuing education modules, providing comprehensive coverage of clinical and practical information.

Cochrane Library Justification:

1. **Evidence-Based Focus:** The Cochrane Library is renowned for its systematic reviews and meta-analyses, which provide high-level evidence on the effectiveness of interventions, including pain management strategies.
2. **High-Quality Reviews:** Cochrane Reviews are rigorously conducted and peer reviewed, ensuring reliability and relevance in clinical decision-making.
3. **Healthcare Impact:** It focuses on evidence that can directly impact healthcare practices and policies, making it crucial for developing guidelines and protocols in MCS.

Google Scholar Justification:

1. **Broad Accessibility:** Google Scholar indexes a wide range of scholarly articles, theses, books, conference papers, and patents across various disciplines, including grey literature that might not be available in other databases.
2. **Comprehensive Search:** It provides a broad search capability that includes diverse sources of information, helping to capture less formal research and reports that are still relevant to the topic.
3. **User-Friendly Interface:** Google Scholar's simple and intuitive interface allows for easy access and retrieval of a wide range of documents.

Grey Literature and Organizational Reports Justification:

1. **Practical Insights:** Grey literature such as reports, guidelines, and conference proceedings from organizations like WHO, FEMA, and the Red Cross provide practical insights and real-world data that are often not found in peer-reviewed journals.
2. **Policy and Guidelines:** These sources often include current policies, guidelines, and recommendations that are crucial for understanding and improving pain management in MCS.
3. **Comprehensive View:** Including grey literature ensures a more comprehensive view of the available evidence and practices, capturing information that is critical for implementation and policymaking.

2. HREC Waiver

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

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29 July 2024

HREC/REF: 589/2024

A/Prof Peter Hodkinson
Emergency Medicine
F51Old Main Building

Email: peter.hodkinson@uct.ac.za
Email: MRRCHR024@myuct.ac.za

Dear Prof Hodkinson

PROJECT TITLE: PREHOSPITAL PAIN MANGEMENT IN MASS CASUALTY SCENARIOS (MPHIL CANDIDATE MR CHRIS MORRIS)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

The HREC confirms that the above-mentioned proposed study is a scoping review.

As the scoping review involves published literature available through publicly accessible electronic databases, research ethics review and approval is not required.

This is in accordance with Section 1.1.8 of the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015), which states: *"Research that relies exclusively on publicly available information or accessible through legislation or regulation usually need not undergo formal ethics review. This does not mean that ethical considerations are irrelevant to the research."*

The HREC acknowledges that MPHIL Candidate, Mr Chris Morris is also involved in this scoping project.

Yours sincerely,

PROFESSOR MARC BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE