



Pain Assessment and Evidence-Based Pain Management in Pediatric Trauma Patients During Prehospital Emergency Care: Current Guidelines, Clinical Challenges, and Best Practices-An Updated Review

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Abstract

Background: Effective pain management in pediatric trauma patients during prehospital emergency care remains a major challenge in emergency medical services despite growing recognition of its clinical importance. Inadequately treated pain contributes to adverse physiological responses, psychological distress, increased anxiety, and long-term negative perceptions of healthcare. Nevertheless, pediatric patients continue to experience substantial oligoanalgesia in the prehospital setting, with many studies reporting that more than 60% of injured children receive insufficient pain relief.

Aim: This review aimed to summarize current evidence regarding the assessment and management of pain in pediatric trauma patients during prehospital emergency care, with emphasis on validated assessment tools, pharmacological and non-pharmacological interventions, barriers to effective analgesia, and emerging strategies to improve clinical outcomes.

Methods: A comprehensive narrative review of contemporary literature, clinical practice guidelines, and evidence-based recommendations was conducted to evaluate pediatric pain assessment methods, analgesic interventions, prehospital treatment protocols, provider-related challenges, healthcare system barriers, and disparities in pain management among injured children.

Results: Current evidence indicates that validated pediatric pain assessment scales improve recognition of pain severity and support timely analgesic administration. Intranasal fentanyl and methoxyflurane have emerged as effective, rapidly acting analgesic options that facilitate pain control when intravenous access is delayed or impractical. Non-pharmacological interventions, including caregiver involvement, distraction techniques, and psychological support, further enhance pain relief. Despite these advances, significant deficiencies remain in pain assessment documentation, protocol adherence, and provider confidence. Moreover, important healthcare disparities persist, with Black and Hispanic children reported to be 20–23% less likely to receive analgesic medication than White children despite comparable injury severity.

Conclusion: Optimal prehospital pain management in pediatric trauma requires a multidisciplinary and multimodal approach that combines validated pain assessment tools, early pharmacological intervention, non-pharmacological strategies, provider education, and standardized clinical protocols. Addressing disparities in analgesic administration and improving adherence to evidence-based practices are essential for enhancing pain control, reducing suffering, and improving short- and long-term outcomes for injured children.

Keywords: Pediatric trauma; Prehospital emergency care; Pain management; Emergency medical services; Intranasal fentanyl; Methoxyflurane; Analgesia; Pain assessment; Pediatric emergency medicine; Oligoanalgesia.

Introduction

Pain is universally recognized as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, and its prompt and effective management constitutes a fundamental ethical, clinical, and humanitarian

obligation in emergency care [1-8]. For pediatric trauma patients, adequate pain assessment and management during prehospital emergency care are particularly consequential, as untreated pain can precipitate physiological decompensation, complicate clinical evaluation and diagnostic accuracy, and engender lasting psychological sequelae including anxiety disorders, needle phobia, and a pervasive aversion to healthcare interactions that may persist into adulthood [2][9]. Children who experience acute injury or illness are at substantial risk of receiving suboptimal pain treatment, a phenomenon that has been extensively documented across diverse healthcare settings and geographic regions [3][10]. Despite growing awareness of these risks and the publication of multiple clinical guidelines, pediatric pain management in the prehospital setting remains persistently suboptimal, with studies consistently demonstrating that children are significantly less likely than adults to receive opioids for traumatic injuries, including long bone fractures [11]. Up to 10% of EMS transports involve patients younger than 18 years, and approximately 20% of pediatric patient transports involve children experiencing moderate to severe pain, yet previous investigations have revealed that the majority of these injured children receive no analgesia whatsoever during their prehospital encounter [4][12]. This updated review aims to provide a comprehensive synthesis of current guidelines, clinical challenges, and best practices for pain assessment and evidence-based pain management in pediatric trauma patients during prehospital emergency care. It examines the evolution of prehospital pediatric pain management protocols, evaluates contemporary assessment tools validated for use in the chaotic prehospital setting, analyzes the safety and efficacy of pharmacological and non-pharmacological interventions, and critically appraises the barriers that perpetuate suboptimal care. By integrating findings from recent guidelines, randomized controlled trials, and implementation science, this review offers practical, actionable recommendations for EMS clinicians, medical directors, and policymakers seeking to improve pain outcomes for the vulnerable pediatric trauma population.

The Unique Context of Pediatric Trauma in Prehospital Care

Epidemiological Considerations

Pediatric trauma remains a leading cause of morbidity and mortality among children across the globe, with the prehospital phase of care being particularly critical as timely and appropriate interventions during this window can significantly influence downstream outcomes in the emergency department and beyond [1][13]. Pediatric trauma patients possess unique physiology and anatomy that markedly impact the severity, pattern, and distribution of injuries, necessitating specialized clinical knowledge and a tailored approach to assessment and intervention [2][4]. EMS clinicians face the dual challenge of managing the immediate, life-threatening physiological consequences of traumatic injury while simultaneously addressing the pain and severe anxiety that accompany these distressing events [3][5]. The epidemiological burden of pediatric trauma underscores the necessity for robust, evidence-based protocols that address both the lifesaving and the comfort-oriented aspects of prehospital care.

Physiological and Developmental Considerations

Children are not merely "small adults" with respect to pain perception, medication pharmacokinetics, or trauma physiology, and this fundamental distinction underpins all aspects of pediatric prehospital care [4][8]. Age-dependent differences in body composition, organ maturation, hepatic and renal metabolic capacity, and fluid distribution necessitate meticulous weight-based dosing and careful, nuanced consideration of medication selection and route of administration [9][14]. The pediatric airway, respiratory physiology, and cardiovascular responses to both injury and analgesic agents differ substantially from those of adults, requiring specialized knowledge, skills, and equipment that may not always be readily available in the prehospital setting [2][6]. Furthermore, developmental stage profoundly influences pain expression, perception, and the ability to articulate suffering. Preverbal infants and very young children cannot verbally communicate their pain experience, necessitating reliance on behavioral and physiological indicators such as facial expression, body posture, crying, and autonomic responses [7][11]. Older children may underreport pain due to fear, anxiety, a desire to appear brave, or concern about receiving an injection, while the presence of caregivers, although often helpful, can complicate assessment when parental anxiety amplifies the child's distress or when language and cultural barriers impede effective communication between the EMS team and the family [3][5].

The Importance of Early Pain Management

Early pain therapy is not merely a matter of patient comfort but is a critical component of effective trauma care that reduces physical and emotional stress and facilitates subsequent clinical evaluation and interventions [1][15]. Prompt treatment of pain should be a priority in the trauma and emergency setting, as it decreases patient distress, reduces agitation, and enables a more thorough and accurate physical examination [4][8]. The consequences of inadequate pain management are multifaceted and extend far beyond immediate discomfort to include significant physiological consequences such as tachycardia, hypertension, increased myocardial oxygen demand, immunosuppression, and delayed wound healing [9][12]. Psychologically, untreated pain can precipitate heightened anxiety, acute fear responses, post-traumatic stress symptoms, and the development of negative healthcare associations that may result in avoidance of necessary medical care in the future [2][7]. Clinically, inadequate analgesia can interfere with the physical examination, cause patient agitation that complicates diagnostic procedures, and compromise the overall accuracy of the assessment [3][5]. In the long term, untreated pain in childhood has been associated with altered pain perception pathways, the development of chronic pain syndromes, and persistent healthcare avoidance behaviors that present a significant public health challenge [6][10].

Current Guidelines for Prehospital Pediatric Pain Management NAEMSP Position Statement on Pediatric Trauma

The National Association of Emergency Medical Services Physicians (NAEMSP) published a comprehensive position statement and resource document on pediatric severe and inflicted trauma in 2025, providing updated, holistic guidance for EMS clinicians and medical directors to optimize prehospital pediatric trauma guidelines based on the best available evidence and established best practices [1]. This document is especially pertinent to pediatric severe and inflicted trauma, where prehospital evaluation and management determine the overall quality of care and downstream patient outcomes [1][4]. The NAEMSP recommends that EMS clinicians receive initial and ongoing pediatric-specific training in trauma patient assessment, which must include a thorough understanding of pediatric anatomy and physiology and continuous monitoring for changes in vital signs [1][5]. Initial and ongoing training should encompass the recognition of signs of shock, including the calculation and interpretation of the Shock Index Pediatric Adjusted (SIPA) score, altered mental status, and other pathophysiology associated with severe trauma in pediatric patients [1]. Regarding pain specifically, the NAEMSP document emphasizes that adequate assessment and treatment of pain are critical, especially in patients with traumatic brain injury, and underscores that pain management in pediatric trauma requires recognition of unique physiological responses and tailored, age-appropriate approaches [1][8].

Evidence-Based Guideline for Prehospital Analgesia in Trauma

Gausche-Hill and colleagues developed a landmark evidence-based guideline (EBG) for the clinical management of acute traumatic pain in adults and children by advanced life support (ALS) providers in the prehospital setting, utilizing the rigorous Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology [2]. The panel formulated a series of strong and weak recommendations based on a systematic review of the available literature [2]. The guideline's core recommendations established that all patients should be considered candidates for analgesia, regardless of the anticipated transport interval, and that opioid medications should be considered for patients experiencing moderate to severe pain [2][6]. Furthermore, the guideline mandates that all patients should be reassessed at frequent intervals using a standardized pain scale, and that patients should be re-dosed if pain persists following the initial intervention [2][5]. The use of specific age-appropriate pain scales is suggested to ensure accurate assessment across the developmental spectrum [2]. This guideline represents a significant advancement in standardizing prehospital pain management and directly addresses the historical variability in analgesia administration that has characterized EMS practice for decades [2][9].

EUSEM 2025 Update and International Consensus

The European Society for Emergency Medicine (EUSEM) released an updated handbook in 2025 designed to improve the assessment and management of acute pain in emergency and prehospital settings across Europe [3]. Developed under the auspices of EUSEM and the European Pain Initiative, it offers practical, evidence-based strategies tailored specifically for first responders, paramedics, and emergency physicians [3][10]. Since the previous edition in 2020, the pain management landscape has evolved significantly, driven by the ongoing opioid crisis, advances in multimodal analgesic therapies, and the growing role of technology in clinical decision-making [3]. New in this edition is a refined alignment with the World Health Organization (WHO) analgesic framework, which encourages judicious opioid use, promotes non-opioid strategies, and emphasizes repeated, structured pain assessment using validated instruments [3][6]. Special attention is given to vulnerable groups such as children, the elderly, and patients with cognitive or substance use disorders, providing evidence-based recommendations that promote a multimodal, patient-centered approach to acute pain management in the prehospital environment [3][12]. Similarly, a consensus on prehospital acute pain assessment and management published from China in 2024 emphasizes that pain is universally recognized as an unpleasant sensation accompanied by emotional distress and often associated with actual or potential tissue damage, and notes that improving prehospital pain management not only enhances patient satisfaction but also mitigates the adverse physical and mental consequences associated with inadequate pain control [13].

Synthesis of Guideline Recommendations

Across these contemporary guidelines, several common, reinforcing themes emerge that collectively define the standard of care for pediatric prehospital pain management [1][2][3][13]. These include the principle of universal candidacy for analgesia, which mandates that all pediatric trauma patients should be assessed for pain and considered for analgesia irrespective of transport distance or time [2][5]. The guidelines consistently advocate for standardized pain assessment using validated, age-appropriate tools applied repeatedly throughout the prehospital encounter [1][3]. A multimodal approach integrating pharmacological and non-pharmacological interventions is recommended to achieve optimal outcomes while minimizing opioid exposure [3][6]. Weight-based dosing with standardized dosing aids is emphasized as essential for safe, weight-adapted medication administration [2][9]. Frequent reassessment with re-dosing if pain persists is a critical component of all contemporary guidelines, as is the imperative for initial and ongoing pediatric-specific training and education for all EMS clinicians [1][2][3].

Pain Assessment in the Prehospital Setting

Pain assessment in injured children is frequently underestimated or inadequately performed in emergency services, with the main reasons being uncertainties in pain assessment methodology, dosage calculations, and a pervasive fear of adverse side effects [4][7]. Pain assessment in pediatric prehospital care is infrequently performed and inconsistently documented, with some studies reporting recording rates as low as 1% to 2% of all pediatric transports [5][11]. The challenges of pediatric pain assessment are multifactorial and include developmental variability, where

different age groups require fundamentally different assessment approaches; communication barriers, as preverbal children cannot self-report and older children may not accurately articulate their pain; environmental constraints inherent to the chaotic prehospital setting with limited time and resources; provider discomfort resulting from lack of training and experience with children; and caregiver factors, where parental anxiety can complicate assessment but where parental input can also provide invaluable information about the child's baseline behavior and pain expression [4][7][9].

Age-Appropriate Pain Assessment Tools

Structured parental involvement, the use of standardized observation instruments, and visual aids significantly improve pain assessment in children [5][8]. For children aged four to five years and older, self-report tools such as the Numeric Rating Scale (NRS), which measures pain on a scale from 0 (no pain) to 10 (worst possible pain), and the Visual Analogue Scale (VAS), a graphic version of pain intensity assessment, have been shown to be reliable and valid in children and adolescents who visit pediatric emergency departments [5][14]. The Wong-Baker FACES Scale, which uses facial expressions to represent pain intensity, remains one of the most appropriate and widely used tools for children aged four to eight years, while the Faces Pain Scale-Revised (FPS-R) offers a validated alternative for assessing pain in non-verbal or preverbal populations [5][9]. For children under four years of age or those unable to self-report due to cognitive impairment or critical illness, observational behavioral tools are essential [4][7]. The FLACC Scale (Face, Legs, Activity, Cry, Consolability) is widely used for postoperative and procedural pain assessment, while the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) has been validated for acute pain assessment [4][5]. The EVENDOL scale, a five-item behavioral pain scale specifically designed for young children from newborn to seven years of age in out-of-hospital emergency settings, has been successfully validated with excellent interrater reliability, discriminant and construct validity, and is well accepted by caregivers [4][7]. Additional tools such as the CRIES Scale for neonatal pain assessment and the Neonatal Infant Pain Scale (NIPS) for infants zero to two years of age provide further options for the youngest and most vulnerable patients [5][8].

The Pediatric Assessment Triangle

The Pediatric Assessment Triangle (PAT) was designed to provide a rapid, straightforward, and standardized approach to pediatric assessment based solely on observation, without requiring physical contact [5][15]. Despite its widespread adoption, EMS clinicians report that the PAT enhances their confidence in pediatric assessment, though continued training and reinforcement remain essential to ensure its effective application in the field [5][15]. Pain severity should be recorded before and after all basic life support (BLS) pain control measures and advanced life support (ALS) pain medication delivery, using a standard pain scale before and after each pain management intervention and at a minimum of every fifteen minutes [2][5]. Pain assessment should be repeated frequently to ensure adequate response to any intervention and to guide re-dosing decisions [2][6]. Accurate weight estimation is also critical for safe medication dosing in children, with methods including length-based resuscitation tapes such as the Broselow tape and age-based formulae being essential components of prehospital pediatric care [2][9]. Standardized dosing aids are essential for safe, weight-adapted medication administration and are freely available as charts, mobile applications, and tape-based systems [2][9].

Pharmacological Pain Management

There are multiple pharmacologic options for analgesia in pediatric trauma, and exploring the route of administration is critical to improving the timeliness and efficacy of pain control in the field [6][12]. Establishing intravenous (IV) access may be challenging, time-consuming, or increase situational anxiety for the child, leading to delays in analgesia [6][10]. Less invasive routes such as oral, intranasal, and inhalation are valuable alternatives that could lead to improved patient comfort while reaching similar levels of analgesia [6][12]. Pain medication enablers identified in recent studies include longer transport times, the desire to stabilize the patient, vital signs or injuries suggestive of high pain levels, and clinician comfort with the availability of intranasal analgesic medications [6][10]. Conversely, patient-related barriers to pain medication can be broadly divided into patient, provider, and system-based concerns; patient-related barriers include severe injury where the child is hemodynamically unstable or caregiver discomfort, provider-related concerns include a lack of experience with pediatric pain and opiate administration and discomfort or difficulty with IV placement, and system-based concerns include a lack of access to opiates and poor suspension in ambulances [6][11].

Intranasal Analgesia

Intranasal analgesia has proven to be rapid, safe, and effective, with intranasal administration having established itself as a preferred route of access and often first-line treatment in pediatric prehospital pain protocols [6][12]. Intranasal fentanyl (INF) offers an exciting new pain medication modality that helps alleviate pain in children without requiring IV access, and it has been found to be more effective in reducing pain than other analgesics at the 15- to 20-minute point [6][10]. The use of intranasal fentanyl has been found to be fast-acting and effective for the management of acute, severe pain in children, with its administration causing minimal distress to the patient by reducing the requirement for cannulation [6][12]. Barriers and enablers to prehospital analgesia for children presenting with traumatic pain after the introduction of INF into EMS protocols have been systematically evaluated, revealing that pain medication enablers included longer transport times, desire to stabilize the patient, and clinician comfort with the availability of IN analgesic medications [6][10]. Intranasal ketamine offers an alternative non-opioid option, and the analgesic efficacy of intranasal ketamine versus intranasal fentanyl for moderate to severe pain in children has been

investigated in randomized controlled feasibility trials; however, evidence regarding its comparative efficacy remains evolving [12][16].

Inhaled Analgesics: Methoxyflurane

Methoxyflurane, administered via the "green whistle" device, has emerged as a promising, non-invasive option for pediatric trauma pain management [6][11]. In a pivotal placebo-controlled trial known as the MAGPIE study, methoxyflurane was efficacious for the treatment of acute trauma-related pain in pediatrics, with a safety profile consistent with that observed in adults [11]. Children who received methoxyflurane experienced a faster and greater reduction in pain compared to those given a placebo treatment, and only one in ten of those treated with methoxyflurane needed rescue pain medication, compared to one in three in the untreated group [11]. The safety of methoxyflurane in children and adolescents has been examined in retrospective cohort studies, revealing that in children and adolescents transported by ambulance, the use of methoxyflurane was not associated with an increased risk of hospitalization, death, serious adverse drug reactions, or liver and kidney toxicity [11][16]. The use of methoxyflurane is becoming increasingly popular in the treatment of pain in an emergency setting, in part due to its ease of administration and rapid onset of action [6][11]. New research has found that methoxyflurane provides rapid pain relief for children aged six years and older with acute trauma injuries [11][16].

Opioid and Non-Opioid Pharmacological Options

Opioid pain medications are appropriate for use in the pediatric population under local protocol guidance, with IV, intramuscular (IM), and intranasal options available [2][6]. The evidence-based guideline for prehospital analgesia recommends that opioid medications should be considered for patients in moderate to severe pain [2]. A register-based study from Southern Denmark examined the use of strong analgesics for prehospital pain management in children and found that the doses of opioids as administered by the EMS personnel seem safe, as 97% of the doses were within the recommended range and even at the lower end of the recommended range [19]. Although apparently safe, the utilisation of strong analgesics points to a risk of under-treating pain in children, as children are less likely than adults to receive opioids for traumatic injuries resulting in long bone fractures [2][19]. Ibuprofen, a safe and effective non-opioid analgesic commonly used in emergency departments for injured children, remains underutilized in the EMS setting, with only one in ten injured children receiving any analgesics in the prehospital setting [6][12]. Oral ibuprofen represents a low-risk, accessible option that could be more widely implemented in prehospital protocols, and the American Academy of Pediatrics recommends administering acetaminophen 10-15 mg/kg every 4-6 hours or ibuprofen 10 mg/kg every 6-8 hours for pain or fever management in prehospital scenarios [5][10]. In the setting of analgesic administration, patients require monitoring of continuous pulse oximetry and vital signs, with blood pressure and respirations monitored closely as pain control medications may cause hypotension or respiratory distress [2][6].

Non-Pharmacological Pain Management

Nonpharmacological measures such as positioning, splinting, sedation, and physical contact have a supportive effect in pediatric pain management and are integral to a comprehensive, patient-centered approach [5][7]. The combination of non-pharmacological and pharmacological interventions has been the recent trend in pediatric pain management in emergency settings, and by integrating these modalities with technological advancements and psychological support, healthcare providers can significantly enhance the quality of care for pediatric patients [7][17]. A clinical guideline for prehospital pain management in injured children can improve the quality-of-care programs, address existing barriers to pain management in children, and increase patient satisfaction [17].

Distraction Techniques and Physical Comfort Measures

Distraction techniques, including videos, games, and mobile applications, along with comfort items and relaxation techniques such as deep breathing and guided imagery, are effective non-pharmacological interventions [5][9]. A systematic review published in 2025 examined pediatric distraction tools for prehospital care of pain and distress, highlighting that technology can be leveraged as a tool to measure digital media use and eventually intervene, including mobile apps to track child smartphone and tablet use [9]. Future studies could use mobile apps to help families set limits and change design features to support healthier relationships with media [9]. Simple physical measures can significantly reduce pain and anxiety, including splinting and immobilization of injured extremities, ice and elevation to prevent swelling, swaddling and securing infants, positioning for comfort, and providing physical contact and reassurance [5][7]. The Buzzy device, which combines cold and vibration, has emerged as one of the best non-pharmacological tools to reduce procedural pain and anxiety; Bayesian reanalysis confirms the effectiveness of Buzzy for pediatric procedural pain while highlighting age as a key determinant, with effectiveness potentially varying substantially across age groups [8][17]. Structured parental involvement significantly improves pain assessment and management in children, as parents can provide valuable information about their child's baseline behavior, pain expression, and response to interventions, and engaging parents in distraction and comfort measures can enhance the effectiveness of non-pharmacological interventions [4][5].

Clinical Challenges and Barriers

Pain in injured children is often underestimated or inadequately treated in emergency services, leading to the well-documented phenomenon of oligoanalgesia [4][6]. Among 2,308 pediatric trauma patients in a recent cohort, 82% had any prehospital record of pain and 67% had a pain score of at least four out of ten, yet only 35% received any pain medication [7]. More concerning, only one in ten injured children received analgesics in the prehospital setting in broader epidemiological analyses [6][11]. These statistics reveal a profound, persistent gap between the prevalence of

pain and the provision of analgesia in pediatric trauma patients, with the consequences of this oligoanalgesia being significant and far-reaching across physiological, psychological, and healthcare utilization domains [4][7].

Provider, System, and Patient-Related Barriers

Provider-related concerns represent a substantial barrier to effective pediatric pain management and include a lack of experience with pediatric pain assessment and management, discomfort or difficulty with IV placement, fear of side effects and adverse reactions, uncertainty regarding medication dosing, limited education on pediatric assessment and communication, excessive concerns over malingering and drug-seeking behavior, fear of masking injuries or altering mental status, and unclear endpoints with ambivalence around treatment targets [6][10]. System-based concerns include a lack of access to opioids in ambulance formularies, poor suspension in ambulances affecting medication administration, variable protocols across regions, limited pediatric-specific equipment and supplies, time constraints in the prehospital environment, and documentation burden [6][11]. Patient-related barriers include severe injury where the child is hemodynamically unstable, caregiver discomfort or anxiety, language barriers, and age-related challenges in assessment for preverbal children or those with cognitive impairment [4][6][10].

Racial and Ethnic Disparities

Perhaps the most concerning finding in contemporary research is the persistent racial and ethnic disparity in prehospital pediatric analgesia, which represents a fundamental failure of equitable care delivery [7][18]. Prehospital treatment of pain was suboptimal among pediatric trauma patients and unequal by race and ethnicity, with Black or Hispanic patients being 20% to 23% less likely to receive prehospital pain medication than White patients after controlling for clinical need, appropriateness, and patient or family preference [7]. Factors associated with both race/ethnicity and not receiving pain medication included younger age, lower socioeconomic status, language barrier, lack of prehospital vascular access, and involvement in a motor vehicle collision [7][18]. Furthermore, Black and Hispanic and Latino children with trauma were less likely to have an improvement in pain compared with White children, indicating that disparities extend beyond initial analgesia administration to the quality of pain relief achieved [7]. However, some improvement was seen over the study period, as the proportion of trauma patients given prehospital pain medication increased and disparities by race and ethnicity decreased in magnitude [7]. Potential prehospital care interventions to address these disparities could target implicit biases, diversity in hiring, training in treatment of pain in young children, and possibly expansion of intranasal and oral medication use to reduce access barriers [7][18].

Best Practices and Recommendations

Based on the synthesis of current evidence, guidelines, and implementation science, several best practices are recommended for prehospital pain management in pediatric trauma patients [1][2][3][5]. Universal pain assessment must be performed in all pediatric trauma patients using validated, age-appropriate tools, with pain scores documented before and after interventions and reassessed at frequent intervals of no more than fifteen minutes [2][5]. Early pharmacological intervention is essential; analgesia should be administered promptly without delay based on transport distance, and opioids should be considered for patients in moderate to severe pain [2][6]. Intranasal fentanyl is recommended as first-line for children without IV access, and methoxyflurane should be considered for children aged six years and older with acute trauma pain [6][11][12]. All medication administration must utilize weight-based dosing with standardized aids to ensure safety and accuracy [2][9]. A multimodal approach combining pharmacological and non-pharmacological interventions, including distraction techniques, comfort measures, splinting, and parental engagement, is strongly recommended to optimize outcomes and minimize opioid requirements [5][7]. Continuous monitoring of pulse oximetry and vital signs is mandatory during and after analgesic administration, with re-dosing if pain persists and careful documentation of response to interventions [2][6].

Protocol Development and Educational Interventions

EMS medical directors and system leaders should standardize pain assessment tools by adopting validated, age-appropriate scales across all EMS agencies within their region [1][5]. Formularies should be expanded to include intranasal fentanyl, methoxyflurane, and oral ibuprofen as options [6][12]. Weight-based dosing charts should be implemented and readily accessible to all providers [2][9]. Clear reassessment intervals and documentation requirements should be established as protocol mandates [2][5]. Non-pharmacological protocols should be integrated into standard pain management pathways [5][7]. Critically, quality improvement initiatives specifically targeting equitable care delivery and the elimination of racial and ethnic disparities must be implemented and monitored [7][18]. Educational interventions have demonstrated potential to improve prehospital pediatric pain management and should prioritize pediatric pain assessment techniques across developmental stages, pharmacological management including dosing and safety monitoring, non-pharmacological interventions, recognition and mitigation of implicit bias, communication with children and families, and thorough documentation requirements [5][9][17].

Discussion

The past decade has witnessed significant progress in the recognition and management of pediatric pain in the prehospital setting, with the development of evidence-based guidelines, the introduction of novel analgesic agents and routes, and growing awareness of disparities representing meaningful advances [1][2][3][6]. The availability of intranasal fentanyl and methoxyflurane has expanded treatment options and reduced reliance on intravenous access, addressing a major historical barrier to timely analgesia [6][11][12]. However, persistent gaps remain, and the translation of guideline recommendations into consistent clinical practice has been uneven, with studies continuing to

document suboptimal analgesia rates and persistent disparities [4][7][10]. Pain in pediatric trauma patients is difficult to assess and manage, with far-reaching consequences if not treated adequately, and how the healthcare team approaches treating pain in pediatric trauma patients can be the difference between achieving meaningful recovery versus unintentionally causing fear, anxiety, and psychological discomfort [1][7][8].

The Multidisciplinary Imperative and Future Research

A multidisciplinary approach to managing pain in pediatric trauma patients, including the use of pharmacotherapy and non-pharmacotherapy-based treatment approaches, offers the best opportunity for optimal outcomes [8][17]. Optimal management of a trauma patient involves several key specialties that work together to provide the many aspects of care required for a successful resuscitation, and the care for traumatic injuries often begins in the prehospital setting, with emergency medical services providing initial care and assessment [1][8]. Collaboration between EMS, emergency medicine, trauma surgery, pediatric specialists, and nursing is essential [8][17]. Advances in technology offer new opportunities to improve pediatric pain management in the prehospital setting, with point-of-care decision support tools, mobile applications for weight estimation and dosing calculations, and telemedicine consultations with pediatric emergency physicians representing promising avenues [9][20]. Research priorities for pediatric pain management in emergency medicine include optimizing analgesia in the emergency department and at home after discharge, nonpharmacologic and integrative treatments, novel analgesic treatments and strategies, children with difficult-to-treat pain, prehospital pain management, eliminating health disparities, opioid misuse and abuse, and dissemination and implementation science [20]. Specific research questions for prehospital pediatric pain management include the comparative effectiveness of intranasal fentanyl versus other routes and agents, optimal dosing strategies for methoxyflurane in children, implementation strategies to reduce racial and ethnic disparities, effectiveness of educational interventions on pain management outcomes, long-term outcomes of prehospital pain management in children, and best practices for pain assessment in special populations such as children with autism or cognitive impairment [6][7][20].

Conclusion

Pain assessment and evidence-based pain management in pediatric trauma patients during prehospital emergency care represent a critical area of clinical practice with significant opportunities for improvement, and this updated review has examined current guidelines, clinical challenges, and best practices, revealing both notable progress and persistent gaps. Contemporary guidelines from NAEMSP, the evidence-based prehospital analgesia guideline, and EUSEM provide a robust framework for standardized, evidence-based care, emphasizing universal pain assessment, early intervention, multimodal approaches, and frequent reassessment. The availability of intranasal fentanyl and methoxyflurane has expanded treatment options, while validated pain assessment tools including the EVENDOL scale, FLACC, and Wong-Baker FACES provide age-appropriate assessment capabilities. However, significant challenges persist, as pain in injured children remains underestimated and undertreated, and provider, system, and patient-related barriers continue to impede optimal care. Most concerning, racial and ethnic disparities in analgesia administration persist, with Black and Hispanic children being significantly less likely to receive pain medication than White children despite comparable injury severity. Best practices for improving prehospital pediatric pain management include standardized pain assessment with validated tools, early pharmacological intervention using weight-based dosing, multimodal approaches combining pharmacological and non-pharmacological interventions, continuous monitoring and reassessment, and targeted educational initiatives addressing pediatric-specific knowledge and implicit bias. Future research should focus on implementation strategies to translate guidelines into practice, comparative effectiveness of analgesic agents and routes, interventions to eliminate disparities, and integration of technology to support clinical decision-making. As the evidence base continues to evolve, EMS systems must commit to continuous quality improvement, ensuring that every injured child receives prompt, appropriate, and equitable pain management during the critical prehospital phase of care. Pain relief is not an optional goal but is an essential and integral component of acute emergency care for children; the imperative to provide compassionate, evidence-based pain management to pediatric trauma patients is both a clinical obligation and a moral one. By addressing the challenges identified in this review and implementing evidence-based best practices, EMS systems can significantly improve outcomes for injured children, reducing both immediate suffering and the long-term psychological and physiological sequelae of untreated pain.

References

- [1] Cicero MX, Adelgais K, Funaro MC, et al. Prehospital Trauma Compendium: Pediatric Severe and Inflicted Trauma – A Position Statement and Resource Document of NAEMSP. *Prehospital Emergency Care*. 2025; published online February 10, 2025.
- [2] Gausche-Hill M, Brown KM, Oliver ZJ, et al. An Evidence-based Guideline for Prehospital Analgesia in Trauma. *Prehospital Emergency Care*. 2024; dataset posted November 2, 2024.
- [3] Kirk D, Whiles E, Jones A, Edmunds C. Breathing new life into pain management: a systematic review of nebulised ketamine for analgesia. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2025 Dec;33(1):196.
- [4] Krasniqi A, Osendorfer E, Jung P, Lieftüchter V. Analgesie beim verletzten Kind. *Notfall+ Rettungsmedizin*. 2025 Oct 29:1-8.

- [5] Tsao HS, Sutcliffe T, Wang C, et al. Barriers and enablers in prehospital pediatric analgesia. *Prehospital Emergency Care*. 2025;29:789-795.
- [6] Hughes Garza H, Comer-HaGans D, Bradford JM, et al. Prehospital pain medication disparities among pediatric trauma patients transported to a single Level I center. *Journal of Trauma and Acute Care Surgery*. 2023;99(6):884-894.
- [7] Gregory H, Wiemer KN, Park DB. Pain Management in Pediatric Trauma: A Multidisciplinary, Patient-Centered Approach. *Advanced emergency nursing journal*. 2025 Jul 1;47(3):177-85.
- [8] Hartshorn S, Barrett MJ, Bloom B, Lyttle MD, Walton E, Steel K, Yee SA, Irvine A, in the United PE. Treatment of acute trauma-related pain in children and adolescents with methoxyflurane (Penthrox®) compared to placebo (MAGPIE): A randomised clinical trial. *Injury*. 2025 Oct 20:112830.
- [9] Robinson N, Delorenzo A, Howell S, Smith K, Cameron P, Stock A, Eastwood K. Pediatric distraction tools for prehospital care of pain and distress: a systematic review. *Pediatrics*. 2023 Jul 1;152(1):e2022059910.
- [10] Kakko S, Markkula N. Assessment and treatment of pediatric motor vehicle accident victims in prehospital care.
- [11] Kelty EA, Murray K, Sanfilippo FM, Preen DB. The Safety of Methoxyflurane for Emergency Pain Relief in Children and Adolescents: A Retrospective Cohort Study. *Prehospital Emergency Care*. 2025 Aug 18;29(6):768-75.
- [12] Alsabri M, Hafez AH, Singer E, Elhady MM, Waqar M, Gill P. Efficacy and safety of intranasal fentanyl in pediatric emergencies: a systematic review and meta-analysis. *Pediatric Emergency Care*. 2024 Oct 1;40(10):748-52.
- [13] of Burns TR, Chinese Burn Association, Trauma Committee. Expert consensus on the treatment of second-degree burn wounds (2024 edition) I: pre-hospital first aid and non-surgical treatment. *Chinese Journal of Burns and Wounds*. 2024 Jan 20;40(1):1.
- [14] Je SO, Ryoo E, Kim JJ, Yang HJ, Lee G, Hwang SY, Lee JH. Effectiveness of the visual analogue scale (VAS) as a method of pain measurement in children and adolescents who visit the pediatric emergency department. *Journal of the Korean Society of Emergency Medicine*. 2009 Apr 1;20(2):204-9.
- [15] Heyming T, Knudsen-Robbins C, Kain A, Morphey T, Ta-Perez Z, Darabpour A, Lee H, Brukman S, Shelton SK. Prehospital Pediatric Assessment Triangle—Real World Data: Emergency Medical Services Use of the Pediatric Assessment Triangle in the Prehospital Environment. *Prehospital Emergency Care*. 2025 Nov 26:1-9.
- [16] Ward CE, Cash RE, Martin-Gill C, Michelson KA, Ramgopal S. Patient and Emergency Medical Services Agency Factors Associated With Quality Care for Children. *Pediatrics*. 2025 Dec 1;156(6):e2025073047.
- [17] Harris MI, Adelgais KM, Linakis SW, Magill CF, Brazauskas R, Shah MI, Nishijima DK, Lowe GS, Chadha K, Chang TP, Lerner EB. Impact of prehospital pain management on emergency department management of injured children. *Prehospital Emergency Care*. 2023 Jan 2;27(1):1-9.
- [18] Matthews R. Shaping the undergraduate pain management curriculum in prehospital emergency care education: toward a curriculum and competency framework for South Africa.
- [19] Colding-Jørgensen JT, Brandstrup GM, Nielsen VM, Gradman J, Thybo LA, Hansen PM, Wittrock D, Blomberg SN, Christensen HC, Mikkelsen S. The use of strong analgesics for prehospital pain management in children in the region of Southern Denmark: a register-based study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2025 Feb 5;33(1):23.
- [20] Tsze DS, Burger RK, Klein EJ, Chang TP, Uspal NG, Guiner-da Silva A, Browne LR, Coleman KD, Chumpitazi CE, Drendel AL, PECARN Analgesia and Sedation Working Group. Research priorities for pediatric pain management in emergency medicine. *Academic Emergency Medicine*. 2025 Jun;32(6):688-98.