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Emergency Medical Services response to wildfires from a public health perspective: A systematic review

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ABSTRACT

As the incidence and intensity of wildfire events continue to increase globally, it is crucial to understand how Emergency Medical Services (EMS) respond to such extreme situations. Hence, this study aimed to synthesize existing evidence on EMS responses during wildfire episodes. A systematic search of five electronic databases (PubMed, Web of Science, Medline Ovid, Embase, and Scopus) was conducted using predefined search terms, with no time or geographical restrictions. This review included peer-reviewed full-text English-language articles that explored the EMS responses during wildfires. After removing duplicate records, the titles, abstracts, and full texts were screened using the eligibility criteria, and data were extracted independently using a data extraction template by two reviewers. Five databases recorded a total of 1339 articles. After removing the duplicates, 723 articles were screened by their title and abstract, and 30 full-text articles were reviewed. Finally, 6 full-text articles were included for data analysis. This review documented that EMS provided counseling support, acute health care services, burn and injury services, services for respiratory and ophthalmology problems, clinical services, and coordination services following wildfire episodes. Additionally, EMS delivers both direct and indirect (using telephone), short- and long-term physical and mental health services, as well as referral health services with clinical and community health services. The study's findings help to understand the current practice of EMS services and identify potential shortcomings. EMS services should be extended to ensure the safeguarding of vulnerable communities from the threat of wildfires as well as the preparedness and resilience of EMS systems should be enhanced to improve patient outcomes and save lives during such episodes.

1. Introduction

Climate change has caused a large increase in the risk of forest fires on a global scale, both in frequency, magnitude, and extension [1,2]; the annual seasons of greatest fire risk will be lengthened, and there will be an increase in the global area with frequent conditions prone to forest fires worldwide [3,4].

In 2023 Canada accumulated 4 consecutive months (from May to

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August) at the highest level of national emergency preparedness (5/5), with up to 1068 active forest fires of which 702 were out of control [5], affecting Canada and several cities in the northern United States [6]. In Hawaii, the most important wildfire in the last 100 years in the US affected numerous urban centers, causing thousands of displaced people and missing, million-dollar losses of infrastructure and 115 deaths so far [7], with air and water quality health issues and the restriction of access to health services [8]. Meanwhile, in the summer of 2023, Europe suffered an unprecedented heat wave, and forest fires broke out in Greece, the largest forest fire recorded in the entire European Union since 2000, which caused more than 20 deaths and thousands of displaced people [9].

In Spain, the year 2023 has been one of significant risk and impact on the territory with several important episodes, such as that of Tenerife (Canary Islands), with more than 26,000 people evacuated [10], in Pinofranqueado (Cáceres, 10,843 ha) and Valdés (Asturias, 9722 ha) with hundreds of evacuees. The European Information System on Forest Fires (Copernicus, EFFIS) estimates that Spain experienced the worst environmental situation due to smoke in the last 20 years, tripling the average number of large *forest fires* (>500 ha) recorded in this period in the last decade [11,12].

Forest fires can cause the destruction and disruption of essential services and infrastructure (health, water and sanitation, food, and housing) [13]. Health systems must actively prepare to face this growing risk and respond to different threats such as the toxicity of smoke (mainly due to particulate matter), impact of health infrastructure and displacements and evacuations of the affected population. There is and excesses of mortality and morbidity related to episodes of clouds of smoke from forest fires [14,15], mainly associated with excess morbidity and mortality due to respiratory and cardiovascular causes [16], being *Particulate matter* (less than 2.5 microns) the greatest concern to public health [17]. The ability of smoke clouds to travel long distances (hundreds of kilometers) and reach highly populated areas, generates a variety of short and long-term health risks [18].

Hence, it is essential to analyze the response provided by health systems, especially those on the front line, the Medical Emergency Systems, which are the first responders deployed to provide health care. For example, the wave of forest fires of 2019–2020 in southeastern Australia caused the death of 33 people directly due to exposure to fires and another 429 deaths and 3230 hospitalizations for respiratory and cardiovascular diseases directly related to smoke inhalation, especially particulate matter (PM 2.5) [19], all of which causes an unprecedented cost for the health system of 1.8 billion euros [20].

As the incidence and intensity of wildfire events continue to increase globally, it is crucial to understand better how EMS responds to such extreme situations. A comprehensive study of EMS responses during wildfires will help evaluate current effectiveness, identify potential shortcomings, and establish best practices. This knowledge is integral to safeguarding vulnerable communities from the threat of wildfires and will enhance the preparedness and resilience of our EMS systems, ultimately improving patient outcomes and saving lives during such disasters. Hence, this study aimed to synthesize existing evidence on EMS responses during wildfire episodes.

2. Methodology

2.1. Study design

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [21] (Supplementary Table S1) and used the narrative synthesis method to report the findings of the included studies due to the higher heterogeneity of variable measurement [22]. Additionally, the PRISMA-P guideline and statement were maintained to write the protocol of this review [23,24]. The protocol has been registered at the International Prospective Register of Systematic Reviews (PROSPERO) with the registration number (CRD42023433345).

2.2. Information sources

Five databases (PubMed, Web of Science, Medline Ovid, Embase, and Scopus) were systematically searched without time and geographical restriction. We also screened the references of all eligible articles to find possible further relevant studies due to literature saturation.

2.3. Search strategy

A systematic and detailed search strategy was developed using MESH terms and keywords on the PubMed database. This review also used the Boolean operators (AND, OR, and NOT) and truncations (*) depending on the specifications of the databases. Moreover, the search terms were finalized after consultation with an expert in this field and a research librarian. The details are in Supplementary Table S2.

2.4. Eligibility criteria

This review included peer-reviewed full-text English-language studies that explored the EMS responses during wildfires. Additionally, studies with quantitative, qualitative, or mixed methods research designs were also included. However, this review excluded studies focusing on wildfire due to conflict and other review articles, protocols, editorials, letters to editors, conference abstracts, commentaries, and opinion pieces. The inclusion and exclusion criteria are shown in Supplementary Table S3.

2.5. Screening procedures of eligible studies

After the database searches, all the search records were managed with Rayyans Qatar Computing Research Institute (QCRI) software, a web-based online tool for managing and reporting systematic reviews and meta-analyses [25]. All the retrieved articles were stored in a single library to detect and remove duplicates. After removing duplicate records, the title, abstract, and full text were screened by two reviewers (H.U. and N.H.M.) to exclude irrelevant studies. A third reviewer (M.K. H) was consulted to resolve any disagreement in the screening process. A flow diagram was prepared to report the study selection process and reasons for exclusion following the PRISMA guidelines [26] (Fig. 1).

2.6. Data extraction and management

À standardized data extraction template in an Excel sheet was prepared, and two reviewers (H.U. and E.M.V.) independently collected specific information following an instruction manual. The data extraction items were collected based on the PICO structure [27]. For example, population characteristics (EMS types), intervention/exposure characteristics (wildfire's location, intensity, and time of occurrence), and outcome characteristics (EMS responses) were extracted. Moreover, general information (e.g., article title, author, year of publication, and year of the study conducted), study characteristics (aim of the study, study design, countries), and the main findings linked to our research questions were also extracted. After the data extraction, a third reviewer (R.C.D.) verified and resolved any disagreements. The data extraction template was presented in the Supplementary Table S5.

2.7. Data synthesis

After the full-text screening of the included studies, this review explored the EMS responses during wildfire events. As the eligible studies were heterogeneous in measurements of variables, study design, and reporting, we followed the descriptive and narrative synthesis method to report the key characteristics and findings of the included studies. One of the benefits of narrative synthesis is that it offers the

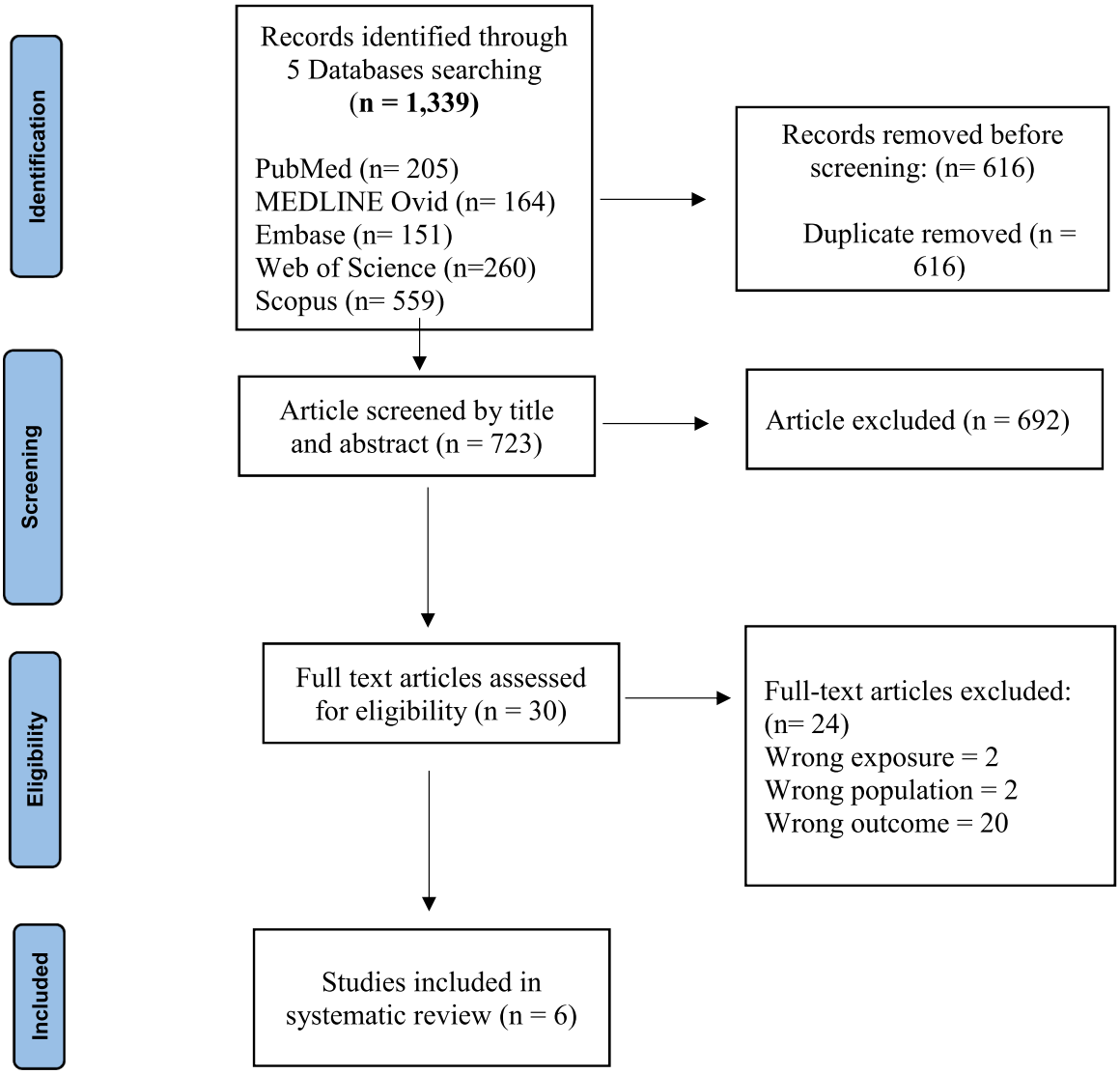

Fig. 1. Articles selection flow diagram.

opportunity to compare the findings of the eligible studies, mainly focusing on the population, exposure, and outcome. However, due to the higher heterogeneity, we did not conduct a meta-analysis and confidence in cumulative evidence.

2.8. Ethical considerations

This review deals with existing published studies without any personally identifiable information of participants. Therefore, ethical approval from the research committee is not required.

2.9. Patient and public involvement

Patients or the public were not engaged in this research design, reporting, or dissemination plan.

3. Results

3.1. Screening of articles

The initial database search records across five databases were 1339 articles. Following the removal of 616 duplications, 723 articles underwent assessment based on their titles and abstracts. Out of these, 692 articles were excluded based on selection criteria. Subsequently, 30 full-text articles were screened for eligibility, with 24 of them being excluded for various reasons. Finally, this review included 6 articles. The study selection process and reasons for exclusion are illustrated in Fig. 1.

3.2. Characteristics of included studies

Among the included studies, three studies were published in Australia, one study was published in the United States, and two studies were published in Canada. Four studies (66.7 %) were retrospective case records, while two studies had a qualitative design. The majority of the wildfires (4 wildfires) lasted for between 19 and 45 days, while two wildfires lasted nearly 90 – 93 days (Supplementary Table S4).

3.3. EMS components/services

Table 1 presents the list of services provided by EMS following wildfire. We documented that EMS provided counseling support following wildfire episodes for both staff and personnel who worked on the wildfire [28]. Additionally, prehospital care and emergency health services, including acute health care services, were crucial services for EMS [29,30]. Burn and injury services, as well as services for respiratory and ophthalmology problems, were also provided by EMS during the

Table 1
EMS components/services (n = 6).

EMS Services	References
Counselling support	
Training and supervision for counseling staff	[28]
On-the-ground counseling support for bushfire recovery centers and media organizations	[28]
Prehospital care and emergency health service	
Prehospital care and emergency health service	[29]
Emergency and acute health care services	[30]
Burn and injury services	
Emergency health care with burn and injury service	[31]
Severe and minor injury services	[32]
Respiratory and ophthalmological problem	[32]
Clinical Services	
Clinical service: Acute service; Allied health; Continuing care	[33]
Supply medications	[32]
Other services	
Interagency networking and service promotion	[28]
Upgrades to bushfire referral databases	[28]
Outreach to affected households	[28]
Community mental health services	[30]
EMS service provider (n = 6)	
Combined National Health Agency	[28,30]
State Trauma and Burn Centre	[31]
Regional Trauma Service and Community Hospital	[32]
Regional Health Centre	[33]
Hospital Emergency Department and Prehospital Patient Care Unit	[29]
Combined National Health Agency	[28,30]
EMS coverage areas (n = 6)	
Physical and mental health service	
Direct health care support	[29]
Short-term and long-term health and mental health services	[30]
Telephone and face-to-face mental health support at state and local levels	[28]
Referral health service	
EMS and Referral Health Service	[31,32]
Clinical and Community Health Service	
Direct, indirect, and contracted clinical services	[33]
Community health services	[33]

wildfire event [31,32]. Moreover, following the wildfire, EMS also offered clinical services such as acute service, allied health care, and continuing care along with medication supply [32,33]. Lastly, except for the services mentioned above, EMS provided other important services such as networking with different departments, preparing wildfire-related databases, and providing mental health services for the community and affected households [28,30].

3.4. EMS service provider

Table 1 also shows the name of the service provider that offered EMS services after the wildfire. Either the health care center alone provided the service or sometimes several health care centers and agencies combinedly provided EMS services. For example, two studies showed that three to four national agencies jointly worked together to provide EMS services for wildfire events [28,30]. On the other hand, state trauma and burn centers, regional trauma, and community hospitals, as well as prehospital patient care units, were the significant EMS service providers following wildfire episodes [29,31–33].

3.5. EMS coverage areas

Table 2 presents more specific areas covered by EMS after wildfires. Our review identified that EMS provided direct and indirect (using telephone), as well as short and long-term both physical and mental health service [28–30]. In addition, EMS provided referral health services with clinical and community health services [31–33]. However, some more exciting findings documented by six included studies about EMS services following wildfires are presented in Table 2.

Table 2
Key findings related to EMS response during wildfire (n = 6).

Study	Place/Name of Wildfire- Year, Country	Key Findings
Reifels et al. [28]	Victoria Wildfire, 2009 Australia	1) Types of remotely delivered health and mental health services in disaster contexts have included information hotlines, triage and referral services, clinical consultation, crisis counseling, and e-therapy. 2) National telemental health services offered as part of the response to the Victorian bushfires provided a useful addition to existing counseling and crisis support. 3) Telemental health services need to be integrated into mainstream services and disaster response structures. 4) All three telemental health services experienced significant increases in overall service uptake levels in the wake of the bushfire
Squire et al. [29]	Los Angeles Wildfire, California, 2009 United States	1) Consideration should be given to expanded training and protocols and training of paramedics to treat minor injuries and illnesses when higher-level medical providers may not be immediately available. 2) The prevalence of injuries observed should be considered when creating protocols and mandatory equipment lists for fireline paramedics.
Fitzpatrick et al. [30]	The Horse Roberta Wildfire- Northern Alberta, 2016 Canada	1) A main service adaptation in response to the crisis included an increased availability of mental health services such as counseling, psychosocial interventions, and outreach support. 2) The needs and expectations of care for Indigenous residents and communities following the wildfire were not adequately met. 3) Adopting and applying a health equity lens in post-disaster recovery planning was highlighted as essential to reducing the disproportionate impacts on Indigenous residents and communities and creating a more sustainable and equitable approach to responding to health-related impacts following a public health emergency.
Cameron et al. [31]	Victoria Wildfire 2009 Australia	1) As a result of the coordinated response, the small number of severe burns did not overload the acute health care system. 2) Prehospital triage is essential in managing a large number of minor ailments to avoid overloading the major burns centers. 3) Ensuring the involvement of senior experienced personnel at the significant burns centers enables rapid assessment and management. 4) Even low numbers of patients with severe burns require substantial surgical resources during the first 72 hours. 5) The Victorian State Trauma System and state burns plan allow reallocation of trauma and emergency patients, ensuring substantial surge capacity at major referral centers. 6) The National Burns Plan (AUSBURNPLAN) provides further

(continued on next page)

Table 2 (*continued*)

Study	Place/Name of Wildfire- Year, Country	Key Findings
		interstate surge capacity in the setting of larger disasters.
Richardson & Kumar [32]	Canberra Wildfire, 2003 Australia	1) Overall, The Canberra Hospital coped well despite significant disruption of staffing and infrastructure. 2) The ED staff specialist activated the "Standby Code Brown" (external disaster) procedure based on available information. 3) As part of the response, clerical staff identified disaster-related cases on arrival; the authors and other ED staff later audited these. 4) There were some weaknesses in previous planning, particularly patient transport and the possibility of hospital evacuation, but the medical outcomes of the response were excellent. 5) Problems that occurred involved interdepartmental or interagency issues.
Matear [33]	Alberta Wildfire, 2016 Canada	What measures would be changed or recommended as a result: 1. proactively establish an ICP (healthcare services) early in anticipation of escalation of events 2. set trigger points for establishing an ICP (healthcare services) as the declaration of a state of local emergency and evacuations within the service area of healthcare services 3. provide emergency communications system (e.g., closed radio system); 4. prepare portable/self-drive emergency and disaster management response unit for rapid ICP deployment 5. establish a system of trained personnel in the ICS roles, ready to deploy within 24 hours; 6. provide mandatory training for both clinical operations and medical staff leaders in the Incident Command System

3.6. Main findings

The systematic review highlights several critical aspects of EMS responses to wildfires from a public health perspective. A major theme that emerged was the integration of telemental health services in disaster response, as observed during the 2009 Victoria Wildfire in Australia, where information hotlines, crisis counseling, and e-therapy saw a significant rise in uptake, emphasizing the need to incorporate these services into mainstream disaster response structures [28]. Similarly, the 2016 Horse Roberta Wildfire in Canada showed the essence of enhancing mental health services, specifically for Indigenous communities, highlighting the need for a health equity lens in disaster planning to confirm equitable access to care [30]. The role of prehospital care and triage was reported in multiple wildfire events, including the 2009 Victoria Wildfire, where effective triage and coordinated response assisted manage minor injuries and prevent overloading burn centers, while also ensuring sufficient surgical resources for severe burns [31]. The 2003 Canberra Wildfire exhibited the efficacy of hospital emergency preparedness through protocols like "Standby Code Brown," though challenges in patient transport and interagency coordination were observed [32]. Lessons from the 2016 Alberta Wildfire underscored the need for proactive Incident Command Planning (ICP), compulsory training for medical staff in disaster management, and the formation of emergency communication systems to improve response efficiency [33]. Furthermore, findings from the 2009 Los Angeles Wildfire indicated the need for expanded paramedic training to manage minor injuries, ensuring timely care when higher-level medical providers are unavailable [29]. Together, these findings emphasize the necessity of robust EMS preparedness, coordination, and adaptive strategies to enhance response effectiveness during wildfire emergencies.

4. Discussion

This study highlights various EMS services, providers, and coverage areas that can help to improve health and medical response to disasters and emergencies like wildfires, including information hotlines, triage, and referral services, clinical consultation, crisis counseling, and e-therapy (system of mental health support and counseling through digital platforms, such as video calls, text messaging, mobile apps, or online chat services). The study also identified several gaps and barriers to emergency responses, such as the absence of training and protocols for paramedics, unavailability of higher-level medical providers, and inadequate mandatory equipment for fireline paramedics, which needs to be addressed. The results of the study comprise increased access to mental health services, such as counseling, psychosocial interventions, and outreach support, which was one of the primary services that adaptations made in response to the crisis, as the needs and expectations of care for local communities and residents after the wildfire were not fully satisfied. The study suggests that post-disaster recovery planning should adopt a health equity lens to reduce disproportionate impacts on local communities and promote sustainable, equitable responses to health-related emergencies.

EMS plays a crucial role in providing prehospital care and medical services. They assess and stabilize patients, prepare first aid, transport patients, and record operations [34]. Similarly, this study found that EMS offers a variety of services, such as clinical services, prehospital care and emergency medical services, counseling support, burn and injury services, and other services like interagency networking, service promotion, upgrades to bushfire referral databases, outreach to affected households, and community mental health services [28–30]. Previous studies also reported that EMS offered a comprehensive disaster response, including fire suppression, public health, and medical needs [35].

EMS providers are a crucial group of medical professionals responsible for providing first aid, treating patients and injuries, transporting patients, and maintaining operational records services during wildfire episodes [36]. While providing these services, they face dangerous situations like severe accidents or life-threatening diseases, making quick decisions and performing complex procedures [36]. In this regard, wildfires in the West require a multimodal approach involving fire extinguishing, medical and public health concerns, and addressing smoke-related effects on the larger population [35]. Additionally, some important factors such as demographic density, locality size, public health policies, and traffic conditions on public roads greatly influence the response performance of medical teams [37,38]. Besides, prehospital triage, senior experienced personnel, and reallocation of trauma and emergency patients also ensured a steady surge capacity at major referral centers [28–33]. Thus, identifying and synthesizing domain-wise EMS services, including barriers and gaps, is essential to developing better plans and programs as the coordinated response to a small number of serious burns does not overload the acute healthcare system.

However, In line with our findings [28–30], previous studies also documented that survivors utilize various private and public recovery resources, including community support, county agencies, FEMA, insurance companies, and philanthropic organizations, to stabilize after a fire [39]. Homeless individuals in California faced significant disruptions during the 2017–2018 wildfires, requiring the support of Homeless Service Organizations (HSOs) as a crucial safety net [40]. Some studies reported that EMS services were sometimes provided by several

healthcare facilities and agencies working together, or the service was offered by a healthcare facility alone. For instance, another study revealed that three or four national agencies collaborated to offer emergency medical services in the event of a wildfire [36]. Therefore, by planning and executing strategies like stress management courses, having psychologist advisors in the emergency medical system, and holding interprofessional meetings, EMS managers and legislators can lessen or alter some of the stresses in this field [36].

The study also found that EMS offered three types of specific EMS coverage areas, including physical and mental health services, referral health services, and clinical and community health services [28–30]. Similarly, recent studies conducted in California showed that the health and medical response to wildfires in California, including facility evacuation and shelter medical support, provides a model of support and resources for other jurisdictions facing increasing wildland fire incidence [35]. On the other hand, studies in the Eastern Mediterranean, Southeastern Europe, and Middle East regions reported that EMS emphasizes the importance of specialized training, sharing expertise volunteer firefighters, specialized vehicles, civil society participation, and advanced data processing and information systems in fire management on contaminated terrain [41]. Therefore, region-specific fire management challenges require locally tailored solutions supported by rational, scientifically based policies, international knowledge transfer, and strengthened regional cooperation [41]. A holistic approach from the EMS perspective was found in SAMU-Asturias response to Asturias wildfires in March-April 2023 with multiple affected areas. In this case, specific actions for EMS were implemented: ambulance relocation to facilitate access to the population; oxygen, oxygen masks, burn care material, and fluids were doubled in all ambulances; six specific logistic vehicles with medical supplies (oxygen, oxygen masks, burn care material and fluids) were placed in strategic areas with risk to be isolated, and primary health care network was integrated in the global response (Fig. 2). It is interesting to highlight that, although EMS is usually linked to short term acute and emergency care, we have found that they play a crucial role in providing services more related to long term outcomes. This may be due to the fact that in EMS daily work, they have integrated a way of working used to face new and unknownd circumstances, and this could be the reason why, when no other agency provide certain long-term service, it is the EMS the one that best has the capacity to adapt to these new circumstances and provide the needed services. This makes us suggest that EMS should be integrated in every phase of the disaster management cycle to identify EMS main strengths in each of them and based on other agencies services [42].

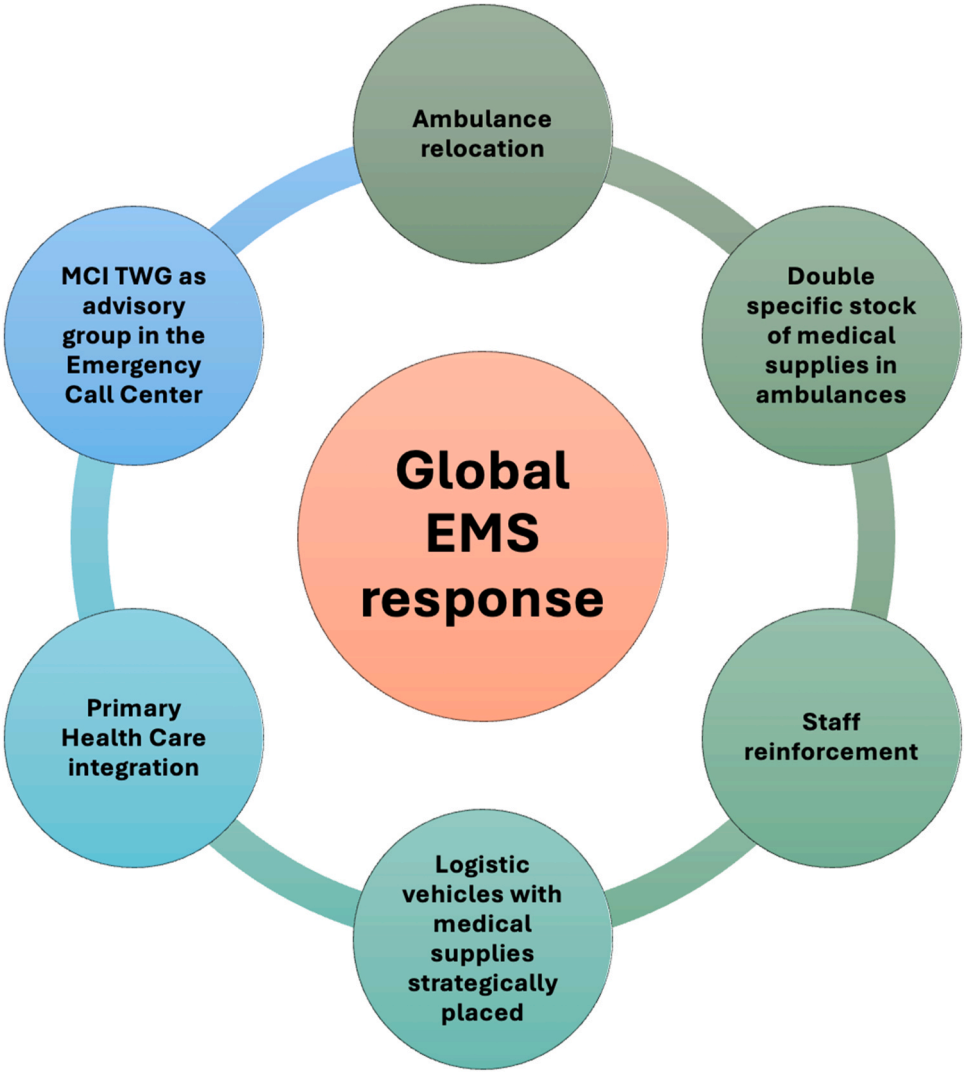

Fig. 2. Global EMS response: example of SAMU-Asturias response to 2023 wildfires. EMS: Emergency Medical Service; MCI: Mass Casualty Incidents; TWG: Technical Working Group.

4.1. Limitations

This review has certain limitations. The high level of diversity among the studies prevented us from conducting a meta-analysis, potentially introducing reporting bias. Our exclusion of non-English language articles and gray literature may have caused us to overlook relevant publications, adding to potential publication bias. Furthermore, our study could not assess surge capacities despite the importance of such assessments in preparing for emergencies like wildfires, as highlighted by multiple studies.

5. Conclusions

As globally wildfires have become increasingly frequent and severe, it is urgent to understand and improve EMS responses during such crises. Findings highlight the critical role of EMS in providing prehospital care, medical services, and mental health support during wildfires. However, gaps such as inadequate training, lack of higher-level medical providers, and insufficient equipment for fireline paramedics were identified. Post-disaster recovery should adopt a health equity lens to address the disproportionate impacts on local communities, ensuring sustainable and equitable emergency responses. It is recommended to enhance access to mental health services for EMS providers and affected communities. Moreover, it is crucial to stress the need for international collaboration and knowledge exchange, making the audience feel part of a global effort. This is beneficial for incorporating best practices and innovative approaches into local and regional wildfire management strategies.

Author contribution statement

RCD: conception and design of the study, acquisition and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted.

NAHM: analysis and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted.

EMV: analysis and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted

RP: analysis and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted

MKH: analysis and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted

HU: design of the study, acquisition of data and analysis and interpretation of data, drafting the article and revising it critically for important intellectual content and final approval of the version to be submitted.

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Declaration of Competing Interest

No conflict of interest for any of the authors

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.burns.2025.107521.

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