Review of Contemporary Philosophy
ISSN: 1841-5261, e-ISSN: 2471-089X
Vol 22 (1), 2023
Pp 4627 – 4638

Prehospital Management of Pediatric Emergencies: Challenges and Innovations for Paramedics

[1]- Fahad Ayed Hassan Al Qahtani,[2]-Ayat Saleh Ali Aldahan,[3]-Saad Mohammed Alharithi,[4]- Hussein Ali Abdo Algohal,[5]-Ali Ahmed Mohammed Alsharif,[6]-Mohammed Moshabbab Abdullah Alqahtani,[7]- Abdullah Saad Alotaibi ,[8]-Bandar Salama Hamad Alanazi,[9]- Ziyad Abdulrahman Ibrahim Alajaji ,[10]-Mohammed Saleem Mahlawi,[11]- Basel Salem Alanazi ,[12]-Abdallh Badr Obaid Almutiri

[1] KSA, Ministry Of Health, Al Quwayiya General Hospital
[2] KSA, Ministry Of Health, Riyadh
[3] KSA, Ministry Of Health, Operations Of The First Riyadh Health Cluster
[4] KSA, Ministry Of Health, Al-Gahma General
[5] KSA, Ministry Of Health, Crisis Management Center, Jazan Region Branch.
[6] KSA, Ministry Of Health, Aseer Health Cluster
[7] KSA, Ministry Of Health, Dawadmi Hospital
[8] KSA, Ministry Of Health, Emergency And Crisis Management And Medical Coordination
[9] KSA, Ministry Of Health, HURAYMILA GENERAL HOSPITAL
[10] KSA, Ministry Of Health, Emergency And Medical Transport Department
[11] KSA, Ministry Of Health, Al Yamamah Hospital
[12] KSA, Ministry Of Health, Third Settlement Riyadh

Abstract

Background: Prehospital care is crucial in emergency medicine, particularly for pediatric patients, as it significantly impacts mortality and morbidity rates. However, disparities in access and quality of these services persist globally, particularly in low- and middle-income countries.

Methods: This narrative review synthesizes recent literature on prehospital management of pediatric emergencies by examining databases such as PubMed up to April 2023. Keywords including "prehospital care," "pediatric emergencies," and "emergency medical services" were utilized to identify relevant studies. The review encompassed various methodological human research, including randomized and observational studies.

Results: The findings reveal that advancements in technology, such as telemedicine and mobile health applications, enhance communication between emergency medical services (EMS) professionals and healthcare providers. Despite these innovations, significant barriers remain, including limited resources, challenges in ethical approvals, and time constraints that hinder the execution of rigorous clinical research in prehospital settings. Moreover, gaps in knowledge related to optimal prehospital treatment methodologies for pediatric patients were identified.

Conclusion: Enhancing prehospital care for pediatric emergencies requires addressing existing challenges through improved collaboration among EMS, hospitals, and academic institutions. The integration of technology and standardized protocols can facilitate better data collection and patient management. Ongoing research is essential to develop evidence-based practices that optimize outcomes for pediatric patients during prehospital care.

Keywords: Prehospital care, pediatric emergencies, emergency medical services, clinical research, technology in healthcare.

Received: 07 October 2023 **Revised**: 22 November 2023 **Accepted**: 06 December 2023

1. Introduction

Prehospital care is an essential component of emergency medicine that entails delivering medical aid to patients before they arrive at a hospital or healthcare institution. The World Health Organization (WHO) reports that injuries and diseases requiring emergency treatment impact millions worldwide, mostly in low- and middle-income nations [1]. Notwithstanding the significance of prehospital care, substantial variations in access to such services exist globally. In some regions, access to emergency medical services may be restricted or nonexistent, whilst in others, the quality of treatment may be substandard. Recently, the American College of Emergency Physicians (ACEP) International Ambassador Country Reports highlighted the disparate access to emergency medical services globally, noting issues such as inequities in access, infrastructural and resource limitations, geographical and financial obstacles, and insufficient international collaboration [2,3]. Notwithstanding these limitations, initiatives are under progress to enhance access to prehospital treatment and mitigate inequities globally. Entities like the WHO and the International Federation of Red Cross and Red Crescent Societies are enhancing training and resources for emergency medical services (EMS) professionals while broadening access to EMS in underprivileged regions.

Prehospital care often serves as the first interaction between a patient and the healthcare system, significantly contributing to the reduction of mortality and morbidity linked to acute diseases and injuries [4]. Clinical research in prehospital care is crucial to guarantee that the treatment administered to patients in this setting is evidence-based and efficacious. This kind of care is often administered by EMS professionals, who are equipped to provide various treatments and interventions to stabilize patients and prepare them for hospital transfer [5]. Prehospital care is crucial for enhancing patient outcomes, since timely intervention may often determine the difference between life and death.

Implementing evidence-based standards and practices may enhance the quality of treatment in the prehospital setting, mitigate the risk of adverse events, and improve patient outcomes [6]. Over the last decade, prehospital care has gotten more complex, as technological advancements and medical treatments enable EMS workers to provide more advanced care in the field. The use of technology in prehospital care is increasingly essential for improving patient outcomes. Significantly, health technology like telemedicine and mobile health applications—including smartphones, tablets, and wearable devices—are propelling this advancement. These technologies possess the capacity to markedly improve communication between prehospital care providers and healthcare professionals [7-9]. The emergence of mobile technology has enabled EMS workers to relay real-time patient data, including essential metrics such as vital signs and electrocardiograms, to hospitals and healthcare providers. This enables hospitals to prepare for the patient's arrival, assuring the availability of critical resources and medical personnel for prompt treatment. Furthermore, novel medical treatments and techniques are now accessible to EMS professionals in industrialized nations, enabling them to provide sophisticated care that was hitherto exclusive to hospital environments [10]. Paramedics are now capable of administering intravenous medications, executing advanced airway management or ultrasonography in critical situations, employing new devices for swift intraosseous access, operating analyzers for cardiac markers or electrolytes in ambulances, and performing life-saving interventions such as needle decompression of tension pneumothorax. Technological and medical developments in prehospital care are revolutionizing the profession and enhancing patient outcomes [11-14].

Recent years have seen an increasing interest in clinical studies about prehospital care. Clinical research in prehospital care is essential to provide healthcare workers with evidence-based recommendations and practices for patient treatment in this setting [15]. Indeed, despite this advancement, substantial gaps remain in our comprehension of optimal prehospital treatment methodologies [16]. A barrier to doing clinical research in prehospital care includes the restricted availability of resources and infrastructure, ethical and regulatory considerations, time limitations, safety issues, data collecting, and the difficulty of choosing a homogenous patient study group [17]. Prehospital care personnel often operate in demanding circumstances, characterized by restricted resources and time limitations. This may hinder the execution of rigorous research in this domain. A further obstacle in executing clinical research in prehospital care is

the need to reconcile research activities with the delivery of prompt and suitable patient care. Prehospital care professionals must consistently prioritize patient demands, which may sometimes clash with the requirements of researchers. Notwithstanding these obstacles, significant progress has been made in clinical studies about prehospital care. Randomized controlled trials (RCTs) have been used to assess the efficacy of several therapies in the prehospital setting, such as advanced airway care, pain management, and mechanical chest compressions during cardiac arrest [18-20]. Moreover, observational studies have been used to ascertain risk factors for adverse outcomes in the prehospital setting and to assess the efficacy of prehospital treatment methods and recommendations. Observational studies have enabled researchers to pinpoint deficiencies in optimal prehospital care methodologies and to formulate ideas for further study [21,22].

This narrative review involved a search of the PubMed electronic database, the predominant platform for English-language medical and scientific literature, up to April 2023. The search terms employed included "prehospital care," "prehospital research," "emergency medical research," "prehospital quality," and "prehospital technology." Supplementary references were obtained by examining the citations in the original papers. This review included all methodological human research, including single-center, multi-center, randomized, and non-randomized, as well as prospective and retrospective investigations.

This review highlights numerous critical aspects for analysis. This encompasses restricted resources and infrastructure, ethical and legal issues, time limitations, data gathering techniques, privacy and safety concerns, along with difficulties in choosing a homogenous research population. The literature research highlights possible solutions to these difficulties. These solutions include promoting strong cooperation between Emergency Medical Services (EMS) and hospital treatment, using (mobile) health technology and artificial intelligence, and implementing standardized procedures and norms. The primary objective of this narrative review is to evaluate the present state of clinical research in prehospital care and identify existing knowledge gaps. Moreover, it aims to elucidate the problems and possibilities that will influence future research initiatives.

2. Current Advances in Prehospital Care

Prehospital care is an advancing domain, with continuous research focused on enhancing patient outcomes and refining emergency medical services [23]. Current clinical research in prehospital care examines several subjects, such as airway management, hemorrhage control, pain management, and stroke treatment [24,25]. Clinical research in prehospital care seeks to determine optimal practices and evidence-based methodologies for treating acute diseases and injuries prior to patient transfer to a hospital [6].

Historically, there was less study focused on the prehospital environment. As EMS systems grew more established and technology advanced, the need for evidence-based methodologies in prehospital treatment became evident. The Advanced Trauma Life Support (ATLS) program, established in the 1970s, is one of the first instances of clinical research in prehospital treatment [26,27]. The program is a methodical strategy for addressing trauma patients in emergency circumstances. It was established by the American College of Surgeons (ACS) as a benchmark for the preliminary evaluation and management of trauma patients. The ATLS program has been expanded to include prehospital treatment and has since received many upgrades aimed at enhancing standardized care, data collecting, quality improvement, and cooperation among healthcare providers [28-46].

The advancement of prehospital care includes improvements in airway management, pain control, and stroke treatment. Current research in airway management includes exploring the use of video laryngoscopy, supraglottic airway devices, and neuromuscular blocking drugs. These efforts seek to enhance the efficacy and safety of endotracheal intubation [47]. Pain treatment is a primary focus of prehospital care, with ongoing research investigating the effectiveness of intranasal fentanyl and ketamine in alleviating acute pain in patients [48]. Moreover, the domain of stroke care is seeing significant expansion in research activities. Research is now investigating the use of mobile stroke units, furnished with sophisticated imaging and treatment technologies, to provide prompt and efficient care to persons displaying acute stroke symptoms [49].

A significant advancement in the progression of clinical research in prehospital treatment originated in the United States with the founding of the National Emergency Medical Services Information System (NEMSIS) in the early 2000s. NEMSIS is a standardized system for data collecting and reporting, including patient information, clinical outcomes, and interventions, particularly tailored for EMS organizations. This collaborative initiative involving federal agencies, EMS stakeholders, and state EMS offices aims to detect trends in prehospital care and to develop a nationwide standard for the collection and dissemination of EMS data [50].

Recently, there has been heightened emphasis on the use of randomized controlled trials (RCTs) in prehospital care research. Randomized controlled trials (RCTs) are regarded as the benchmark for assessing the efficacy of medical therapies, and their use in prehospital care has resulted in substantial progress in the discipline. A recent randomized controlled trial compared prehospital epinephrine to placebo in patients experiencing out-of-hospital cardiac arrest and showed that epinephrine enhanced survival rates to hospital discharge [51]. The research was executed as a randomized, double-blind experiment with 8014 participants across 10 nations. The patients were randomly allocated to receive either epinephrine or a placebo during resuscitation attempts. The main end measure of the trial was survival to hospital release with a satisfactory neurological result. Secondary outcomes included the recovery of spontaneous circulation, survival until hospital admission, and adverse effects. The research indicated that the survival rate of hospital release with a positive neurological result was greater in the epinephrine group than in the placebo group. Nonetheless, the investigation revealed that the administration of epinephrine correlated with an increased incidence of severe neurological damage among survivors. The study underscores the need for more research and enhanced resuscitation methods to optimize patient outcomes in cardiac arrest scenarios.

Alongside randomized controlled trials, there has been a heightened emphasis on observational studies in prehospital care research. Observational studies enable researchers to assess the efficacy of treatments in practical environments and provide significant insights into the effectiveness of interventions that may be impractical to examine via randomized controlled trials (RCTs). New observational research evaluated the impact of prehospital resuscitation with hypertonic solutions on coagulation and fibrinolysis in patients experiencing severe hemorrhagic shock. The study encompassed 34 patients who underwent prehospital resuscitation utilizing hypertonic saline and dextran. It underscores the potential adverse effects of prehospital resuscitation with hypertonic solutions in individuals experiencing traumatic hemorrhagic shock, particularly regarding coagulation and fibrinolysis, thereby advocating for additional research to ascertain optimal resuscitation strategies for this patient population [52].

3. Principal Obstacles in Prehospital Care

Conducting clinical research in prehospital care has distinct problems that might hinder the quality and feasibility of studies in this domain. Prehospital research requires meticulous preparation and implementation due to limited resources, logistical restrictions, ethical issues, and patient safety concerns, in order to guarantee accurate and trustworthy outcomes. Comprehending the problems and possibilities in prehospital clinical research is crucial for developing the discipline and enhancing patient care. In this context, Figure 1 illustrates that the feasibility phase is paramount for any clinical researcher, encompassing essential limited steps such as scientific methodology, personnel management skills, ethical and regulatory compliance, financial dynamics, participant recruitment, information technology and systems, institutional commitment, sample size and power calculation, and objective/endpoint determination. It also delineates the organization and operational communication of these elements for activities including financing, patient recruitment, informed consent processes, safety and protocol deviation reporting, investigational medicinal product administration and destruction, and staff training, all aimed at designing clinical research from observational to investigational phases within the action plan.

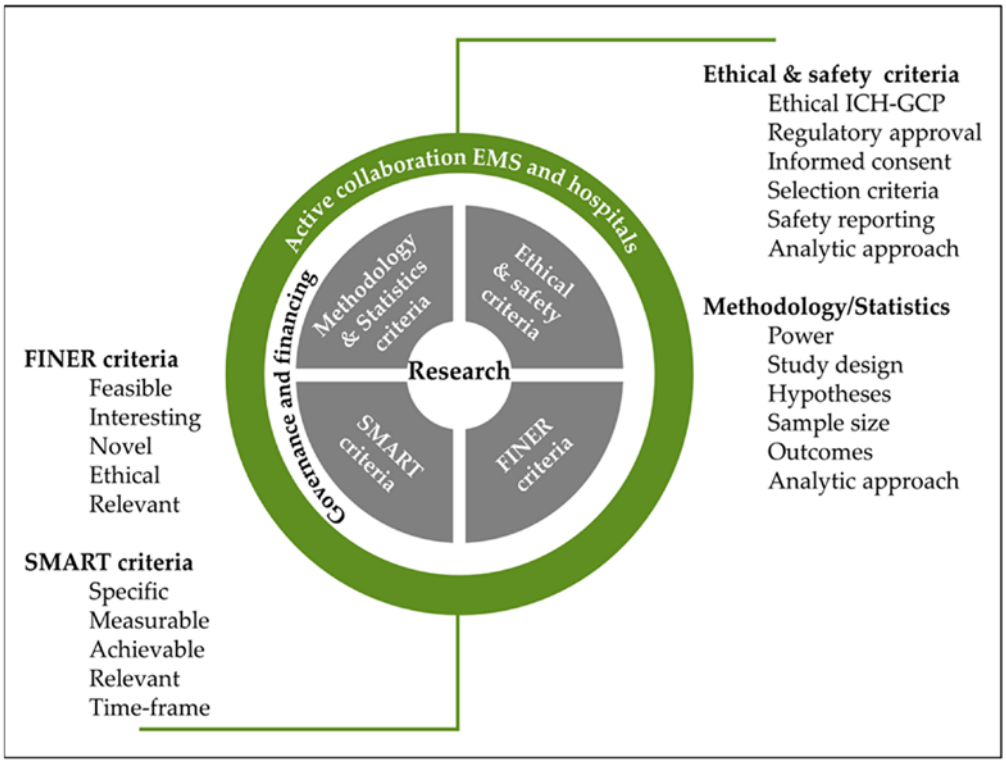

Figure 1. Criteria for the feasibility of developing and achieving success in a clinical research study focused on prehospital care.

4. Constrained Resources and Infrastructure

The restricted resources in prehospital care for research provide considerable obstacles to scientific inquiry, leading to insufficient sample sizes, poor data collecting, and variable results. The problems arise mostly from the characteristics of prehospital care, whereby medical practitioners must address emergency circumstances with limited time, resources, and knowledge [53]. A major difficulty in prehospital care research is the restricted availability of financing. Prehospital care often suffers from inadequate funding and is given less attention relative to other sectors of healthcare. The deficiency of financing results in a restricted array of resources to facilitate study in this domain. Consequently, several researchers have difficulties in obtaining financing for their inquiries, potentially resulting in underpowered studies with restricted generalizability [54]. Emergency medical services professionals often have excessive workloads, prioritizing the provision of rapid medical treatment to patients [55]. Consequently, recruiting staff for research projects or dedicating time to data collection might be arduous. Furthermore, prehospital care infrastructure is often fragmented, including many entities that use distinct protocols and resources [56]. This complicates the standardization of data collection and processing across several locations, resulting in uneven conclusions. The absence of access to prehospital care data is a substantial impediment to study in this domain [57]. Prehospital care data are often fragmented and scattered across several entities, complicating the collection, integration, and analysis of the information. Data privacy and security concerns may restrict data exchange across agencies and groups, thus complicating the research process. Notwithstanding these limitations, there is an increasing acknowledgment of the significance of prehospital care research in enhancing patient outcomes and refining care delivery.

5. Ethical Considerations

Conducting clinical research in the prehospital environment presents challenges owing to many ethical issues that must be addressed [58-60]. This encompasses issues about informed consent, confidentiality, privacy, and autonomy. Moreover, the prehospital environment presents distinct problems, including time limitations, patient severity, and the likelihood of crises, which might further complicate the ethical implications of doing research in this context. A primary ethical aspect in prehospital research is informed

consent. Patients in the prehospital environment often experience distress and may be incapable of giving informed permission for study involvement [61]. Furthermore, circumstances may arise in which obtaining informed permission promptly is unfeasible owing to the patient's health or the exigency of the situation [62]. In such instances, alternate approaches for acquiring informed permission, such as postponed or waived consent, may need consideration [63]. Confidentiality and privacy are significant ethical issues in prehospital research. Patients' medical information is confidential and requires safeguarding. Researchers must implement measures to guarantee the confidentiality of patients' data and prevent unwanted access. Furthermore, patients' privacy rights must be upheld, and their personal information should be obtained just for explicitly specified and elucidated study aims. A further significant ethical concern in prehospital research is autonomy. Patients have the freedom to choose their treatment, and their autonomy must be honored throughout the research process. Patients must have the chance to refuse involvement in research, and their decisions should be honored without adverse effects on their treatment [64]. Ethical issues in prehospital research are crucial to guarantee that studies are done respectfully, safely, and advantageously for patients. Researchers and EMS professionals must recognize and include these ethical issues while developing and executing research projects in the prehospital environment.

6. Effects of Time Limitations

Timeliness is critical in prehospital treatment. Emergency medical responders must operate swiftly and effectively to provide essential treatment to patients in crisis circumstances. In cases of heart attack, stroke, or catastrophic injury, every second is critical for delivering life-saving care to those in need. Given the paramount importance of time in prehospital treatment, emergency medical responders must operate under pressure and prioritize their activities to enhance the likelihood of a favorable result. In this environment, comprehending and adeptly managing time limitations in prehospital treatment is crucial for preserving lives and enhancing patient outcomes [65,66].

Researchers may have a constrained timeframe to gather data in prehospital care environments, particularly when studying emergency medical responders in real-world scenarios [67]. They must efficiently gather precise and significant data within a limited timeframe while reducing the effect on patient care. Time restrictions may result from several circumstances, including the need to swiftly stabilize and transfer patients, the unpredictability of emergencies, and the restricted availability of EMS services [68]. To optimize the advantages of prehospital research, it is crucial to mitigate the temporal limitations on study execution, data acquisition, analysis, and privacy concerns inherent to this environment [69].

7. Safety Issues

Prehospital care workers often function in high-pressure settings, necessitating quick and precise decision-making to provide optimal patient outcomes. A primary concern in prehospital care research is safeguarding the well-being of both patients and care workers. Given the exigent circumstances of prehospital treatment, clinicians may encounter perilous environments or violent occurrences, increasing the likelihood of injury or damage. Researchers must use suitable methods to guarantee the safety and welfare of all participants in prehospital care study. This may include the implementation of stringent guidelines to mitigate hazards and ensuring that all prehospital care professionals have adequate training and instruction on research protocols [70]. These rules and procedures aim to guarantee that patients have the utmost quality of treatment while reducing the likelihood of medical mistakes or adverse outcomes. These protocols may include processes for evaluating patient requirements, establishing a suitable treatment plan, and ensuring the safe transportation of patients to the hospital [71]. The problems and hazards inherent with prehospital treatment include environmental elements like inclement weather, as well as patient-specific considerations such as the severity of the ailment, comorbidities, and the patient's age or choices [72]. Moreover, healthcare providers must address transportation-related hazards, including accidents or equipment failures [73].

A major difficulty is the absence of medical resources often seen in a hospital environment [74]. This necessitates that prehospital clinicians must swiftly make judgments based on the information at hand, sometimes with few resources available. This may result in scenarios when healthcare practitioners must

depend on their training and expertise to provide treatment promptly and efficiently. A further problem in prehospital care is the need for good communication among healthcare personnel [75]. Prehospital providers must communicate efficiently with one another and with hospital personnel to guarantee that patients get necessary treatment. Failures in communication may result in treatment delays, misdiagnoses, and other negative outcomes. Training is a crucial element in guaranteeing safety in prehospital treatment. Healthcare personnel must complete comprehensive training to evaluate patient requirements, provide appropriate treatment, and react to crises. Continuous training and education are essential for healthcare personnel to remain current with the newest methods and best practices [76]. Another essential element is the use of suitable equipment and technology. Healthcare personnel depend on many instruments and apparatus to provide care, including defibrillators, oxygen tanks, and stretchers. Maintaining this equipment in optimal condition is crucial for delivering safe and effective treatment [77].

Healthcare professionals face several obstacles and dangers while delivering treatment outside of a hospital environment, making safety policies and procedures crucial for risk mitigation [78]. Effective communication, continuous training, and the use of suitable equipment and technology are essential elements for assuring patient safety in pre-hospital care. By emphasizing safety in all facets of prehospital care, healthcare practitioners may enhance patient outcomes and provide the utmost quality of care.

Clinical research in prehospital care is crucial for enhancing the quality of patient care in this setting. Notwithstanding the obstacles, researchers in this domain have achieved considerable advancements in recognizing effective therapies and enhancing patient outcomes. Research can elucidate optimal strategies for emergency response and condition management, in addition to fostering the development of innovative technology and treatments for prehospital care. Ongoing research and innovation will be essential to guarantee that prehospital care professionals possess evidence-based standards and practices for patient treatment in this vital context.

To tackle the obstacles of prehospital clinical research, researchers must meticulously prepare and implement their studies, considering the distinct limitations and factors of prehospital treatment. This may include collaborating closely with EMS agencies and other healthcare practitioners to develop research guidelines and guarantee that investigations are executed safely and ethically. Furthermore, researchers would need to use emerging technology and data sources to gather and evaluate information from prehospital care settings.

8. Conclusions

In summary, clinical research in prehospital care is crucial for enhancing patient outcomes and formulating evidence-based best practices. The progression of clinical research in prehospital care has resulted in substantial breakthroughs, enhancing outcomes for patients experiencing acute medical crises. The domain of prehospital care poses several hurdles to clinical research, such as restricted resources, ethical dilemmas, time limitations, safety issues, and difficulties in data collection and processing. There are numerous opportunities and perspectives for enhancing clinical research in this domain, including the implementation of telemedicine and remote monitoring, simulation-based training, standardized protocols and guidelines, and collaborations among EMS providers, hospitals, and academic institutions.

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إدارة الطوارئ لدى الأطفال قبل الوصول إلى المستشفى: التحديات والابتكارات للمسعفين

الملخص

الخلفية :تعتبر الرعاية قبل الوصول إلى المستشفى أمرًا حيويًا في طب الطوارئ، خاصةً للمرضى الأطفال، حيث تؤثر بشكل كبير على معدلات الوفيات والمراضة. ومع ذلك، لا تزال الفجوات في الوصول إلى هذه الخدمات وجودتها قائمة على مستوى العالم، لا سيما في البلدان ذات الدخل المنخفض والمتوسط.

الطرق :تستعرض هذه المراجعة السردية الأدبيات الحديثة حول إدارة الطوارئ لدى الأطفال قبل الوصول إلى المستشفى من خلال فحص قواعد بيانات مثل PubMed حتى أبريل 2023. تم استخدام كلمات مفتاحية مثل "الرعاية قبل الوصول إلى المستشفى"، "طوارئ الأطفال"، و"خدمات الطوارئ الطبية" لتحديد الدراسات ذات الصلة. شملت المراجعة مجموعة متنوعة من الأبحاث البشرية المنهجية، بما في ذلك الدراسات العشوائية والدراسات الملاحظة.

النتائج :تكشف النتائج أن التقدم في التكنولوجيا، مثل الطب عن بُعد وتطبيقات الصحة المحمولة، يعزز التواصل بين محترفي خدمات الطوارئ الطبية (EMS)ومقدمي الرعاية الصحية. على الرغم من هذه الابتكارات، لا تزال هناك حواجز كبيرة، بما في ذلك الموارد المحدودة، والتحديات المتعلقة بالموافقات الأخلاقية، والقيود الزمنية التي تعيق تنفيذ الأبحاث السريرية الصارمة في بيئات ما قبل المستشفى. علاوة على ذلك، تم تحديد فجوات في المعرفة المتعلقة بأساليب العلاج الأمثل قبل الوصول إلى المستشفى للمرضى الأطفال.

الخاتمة :يتطلب تحسين الرعاية قبل الوصول إلى المستشفى في حالات الطوارئ للأطفال معالجة التحديات الحالية من خلال تعزيز التعاون بين خدمات الطوارئ الطبية، والمستشفيات، والمؤسسات الأكاديمية. يمكن أن يسهل دمج التكنولوجيا والبروتوكولات الموحدة جمع البيانات بشكل أفضل وإدارة المرضى. إن البحث المستمر أمر ضروري لتطوير ممارسات قائمة على الأدلة تهدف إلى تحسين النتائج للمرضى الأطفال أثناء الرعاية قبل الوصول إلى المستشفى.

الكلمات المفتاحية :الرعاية قبل الوصول إلى المستشفى، طوارئ الأطفال، خدمات الطوارئ الطبية، البحث السريري، التكنولوجيا في الرعاية الصحية.