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Pain management therapies used by non-physician emergency medical services clinicians: a scoping review with implications for education

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Abstract

Background

Pain is a common reason for emergency medical services (EMS) utilisation, and effective pain management is a core responsibility of EMS clinicians. As EMS education increasingly occurs within higher education and clinicians assume broader, more autonomous roles, curriculum development requires an understanding of the therapies, contexts and patient populations represented in the evidence base. This scoping review aimed to map pain management therapies used by non-physician EMS clinicians and identify the operational settings, patient populations and pain types represented in the literature, to inform EMS competency and curriculum development.

Methods

The review was conducted in accordance with JBI methodology and reported according to the PRISMA extension for Scoping Reviews. Searches of MEDLINE (via PubMed), CINAHL, Scopus and Web of Science were conducted without date restrictions. Eligible sources comprised peer-reviewed primary and secondary studies in English reporting pain management therapies administered by non-physician EMS clinicians in prehospital settings. Data were charted and synthesised descriptively. The a priori protocol was registered on the Open Science Framework.

Results

Of 9,082 records identified, 152 evidence sources were included: 108 primary studies and 44 secondary studies published between 1972 and 2025. The evidence encompassed four non-pharmacological therapies, 16 pharmacological therapies, three procedural approaches and two enabling interventions, with research concentrated on opioids, ketamine, nitrous oxide and methoxyflurane. Most evidence originated from high-income countries, particularly the United States, United Kingdom, Australia and Canada, and predominantly concerned adults, acute traumatic pain and ground ambulance operations. Paediatric and older adult populations, obstetric, chronic and palliative pain, and low- and middle-income settings were sparsely represented. Intravenous, intranasal, inhaled and other needle-minimising routes were prominent contextual enablers of pain management.

Conclusions

The evidence on prehospital pain management is broad but unevenly distributed across therapies, populations and settings. The findings indicate that EMS pain management curricula should address not only individual therapies but also pain assessment and reassessment, clinical reasoning, route selection, contextual adaptation, communication, monitoring and multimodal care. This evidence map can inform

competency development, curriculum design and priorities for future clinical and educational research in EMS pain management.

Introduction

Pain is a common presentation to Emergency Medical Services (EMS), with reported prevalence rates ranging from 27.7% to 55% (1–4). Effective pain relief is recognised as a core responsibility of EMS clinicians and an important indicator of service quality (5, 6) (also referred to as paramedics, Emergency Medical Technicians). This responsibility reflects both the harmful physiological and psychological consequences of untreated pain (7) and the broader ethical obligation to reduce suffering. (8) EMS is optimally positioned to manage pain early, and organizational and societal expectations that EMS do so are rational and justified.

Despite its importance, deficiencies in prehospital pain management continue to be reported internationally. (3, 9) These shortcomings have been associated with clinician knowledge, skills and attitudes, as well as operational and organisational factors that influence pain assessment and treatment. (4, 9–13) While multiple factors contribute to pain management performance, education remains an important mechanism through which pain management competencies may be developed and sustained.

The educational context of EMS is also evolving. Over recent decades, paramedicine has undergone substantial professionalisation, although unevenly across jurisdictions. (14–16)

This process has been accompanied by expanding clinical responsibilities, greater practitioner autonomy, formal regulation or registration, and the progressive relocation of education into higher education institutions. (14–16). Collectively, these developments have strengthened the emergence of paramedicine as a distinct discipline with its own educational standards, professional identity and growing research base.

Contemporary EMS roles have also expanded beyond the management of acute injury and illness to include areas such as palliative care (17) and community paramedicine (18). Rising global rates of chronic pain (19, 20) increase the likelihood that EMS clinicians will encounter diverse and complex pain presentations. However, evidence concerning pain management in palliative care and chronic pain by EMS remains limited, with existing research largely describing exposure, service needs and practice gaps rather than informing management strategies, education or capability development (17, 21). Taken together, these developments and gaps underscore the need for deliberate, evidence-informed development of competencies and curricula that are responsive to patient, practitioner and health system needs.

Curriculum-level research suggests that educational programmes may not always fully reflect the profession's evolving scope of practice. (22) For instance a recent study in Australia found that undergraduate paramedicine curricula remained strongly concentrated on emergency response, while

primary healthcare, community engagement, governance and integration with broader health and social services received comparatively less emphasis. These findings suggest that curriculum development must continually adapt to ensure alignment between educational preparation and the changing realities of paramedic practice. (22).

Education, competence and curriculum development thus face a challenge of evidence and implementation. To address this challenge, we undertook a project aimed at developing a competency framework and curriculum implementation recommendations for pain management in emergency medical services education. A preliminary exploration of the literature did not identify published EMS-specific pain management competency frameworks or contemporary EMS-focused pain curricula. Existing EMS-focused educational literature was limited in scope and dated (23, 24). Work on curricula for emergency departments (ED) (25), and The International Association of the Study of Pain (IASP) have also developed competencies and curricula for a number of health professions. (26, 27) None of these were developed for EMS clinicians, and may not adequately reflect the knowledge, skills and attitudinal demands of prehospital practice.

The operational context of EMS clinicians varies across jurisdictions and service models, including ground ambulance response, aeromedical retrieval, interfacility transfer, wilderness rescue and military settings. Pain management within these contexts is influenced by multiple factors relevant across these contexts and is influenced by several characteristics of prehospital care, including the use of non-physician clinicians to make decisions, time-critical assessment and treatment, variable scopes of practice, resource constraints, limited clinical information and the need for rapid analgesia.

Understanding the breadth of pain management therapies used within EMS and the contexts in which they are applied became an essential first step in informing competency and curriculum development. Preliminary searches of JBI Evidence Synthesis and the Cochrane Database of Systematic Reviews did not identify scoping or systematic reviews that holistically mapped the pain therapies applied by EMS clinicians, where the evidence is generated, and the contexts, populations and pain types represented in the evidence base. This represented a gap not only in the clinical literature, but also in educational evidence required to inform curriculum design, competency frameworks, continuing professional development and regulatory decision making.

This scoping review aimed to systematically map pain management therapies used by non-physician EMS clinicians globally, and to identify the clinical contexts, operational settings, patient populations, and pain types in which these therapies are applied. The resulting evidence map was intended to inform EMS competency development, curriculum design, continuing professional education and regulatory decision-making.

Methods

A broad review scope was adopted to capture the diversity of EMS practice. Including all contexts was intended to support transferability of insights across EMS environments, while the absence of date

restrictions allowed therapies to be captured within the evolution of prehospital pain management. This approach aligns with the exploratory intent of scoping reviews.

The methodology developed by JBI (28) was used and reported according to the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 'Extension for Scoping Reviews' (PRISMA-ScR). (29) The *a priori* protocol was developed collaboratively and registered on the Open Science Framework (OSF) (https://osf.io/dfwge/?view_only=2faffbb3705b4986bbfcd72050342c40). There were no documented contestations or enhancements. The review question (What is the evidence for the use and application of pain management therapies by prehospital emergency medical care providers in prehospital emergency care?), was developed using the Population–Concept–Context (PCC) framework.

Eligibility criteria

The search included evidence on pain therapies administered by non-physician EMS clinicians, including specialist prehospital nurses in prehospital settings associated with EMS. Eligible contexts included primary emergency response, interfacility transfers, critical care retrieval, medical and wilderness rescues, and clinic or site-based services in ground and aeromedical operations in both civilian and military environments.

Both peer-reviewed primary and secondary studies published in English were included, without date restrictions. Primary studies included experimental, observational and qualitative designs. Secondary evidence included systematic reviews, scoping reviews, narrative reviews and rapid reviews. Secondary evidence was deliberately included to map existing synthesis and identify evidence consolidation. Because the objective was to map the breadth and distribution of evidence rather than estimate effectiveness, both primary and secondary evidence were included. Studies were excluded if they focused solely on the epidemiology of prehospital pain without exploring EMS clinician involvement. Theses, dissertations, conference posters, and abstracts were also excluded, as well as mixed context studies where prehospital physician generated data could not be separated from EMS clinician data. For studies involving both prehospital and in-hospital phases, only prehospital data was extracted, to prioritize context.

Data were synthesized descriptively using an iterative approach. Charted data were grouped conceptually into categories. These categories formed the structure of the results. Quantitative data were summarized using frequencies and/or proportions and qualitative patterns were synthesized narratively. Per JBI we did not critically appraise the included studies, instead any limitations were described in the discussion (e.g. the exclusion of unstable patients). Ethical aspects of the included studies were not explicitly charted, though all studies were from peer reviewed publications, and we assumed standard ethical oversight.

Search Strategy

A multilevel search strategy was implemented in November 2025 across Medline (via PubMed), CINAHL, Scopus, and Web of Science databases. The search strategies were developed in conjunction with a university information specialist. The PubMed search strategy is presented in Table 1, with the other search strategies in the supplementary material. Reference lists of included evidence were hand-searched for additional records.

Table 1: Pubmed search strings

Pubmed
Pubmed Search 26 November 2025: Pharmacological Therapies. Results = 3304
((((Emergency Medical Technician OR EMT OR Paramedic)) OR ("Emergency Medical Technicians"[Mesh])) OR (((Emergency Medical Service OR EMS OR Ambulance Service OR Ambulance OR Pre-hospital OR Prehospital OR Extended Practice OR Community Paramedicine OR Helicopter Emergency Medical Services OR Aeromedical OR Critical Care Retrieval)) AND ("Emergency Medical Services"[Majr]))) AND (((Pain management OR pain reduction OR analgesic)AND (Drug Therapy OR Opiate OR Opioid OR Morphine OR Fentanyl OR Tramadol OR Ketamine OR Methoxyflurane OR Entonox® OR Nitrous Oxide OR Paracetamol OR Non-steroidal anti-inflammatory drug)) OR ((("Analgesics"[Mesh]) AND ("Analgesics, Non-Narcotic"[Mesh] OR "Analgesics, Opioid"[Mesh] OR "Analgesics, Short-Acting"[Mesh] OR "Pain"[Mesh] OR "Narcotics"[Mesh] OR "Anti-Inflammatory Agents, Non-Steroidal"[Mesh] OR "Analgesia, Obstetrical"[Mesh] OR "Ketamine"[Mesh] OR "Analgesia"[Mesh])) AND ("Pain Management"[Majr]))) Filters: English
Pubmed Search Results 26 November 2025: non-Pharmacological therapies: Results = 431
(((Emergency Service* OR EMS OR Ambulance Service OR Ambulance OR Pre-hospital OR Prehospital) OR (Emergency Medical Technician OR EMT OR Paramedic)) AND ((Pain management OR pain reduction OR analgesi*))) AND ((Nonpharmacological analgesi* OR nonpharmacological pain management OR TENS OR Transcutaneous Electrical Nerve Stimulation OR Acupuncture OR Acupressure OR splint)) Filters: English

Selection of Sources of Evidence

All identified records were imported into Rayyan (30), an open-source web-based knowledge synthesis platform. Two reviewers (RM and MF) independently screened an initial calibration set of 25 articles, refined the approach through comparison and discussion, and then independently screened titles and abstracts. Full-text articles of eligible records were then retrieved and assessed independently. Disagreements were resolved through discussion, with a third reviewer (NN) available for adjudication. The PRISMA-ScR flow diagram (29) summarizes the selection process. Evidence identified through “other means” included reference list screening of included articles.

Data Charting and Extraction

The data charting tool was constructed as an online Microsoft Form (Microsoft LLC) and piloted and refined using the initial calibration articles. Reviewer disagreements were resolved through discussion and alignment with predetermined inclusion/exclusion criteria.

Data Items

Abstracted data included study characteristics (e.g. design, year, country), context (e.g. ground transport/air medical services, military/civilian, primary response/transfer), applied therapies (e.g. medicines and procedures), patient demographics (e.g. age group, pain type, clinical condition), and pain management strategies (dosages, route of administration, effectiveness and adverse events). The full data charting tool is available in the supplementary material.

Results

Selection of sources of evidence

The search and selection process yielded 152 sources (Fig. 1).

[insert Fig. 1 **here]**

Characteristics of sources of evidence

Evidence for pain management interventions and therapies in PEC spanned from 1972 to 2025, with primary evidence (n = 108) predominating, of which 31% (n = 34) were cohort studies, 19% (n = 20) were randomized controlled trials and 21% (n = 23) were analytic cross-sectional studies (Table 2). Secondary evidence (n = 44) was constituted of mostly narrative reviews (43%, n = 19) and systematic reviews (41%, n = 18). The search yielded only three scoping reviews.

Table 2
Evidence type

Primary Studies (N = 108)	
Evidence type	n (%)
Cohort Studies	34 (31)
Randomised Controlled Trials	20 (19)
Analytic Cross-Sectional Studies	23(21)
Descriptive Cross Sectional	10 (9)
Quasi Experimental Studies	8 (7)
Case Series	5 (5)
Case Control Studies	3 (3)
Qualitative Studies	2 (2)
Case Reports	2 (2)
Mixed Method Studies	1 (1)
Secondary Evidence (N = 44)	
Narrative Reviews	19 (43)
Systematic Reviews	18 (41)
Scoping Reviews	3 (7)
Rapid Reviews	2 (5)
Systematic Reviews with Metanalysis	2 (5)

The countries in which primary data was collected are (in descending order): United States of America (USA) (n = 27) (31–57), United Kingdom (UK) (n = 14) (58–71), Australia (n = 12) (72–83), Canada (n = 11) (84–94), Germany (n = 8) (95–102), Austria (n = 6) (103–108), Sweden (n = 6) (109–114), Denmark (n = 3) (115–117), Switzerland (n = 3) (118–120), Iran (n = 2) (121, 122), Czech Republic (n = 2) (123, 124), France (n = 1) (125), Hungary (n = 1) (126), Iraq (n = 1) (127), Ireland (n = 1) (128), Singapore (n = 1) (129) and the Netherlands (n = 1) (130). The military medical systems of the USA and UK contributed 6 studies, conducted in the context of soldiers in combat. (131–136) Two studies were only described as collecting data in “Central Europe” (137, 138), without specifying a country. The geographical distribution of primary studies is shown in Fig. 2. **[insert** Fig. 2 **here]**

Scope of therapies

Therapies were categorized as pharmacological therapies, nonpharmacological therapies, and enabling procedures (Table 3).

Table 3
Scope of therapies by routes of administration and nature of evidence

Nr	Therapy under study †	Primary evidence (n)	Secondary Evidence (n)
NON-PHARMACOLOGICAL THERAPIES			
1	Acupressure/Auricular Acupressure (103, 106, 108, 139–142)	3	4
2	Transcutaneous Electrical Nerve Stimulation (TENS) (104, 126, 137, 138, 140–143)	4	4
3	Warming (107, 142)	1	1
4	Splinting (Traction Splinting/Simple Splinting (Femur) (121, 140, 144, 145)	1	3
PHARMACOLOGICAL THERAPIES			
Inhaled Therapies			
1	Nitrous Oxide (50% Nitrous Oxide/50% Oxygen) (31, 41, 51, 56, 58, 61, 66, 68, 69, 71, 84, 85, 88, 90, 125, 140, 144–153)	15	11
2	Methoxyflurane (72–75, 77, 79, 80, 83, 105, 109, 114, 118, 119, 129, 140, 145, 146, 148, 150, 152–164)	13	18
Opioid Analgesics			
3	Morphine IV (32, 34, 37, 44, 53, 66, 67, 73, 76, 78, 79, 81, 94–96, 98, 100–102, 111, 121, 140, 144–149, 151, 155, 156, 165–170)	17	16
5	Morphine IM (43, 53, 132, 135, 155, 160)	4	nil
6	Fentanyl IV (32, 33, 35, 37, 39, 42, 44, 45, 47, 53, 54, 76, 79, 91, 92, 94, 100, 101, 111, 115, 116, 140, 144–149, 151, 156, 165, 166, 169, 170)	18	13
7	Fentanyl IO (45)	1	nil
8	Fentanyl IM (39, 45, 53)	3	nil
9	Fentanyl Transmucosal IN (43, 45, 49, 73, 77, 79, 81, 89, 117, 128, 145, 147, 148, 152, 155, 156, 165, 171)	9	7
10	Fentanyl Subcutaneous SC (87, 89)	2	nil
11	Fentanyl Oral Transmucosal Citrate (61, 120, 133, 136, 148, 152, 165)	4	3
12	Fentanyl Nebulizer (45)	1	nil
13	Sufentanil IV (123, 124)	2	nil
14	Sufentanil SL (48)	1	1

Nr	Therapy under study †	Primary evidence (n)	Secondary Evidence (n)
NON-PHARMACOLOGICAL THERAPIES			
15	Alfentanil IV (113, 148)	1	1
16	Tramadol IV (68, 145, 147, 148, 151, 166, 170)	1	6
17	Tramadol IM (129)	1	nil
18	Pentazocine IV (127, 149, 169, 172)	1	3
19	Nalbuphine IV (55, 59, 64, 65, 70, 96, 99, 102, 151, 166)	8	2
20	Nalbuphine IM (59)	1	nil
21	Piritramide IV (95, 98, 99)	3	nil
Dissociative Analgesics			
22	Ketamine IV (33, 36, 38, 40, 44, 53, 67, 76, 111, 127, 131, 144–149, 156, 165, 166, 168, 169, 172–176)	13	16
23	Ketamine IM (40, 53, 131, 134, 145, 156, 165, 169, 172–174, 176)	4	8
24	Ketamine IN (40, 47, 84, 86, 112, 131, 145, 165, 169, 171, 172, 174, 176, 177)	9	10
25	Esketamine/S-Ketamine IN (95, 97, 110, 112)	4	nil
26	Esketamine IV (102)	1	nil
27	Ketamine IO (40, 131)	2	nil
28	Ketamine Transmucosal SL (83)	1	nil
29	Ketamine Nebuliser (45, 50, 52)	3	1
Non-Steroidal Anti-Inflammatory Drugs			
30	Ketorolac IV (46, 122, 145, 166)	2	2
31	Ibuprofen Oral-enteral (128, 156)	1	1
32	Metamizole IV (95, 98)	2	nil
33	Metamizole (route not specified) (101)	1	nil
Centrally Acting Non-Opioid Analgesics			
34	Paracetamol/Acetaminophen Oral (60, 83, 144, 145, 165)	2	3
35	Paracetamol IV (46, 60, 66, 96, 99, 102, 122, 124, 145, 147)	8	2
Anti-Spasmodic			

Nr	Therapy under study †	Primary evidence (n)	Secondary Evidence (n)
NON-PHARMACOLOGICAL THERAPIES			
36	Butylscopolamine IV (102)	1	nil
37	Butylscopolamine (route not specified) (101)	1	nil
PROCEDURES			
1	Fascia Iliaca Compartment Block (FICB) (Lidocaine with adrenalin) Chirocain (62, 63, 66, 78, 112, 130, 140, 145, 148, 167, 178–181)	6	nil
2	Femoral Nerve Block (145)	Nil	1
3	Digital Nerve Block (Lidocaine 2%) (82)	1	nil
ENABLING PROCEDURES			
1	Patient Controlled Analgesia (93, 179)	1	1
2	Telemedicine (95, 98)	2	nil
† Studies may contain more than one criterion and be counted more than once.			

***insert** Table 3 **here (located after references)**

Non-pharmacological Therapies

We identified evidence of four non-pharmacological therapies. Acupressure was studied in 3 randomized controlled trials (RCT) for traumatic pain. (103, 106, 108) Barker et al. (103) studied auricular acupressure using 1mm plastic beads taped to ear acupoints in older adults with hip fractures. Kober et.al. (106) studied acupressure in minor trauma and Lang et al. (108) in isolated radius fractures, both studies applying pressure with fingertips. Secondary evidence consisted of a systematic review (SR) (139) exclusively on acupressure and two broader reviews (an SR (140) and scoping review (141)) of multiple non-pharmacological therapies.

Transcutaneous Electrical Nerve Stimulation (TENS) was studied in four RCTs; in lower back pain, (104) acute pelvic pain, (126) urolithiasis (138) and for traumatic hip pain (the only study in trauma). (137) In terms of secondary evidence, 2 SRs were conducted, (140, 143) 1 including metanalysis, (143) a Narrative Review (142) and a scoping review. (141) A quasi-experimental study (121) compared pain relief provided by traction splints and simple splints in in femur fracture. Secondary evidence for splinting consisted of a SR (140), a scoping review (144) and a narrative review. (145) A single RCT studied active warming with an electric blanket, in cholelithiasis (107), and warming was discussed for pain relief and patient satisfaction in a Narrative Review. (142)

Pharmacological Therapies

The evidence showed the application of 16 pharmacological therapies (Table 2). There was a disproportionate research emphasis on opioids, specifically morphine and fentanyl, ketamine, and the inhaled therapies Nitrous oxide and methoxyflurane.

Opioids

We identified evidence for seven opioids. Morphine, a μ-receptor agonist (96) was studied in 14 primary studies and discussed in 16 secondary studies. Primary research included use in acute traumatic pain (n = 13) (32, 37, 44, 53, 66, 73, 76, 79, 81, 96, 100, 101, 111), acute non-trauma pain (n = 9) (37, 44, 53, 73, 79, 81, 96, 100, 101), Ischaemic chest pain (n = 4) (34, 81, 94, 100, 101), and back pain (n = 1). (101) Secondary evidence has morphine examined alongside other therapies in 11 SRs, (140, 146–149, 156, 167–170, 182) one scoping review (144) and four Narrative Reviews. (145, 151, 165, 166). Fentanyl was studied in 23 primary studies for traumatic pain, (32, 33, 35, 37, 39, 42, 44, 49, 53, 54, 73, 79, 81, 89, 91, 92, 100, 101, 115–117, 128) non-traumatic pain, (33, 37, 39, 42, 44, 53, 73, 79, 81, 89, 92, 100, 101, 115, 117, 128) ischemic chest pain, (39, 81, 94, 100, 101, 117) and back pain(one study). (101) Sixteen secondary studies included 8 SRs, (140, 146–149, 156, 169, 170, 182), 5 Narrative Reviews, (145, 151, 152, 165, 166) a rapid review (171) and a scoping review. (144)

Nalbuphine appeared in 7 primary studies (55, 59, 64, 65, 70, 96, 102) and was used in the UK (59, 64, 65, 70), USA (55) and Germany (96, 102) for acute trauma pain, (55, 59, 64, 65, 70, 96, 102) non-traumatic pain, (55, 65, 70, 96, 102) ischaemic chest pain (59) and back pain (55) Two studies assessed nalbuphine in combination with paracetamol. (96, 102) Another agonist-antagonist, pentazocine, was studied in primary evidence comparing in Iraq. (127) This primary study was also included in three SRs. (149, 169, 172) Piritramide, a synthetic opioid used in in two German studies. (95, 98) Tramadol was studied in a quasi-experimental study, (68) and an RCT (129), as well as in 3 SRs (147, 148, 170) and 3 narrative reviews. (145, 151, 166) Short-acting synthetic opioids included IV alfentanil in a Swedish retrospective cross-sectional descriptive study examining traumatic and non-traumatic pain, (113) and sufentanil, used in three studies in both SL (48) and IV routes. (123, 124)

Ketamine

Ketamine was well studied with primary studies in trauma pain, (33, 36, 38, 40, 44, 47, 50, 52, 53, 57, 76, 83, 84, 97, 111, 127, 131, 134) non-traumatic pain (sickle cell pain, lumbar pain, headache and abdominal pain, (50) gastrointestinal conditions (53) and cardiac pain (83)), and to facilitate painful procedures, or for sedation (40, 57). Secondary evidence for the use of ketamine included 9 SRs, (146–149, 156, 168, 169, 172, 173) 7 narrative reviews, (145, 152, 165, 166, 174–176) a scoping review (144) and a rapid review (171).

Inhaled therapies

Nitrous oxide (self-administered 50:50 nitrous oxide/ oxygen) was the first prehospital medication to appear in the literature, dating to 1972. (71) It was studied in 15 primary studies. (31, 41, 51, 56, 58, 61, 66, 68, 69, 71, 84, 85, 88, 90, 125) Methoxyflurane was studied in 12 primary studies (72–75, 77, 79, 80, 105, 109, 114, 119, 129) in acute traumatic pain, (72–75, 77, 79, 80, 105, 109, 114) non-traumatic pain, (72–75, 77, 79, 80, 105, 109, 114, 119, 129) back pain (74) and chest pain; (80) and in 1 SR, (183) 1 rapid review (164) and 7 narrative reviews (150, 157–160, 162, 163) addressing acute traumatic pain, (150, 157–160, 162–164, 183) non-traumatic pain (150, 158–160, 162–164, 183) and procedural pain. (164) Contexts included primary ground ambulance response, secondary evidence also dealt with methoxyflurane in critical care retrieval, (164) military contexts, (159, 160) aeromedical and wilderness contexts (157) and battlefield use. (160) While Nitrous oxide is not typically used for severe pain, (61) several methoxyflurane studies reviewed its use in severe pain. (74, 119, 129)

Paracetamol and Non-steroidal Inflammatory Drugs (NSAIDS)

Paracetamol (acetaminophen) use was documented in 6 primary studies (60, 66, 83, 96, 102, 122), 2 of which were RCTs (66, 122), a case control study (60) and 2 cross sectional (analytic) studies (96, 102). In secondary evidence, paracetamol featured in a SR (147), 2 narrative reviews (145, 165) and a scoping review. (144) Three non-steroidal anti-inflammatory drugs (NSAIDS) featured in the evidence. Ketorolac used for adults and pediatrics with moderate to severe pain (traumatic and non-traumatic), (122) and discussed in 3 narrative reviews. (145, 166, 184)

Ibuprofen was discussed in one pediatric primary study, as an adjunct to IN fentanyl, (128) and secondary evidence mentioned in 1 SR (146) citing Murphy et al. (128) Metamizole was reported as an adjunct to fentanyl and morphine in a cross-sectional analytic study (101) and in a cohort study investigating telemedicine. (98)

Antispasmodics

Evidence for use of the antispasmodic and anticholinergic agent butylscopolamine is limited to two primary studies. (101, 102) In both, it was used alongside paracetamol/nalbuphine (102) and morphine/fentanyl combinations (101) in trauma and non-trauma pain.

Procedures

Fascia Iliaca Compartment Block (FICB) was the subject of six primary studies (62, 63, 66, 78, 112, 130), including two qualitative studies exploring patient and EMS clinicians' experiences. (62, 63) All studies focused on traumatic injury. Eight secondary sources discussed FICB: four SRs, (140, 148, 167, 180) one systematic review with meta-analysis, (178) one narrative review (145), and one scoping review. (181) A single case report described a digital nerve block for reduction of a fifth finger dislocation. (82)

Enabling Procedures

In jurisdictions where EMS clinicians have limited access to medicines, telemedicine and patient-controlled analgesia (PCA) have expanded access to pain relief. (93, 95) Two German studies used telemedicine to broaden access to medications, (95, 98) while a Canadian study examined PCA to deliver opioid therapy during interfacility transfers. (93)

Operational contexts and populations

Most primary evidence focused on adults (> 18 years) (n = 53), followed by mixed adult-pediatric populations (n = 41) (Table 4). Seven studies focused on pediatrics exclusively. (35, 38, 40, 49, 72, 73, 128) Mixed age and pediatric studies had inconsistent age bounds. Older patients were included in many studies, but only two focused exclusively on adults over 65 years, studying auricular acupressure (103) and fascia iliaca compartment block (112). All studies included both sexes, except one on TENS for acute pelvic pain, enrolling only females. (126) Secondary evidence also showed a similar pattern with most reviews addressing adults only (n = 21) and fewer addressing a mixed adult-pediatric population (n = 140). Pediatrics were the exclusive focus in only five reviews, while no secondary evidence focused solely on older adults (65+). When mapped against routes of administration, pediatric studies favoured research into needle minimizing approaches. (73, 156, 183)

Most research was conducted in the context of ground-based primary response operations (n = 72) with only four in the aeromedical primary response context. (35, 91, 92) One study evaluated both primary response and critical care retrieval in the aeromedical environment (57) and 1 in Critical Care Retrieval (CCR) ground ambulances. (93) Six studies addressed the military or battlefield context (131–136) and 4 primary studies addressed application of pain therapies in wilderness or mountain rescue. (61, 105, 110, 120)

In terms of secondary evidence, the bulk of secondary evidence addressed pain therapies on ground ambulance responses, with 20 secondary studies. (140–143, 148–151, 156, 157, 164, 166, 168, 171, 175, 179, 180, 182) 4 studies discussed pan therapies in military environments (148, 159, 160, 173) and 2 narrative reviews discussed the wilderness and mountain rescue environment. (145, 157) Two reviews (rapid review) (164) and a narrative review (157) discussed methoxyflurane in aeromedical environments.

Pain types and etiologies

Acute trauma pain was reported in 101 primary studies (Table 4), with 38 focusing exclusively on trauma pain. Acute non-trauma pain was reported in 59 studies, but only four exclusively non-trauma. (77, 107, 126, 138) Two studies examined analgesics for ischaemic chest pain (34, 94), while 12 included cardiac pain with other causes. (31, 39, 58, 59, 80, 81, 83, 87, 88, 95, 100, 117) Back pain was the focus in one study (104) and included with other causes in four more. (55, 74, 95, 101) Two primary studies reported

on obstetric pain with other causes, one using Nitrous oxide (58) and the other addressing morphine, fentanyl, and methoxyflurane. (79)

Table 4
Populations, pain types and contexts of operations

Populations represented in evidence	**Primary evidence N = 108 n(%)**	**Secondary Evidence N = 44 n(%)**
1. Exclusively Adults > 18 years (less than 65 years)	53 (49)	22 (50)
2. Adults and Pediatrics	43 (40)	14 (39)
3. Exclusively adults > 65	2 (1)	0 (0)
4. Pediatrics	12 (11)	5 (11)
5. Age not reported	6 (5)	3 (7)
Pain types†		
6. Acute Trauma Pain	101 (94)	42 (95)
7. Acute non-Trauma Pain	59 (55)	23 (52)
8. Ischaemic Chest Pain	15 (24)	1 (2)
9. Obstetric Pain	2 (1)	0 (0)
10. Back Pain	5 (5)	1 (2)
Context of Operation†		
11. Primary Response: Ground ambulance	91 (84)	18 (41)
12. Primary Response: Air Ambulance	4 (4)	1 (2)
13. Critical Care Retrieval: Air ambulance	4 (4)	1 (2)
14. Critical Care Retrieval: Ground Ambulance	1 (1)	0 (0)
15. Military/Battlefield	6 (6)	6 (14)
16. Wilderness/Mountain Rescue	6 (6)	3 (7)
17. Contexts not differentiated	0 (0)	20 (45)
† Studies may contain more than one criterion and be counted more than once.		

Routes of Administration

Routes of access appeared to be key enablers of timely pain management. The evidence identified eight routes of administration: intravenous (IV), intraosseous (IO), intramuscular (IM), subcutaneous (SC),

transmucosal - intranasal (IN), transmucosal – oral (buccal and sublingual), oral (enteral) and inhaled (vapors, gases and nebulized aerosols). In this review nebulization is classified as inhaled though we acknowledge aerosols may be considered transmucosal. We thus foreground the mechanism of delivery rather than pharmacokinetics.

IV administration was most frequently reported, appearing in 38 primary studies (Table 2), and used for morphine, fentanyl, ketamine, tramadol, nalbuphine, paracetamol, piritramide and sufentanil. IO administration was reported in ketamine studies (40, 131) and might have been used for fentanyl in a third study (45). Primary evidence for IM administration was reported for morphine (53, 132, 135), fentanyl (39), tramadol (129) nalbuphine (59)and ketamine. (40, 53, 131, 134) Battlefield research – despite a long history of military application - showed dissatisfaction with the IM route for morphine (132, 135) and the route was considered unreliable. (160) This prompted a search for alternate therapies. (160) The versatility, safety and effectiveness of ketamine through the IM route made it attractive for battlefield use. (134)

Transmucosal administration took place through the IN, SL, and oral/buccal routes. Nineteen primary studies (Table 2) explored intranasal preparations: morphine, (135) fentanyl (43, 49, 73, 77, 79, 81, 89, 117, 128) and Ketamine (40, 97, 131) (47, 84, 102, 110, 112). Intranasal was often described as an effective, enabling and needle-free route, especially in pediatrics, though with some constraints (taste, runoff and volumes). The oral transmucosal route allowed delivery of fentanyl using a lozenge (oral transmucosal fentanyl citrate) in military (133, 136) and wilderness environments, (61, 120) allowing easy, titratable relief without IV lines or needles. A novel SL approach used a ketamine impregnated wafer (83) to address long transport times and cost/feasibility considerations.

Inhaled routes of administration were used to deliver nitrous oxide, methoxyflurane, fentanyl (45) and ketamine (via breath actuated nebulizer). (50, 52) Noninvasiveness and portability were motivators for this route, though nitrous oxide is constrained for portability because of the need for pressurized cylinders.

Two primary studies explored SC fentanyl (87, 89) to avoid IN specific issues (swallowing, run-off and small volumes) (87), illustrating the contextual influence of route selection. Finally, oral/enteral therapy appeared less commonly in the evidence and seemed to be reserved for less severe pain. Oral paracetamol was explored in two primary studies (60, 83), and three secondary studies (144, 145, 165) and a single primary study in pediatrics examined ibuprofen. (128)

Effectiveness and safety

A pattern of the findings was that included studies generally reported clinically meaningful reductions in pain across therapies, populations and contexts The entire evidence base demonstrated clinically meaningful pain reduction. Ketamine (44, 53, 127, 168) and FICB (78, 112, 130) appeared to show greatest pain reductions, frequently outperforming comparators. Some therapies showed weaker performance than comparators and often with more associate nausea and vomiting. (68, 129, 147),

though still providing pain relief. In direct comparison, methoxyflurane produced faster, and better pain relief than IM tramadol. (129) Tramadol was effective, though it did result in greater proportions of nausea. (68) Secondary evidence echoes these findings, noting higher nausea rates (148) and inferiority to other opioids. (166)

Nalbuphine was effective overall (55, 99), but seemed most useful as part of a multimodal strategy, (96) although some studies reported less pain relief with some rescue analgesia needs (65, 70) and weaker performance in trauma compared to non-trauma. (102) Methoxyflurane was effective, but less potent than opioids in moderate to severe pain. (79, 158, 183) Oral paracetamol was effective and safe, but less effective than ketorolac. (122) Nitrous oxide was effective, but due to rapid offset less suitable for severe trauma or prolonged transport than opioids. Nitrous oxide was less effective than opioids for severe pain (88) and came with practical limitations due to the need for pressurized cylinders. (90)

Morphine, fentanyl and non-pharmacological therapies (TENS, acupressure, warming and splinting) showed meaningful pain reductions without adverse events. (103, 106, 108, 139–142) (104, 107, 121, 126, 137, 138, 140–145) FICB was consistently effective, showing high success rates (180) and consistently showing high, rapid reductions in pain scores, comparative or better than opioids. (78, 112, 130)

In terms of safety, no class showed a systematic pattern of harm. Most reported adverse events were mild, self-resolving and did not cause harm. Serious adverse events or those requiring intervention were rarely reported. Some therapies showed more frequent adverse events but were still regarded as safe. Tramadol showed more nausea and vomiting (68, 147) than comparison groups, and may have been less effective, than comparison therapies. (68, 129, 147)

Sedation was more frequent with methoxyflurane, including in young children (72) and mild sedation and dizziness was common in adults. (79, 80) Of note, unstable or severely injured patients, or patients with abnormal vital signs were systematically excluded from the primary research, as were patients requiring resuscitation. Thus, findings of effectiveness and safety in this evidence are largely for *stable*, and less severely injured patients.

Discussion

This scoping review mapped pain management therapies across diverse prehospital settings, patient groups and operational contexts. Although the findings hold implications for clinical practice, this discussion focuses primarily on their relevance for EMS education. Contemporary approaches to competency framework development emphasize that health professions education (HPE) should be grounded in professional practice, and the context in which that practice occurs. (185) Competency frameworks are viewed as representations of practice rather than collections of knowledge, skills and attitudes. (186) Transformative models of HPE emphasize that curricula should respond to patient (and practitioner/student) needs, population health needs and health system realities rather than historical

educational and practice traditions (187). The association of curriculum content with real world care has been identified as a research priority as has teaching for diversity. (188)

From this perspective, this review provides an evidence-informed map of the prehospital pain management practice landscape by non-physician EMS clinicians. It offers a foundation from which curriculum development, competency frameworks and continuing education and regulatory standards may be informed. Taking the review findings together, we suggest that prehospital pain management is highly contextual and that educationalmay benefit from emphasizing integrated approaches rather than focusing exclusively on individual therapies.

The evidence identified in this review encompasses a range of pharmacological, non-pharmacological, procedural, and enabling approaches to prehospital pain management; however, it is unevenly distributed across populations, settings, and therapies. Research is concentrated predominantly on acute traumatic pain in adults, ground ambulance operations, and a limited number of pharmacological interventions, particularly opioids, ketamine, and inhaled analgesics. In contrast, pediatric, older adult, obstetric, chronic pain, and palliative care populations, as well as evidence generated in low- and middle-income countries (LMICs), remain substantially underrepresented. This pattern reflects wider trends in the health research literature, where LMICs contribute disproportionately to the global burden of disease yet remain underrepresented in research production (189–191) When considered in relation to age and gender, the findings reveal additional contextual gaps and offer further insight into broader inequities within pain research. Globally, pain prevalence is higher among women than men and increases with age, while also being influenced by social inequality (192). At the same time, the burden of pain appears to be increasing disproportionately within LMICs, despite these settings contributing relatively little to the pain research evidence base. (193)

The uneven distribution of the evidence identified in this review raises important questions of educational equity and social accountability for EMS education. Health sciences often take an “evidence-based” approach to activities, including education, however, competency frameworks and curricula which rely too heavily on, or are not critical enough, of research evidence may inadvertently under-represent patient populations, KSAs, or operations which are contextually important to their student groups. This is an especially pertinent risk for education in LMICs, or for an emerging profession such as Paramedicine. For Emergency Medical Services (EMS) education, these patterns raise important questions regarding the alignment between the available evidence and the realities of contemporary practice. EMS systems operate across diverse contexts, including ground ambulance response, interfacility transfer, critical care retrieval, aeromedical services, and wilderness or remote environments, while caring for varied patient populations such as children, older adults, obstetric patients, and individuals with non-traumatic pain conditions. Yet many of these contexts and populations are sparsely represented in the evidence base identified by this review.

Emerging literature further suggests that palliative care and chronic pain are becoming increasingly important areas of EMS practice, reflecting the growing global burden of these conditions. (17, 19–21)

However, evidence informing prehospital pain management therapies and strategies within these domains remains limited. This is an area of potential mismatch between research evidence, education and training, and operational patient load.

Frenk et al. (187) argued that one of the shortcomings of health professions education is a mismatch between graduate capabilities and the needs of patients, populations and healthcare systems. The present findings suggest that EMS educators should consciously guard against reproducing gaps in the evidence base and instead ensure that learners are exposed to pain management scenarios across the patient lifespan, across diverse pain mechanisms and across varied resource contexts. Curriculum designers should exercise care during needs assessment and make appropriate choices when selecting competencies and designing curricula.

A key finding of this review (notwithstanding that no meta-analysis was conducted) was that prehospital pain management is highly contextual, with the choice and application of therapies influenced not only by therapeutic class, but also by route of administration, patient characteristics, operational environment, and operational feasibility. This variability suggests that effective pain management is not simply a matter of knowing the available therapies but understanding how therapeutic options interact with the circumstances of care. For example, nitrous oxide may provide effective analgesia, but the delivery apparatus and preparation of the analgesic can limit its use in mountain rescue (61), requiring selection of alternatives to enable interventions such as splinting. Similarly, needle-minimizing approaches, including intranasal medicines (152), nebulized ketamine (45, 50, 52)and non-pharmacological therapies, may be particularly useful in pediatric patients, where intravenous access can increase fear and anxiety for patients and practitioners (194). Telemedicine, and the communication skills that go along with it, may be necessary to expand access to analgesia in jurisdictions with restrictions on opioid administration (87, 95). These examples suggest that pain management depends on EMS clinicians matching available therapies to context, patient needs and operational realities. The evidence identified in this review highlights the importance of pain assessment, route selection, communication, monitoring and multimodal approaches to pain management. This requires the integration of knowledge, practical skills, clinical reasoning and contextual judgment, rather than simply being competent in the use of individual therapies. Pain management should therefore not be taught as a discrete technical skill, because no education programme can prepare students for every clinical situation or for the ways in which EMS operations may change over time. Indeed, pain, being multidimensional in nature, itself requires more than clinical skills, but attitudinal development and affective attributes. (195) Coupled with the contextual requirements of prehospital practice, and teaching pain management as discrete and isolated skills may inadequately reflect the multidimensional nature of pain and the contextual requirements of prehospital practice.

The findings suggest that EMS education may benefit from moving beyond preparation for predetermined tasks alone, towards developing the ability to select, combine and adapt pain management strategies across changing clinical and operational contexts.

This aligns to the concept of a capability. (196, 197) In complex and variable practice environments, effective pain management depends not merely on knowing which therapy to administer, but on recognising patient needs, selecting appropriate interventions, adapting to contextual constraints, monitoring response and adjusting care accordingly. Such capabilities are particularly important in EMS, where clinicians frequently practice with incomplete information, constrained resources, variable transport times and differing regulatory permissions. This suggests that pain management programmes should focus not only on knowledge of analgesic therapies but also on clinical judgment, contextual adaptation, problem solving, communication and reflective decision-making.

As a practice analysis, the review also provides preliminary insights into potential domains for EMS pain management competency development. Competency framework development requires multiple sources of evidence, stakeholder engagement and validation processes (186) and therefore cannot be completed through a scoping review alone. Nevertheless, the patterns identified within the literature suggest several domains that may warrant consideration in future framework development. These include pain assessment and reassessment; pharmacological pain management; non-pharmacological and procedural pain management; route-selection reasoning; patient-centered communication; monitoring and patient safety; contextual adaptation and clinical judgment; ethical and equitable pain care; and evidence-informed practice. Importantly, these domains extend beyond administration of individual therapies and instead reflect the broader capabilities required for effective pain management across diverse prehospital settings.

The diversity of therapies, contexts and patient groups identified in the review also has implications for curriculum design. Because pain management capability develops through repeated application in different situations, a spiral curriculum may be particularly appropriate. Such an approach would allow learners to revisit core concepts such as pain assessment, communication, pharmacology and monitoring while progressively integrating greater complexity through trauma, medical emergencies, pediatrics, older adults, palliative care, retrieval medicine and resource-constrained environments. Spiral curricula facilitate increasingly sophisticated understanding through repeated engagement with concepts at higher levels of complexity (198) Such an approach may better reflect the developmental trajectory required for prehospital pain management capability than isolated instruction.

Limitations

This review has several limitations. First, as a scoping review, its purpose was to map the breadth, nature and distribution of the evidence rather than evaluate intervention effectiveness or determine the superiority of specific therapies. Consistent with scoping review methodology, no critical appraisal of included studies was undertaken. Consequently, the findings should not be interpreted as evidence supporting the inclusion or exclusion of particular therapies within clinical guidelines, formularies or scopes of practice.

Second, the search was limited to English-language publications indexed in four databases and excluded grey literature. Relevant evidence may therefore have been missed, particularly unpublished studies,

reports, theses and evaluations containing null or negative findings. The exclusion of grey literature may also have introduced publication bias.

Third, the review focused specifically on studies investigating pain management therapies administered by non-physician EMS clinicians. Studies addressing the epidemiology of prehospital pain, broader management of clinical conditions, or mixed physician-paramedic models where EMS clinician data could not be isolated were excluded. As a result, some therapies, approaches and contextual factors relevant to prehospital pain management may not have been captured.

Fourth, the inclusion of both primary and secondary evidence may have resulted in overlap between evidence sources, potentially increasing the apparent prominence of therapies that have been repeatedly synthesized. Similarly, the broad inclusion criteria encompassed diverse operational contexts, patient populations, EMS systems and regulatory environments, which limits direct comparison between studies and may reduce transferability of findings to specific jurisdictions.

Finally, the review reports effectiveness and safety findings descriptively and these data were not synthesized in a manner that would permit conclusions regarding comparative effectiveness, treatment recommendations or clinical decision-making. Rather, the findings should be interpreted as an evidence map intended to identify patterns, gaps and opportunities for future research, competency development and curriculum design. Importantly, many primary studies excluded unstable, critically ill or severely injured patients, meaning that the effectiveness and safety findings predominantly reflect more stable patient populations. This limitation should be considered when interpreting the applicability of the evidence to the full spectrum of prehospital practice.

Conclusions

The review contributes an evidence map that can inform curriculum development and capability planning. The range of therapies identified suggests that pain management curricula should not be limited to drug indications, doses and adverse effects, but should address the broader clinical reasoning required to select, combine and adapt therapies in context. This includes assessment and measurement of pain, route selection, multimodal therapy, escalation of care, monitoring, documentation, communication and patient-centered decision-making. The International Association for the Study of Pain curriculum outlines similarly emphasize the multidimensional nature of pain, pain assessment and measurement, management approaches and application to clinical conditions (26). These domains provide a useful organizing structure, but the findings of this review suggest that they require contextual adaptation for EMS education, where clinicians often practice with limited resources, restricted formularies, variable scopes of practice and incomplete clinical information. (187)

Future research should therefore include both clinical and educational priorities. Clinical research is needed in underrepresented populations, pain types and settings, particularly unstable or severely injured patients, children, older adults, obstetric patients, palliative and chronic pain presentations, and low- and middle-income contexts. Educational research should examine how pain management is

currently represented in EMS curricula, which competencies graduates require, how these competencies can be assessed, and which teaching approaches best develop multimodal and context-sensitive pain management capability. Studies linking curriculum design, clinician competence, clinical behavior and patient outcomes would be particularly valuable. Research should also explore the translation of evidence into regulatory standards, educational guidance and operational protocols, so that the evidence base informs practice capability rather than remaining a descriptive map of therapies.

Abbreviations

EMS
Emergency Medical Services
IM
Intramuscular
IN
Intranasal
IV
Intravenous
SC
Subcutaneous
SL
Sublingual

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Human Research Ethics Committee of the University of Cape Town (HREC **614/2020).** The secondary nature of the research meant that there were no human participants, and no individual consent was obtained.

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests

Authors' contributions

RM: Conceptualization; Data curation; Methodology; Formal analysis; Investigation; Project administration; Validation; Visualization; Writing - original draft; Writing – review and editing.

MF: Formal analysis; Investigation; Validation; Visualization; Writing - original draft; Writing – review and editing.

PH: Conceptualization; Validation; Visualization; Methodology; Writing - original draft; Writing – review and editing.

NN: Conceptualization; Methodology; Validation; Visualization; Writing the original draft; Writing – review and editing.

All authors approved the final submission and agreed to accountability for the research.

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Authors' information (optional)

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Figures

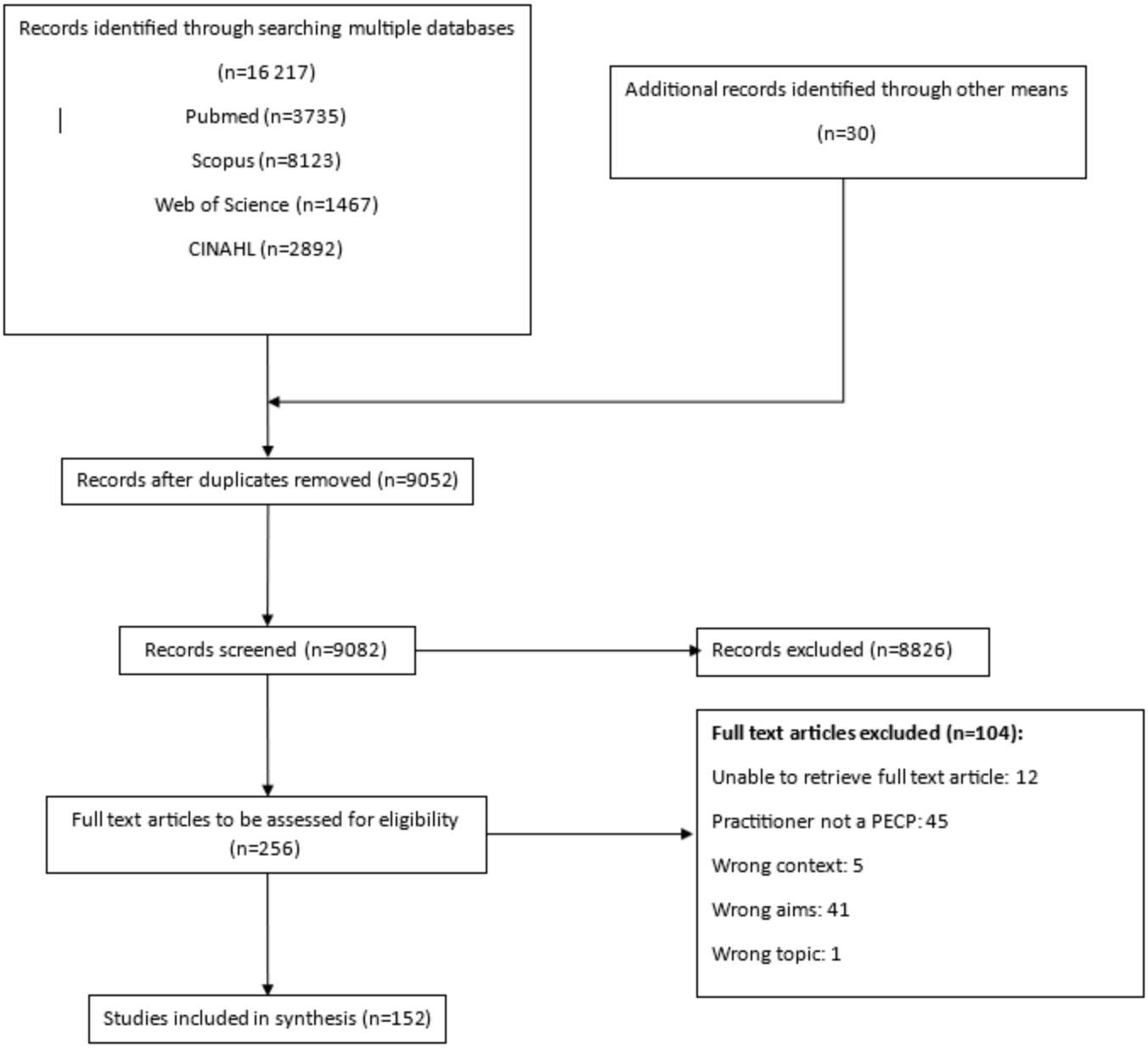


Figure 1

PRISMA ScR flow diagram

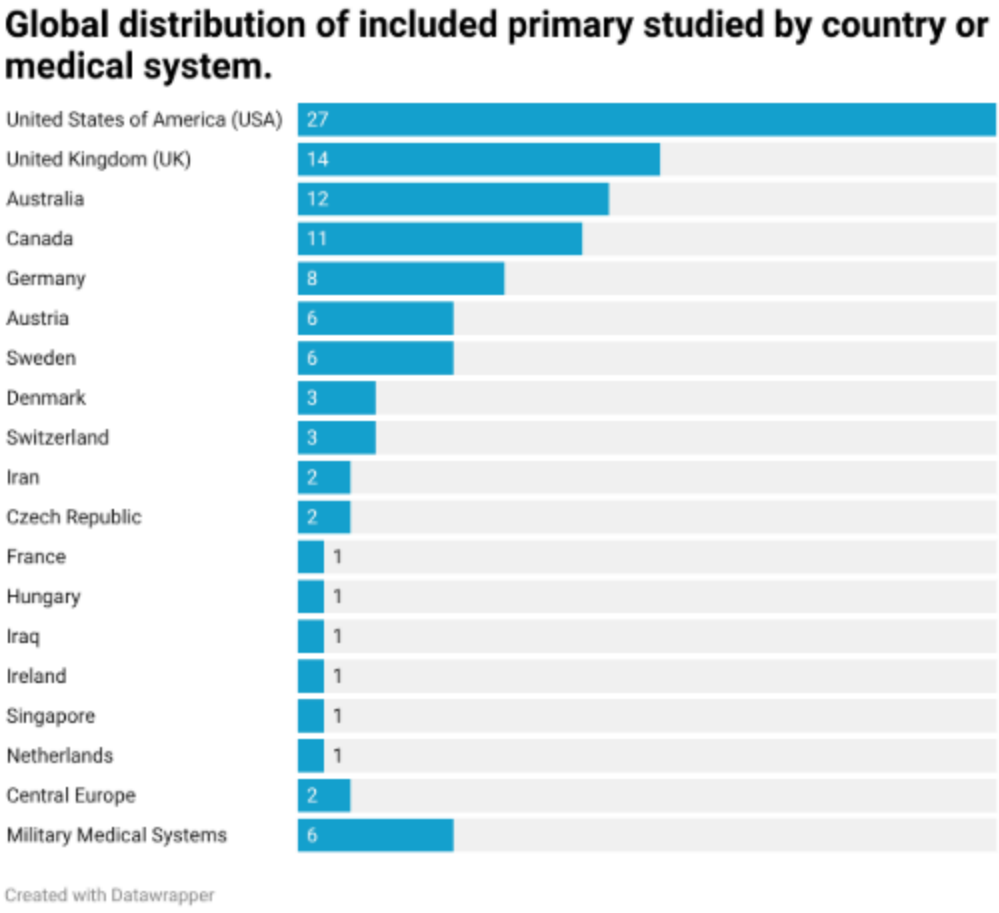


Figure 2

Distribution of primary research by country of origin

Supplementary Files

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