Review Paper

Investigating the Role of Artificial Intelligence in Pediatric Emergencies: A Narrative Review

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ABSTRACT

Background: Artificial intelligence (AI) and machine learning (ML) are transforming healthcare by enhancing diagnostic accuracy, predictive capabilities, and clinical decision-making. In pediatric emergencies, where rapid diagnosis and treatment are critical, AI offers unique advantages, including addressing challenges like complex comorbidities and limited access to specialized care.

Objectives: This narrative review examines the current applications, benefits, and limitations of artificial intelligence in pediatric emergencies, focusing on diagnostic support, predictive analytics, clinical decision-making, and medical imaging.

Methods: A systematic review of articles (2013–2023) from PubMed, Scopus, and Google Scholar was conducted using keywords such as “artificial intelligence” and “pediatric emergencies.” Relevant studies were identified and analyzed for AI’s clinical applications, outcomes, and impact.

Results: Diagnostic support has seen significant advances with AI models improving the early detection of conditions like pediatric sepsis, offering better accuracy and timeliness compared to traditional methods. In predictive analytics, AI tools forecast clinical deterioration in pediatric patients, enabling preemptive interventions in critical care settings. Clinical decision support systems (CDSSs) powered by AI assist clinicians with real-time recommendations, reducing errors and improving adherence to guidelines. In medical imaging, AI enhances the interpretation of imaging studies such as x-rays and computed tomography scans, expediting the diagnosis of fractures, hemorrhages, and other conditions.

Conclusions: AI holds significant promise in transforming pediatric emergency care by enhancing accuracy, efficiency, and outcomes. However, addressing challenges related to data quality, ethical considerations, and workflow integration is critical to unlocking its full potential. Collaborative efforts between clinicians, data scientists, and policymakers will be essential for successfully implementing AI in this field.

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Introduction

Scientific and technological progress has been greatly enhanced by the emergence of artificial intelligence (AI), with machine learning (ML) serving as a crucial catalyst. ML allows computers to learn autonomously without direct programming by merging principles from computer science and statistics [1, 2]. The rise of innovative tools like ChatGPT, Bard, and Glass AI 2.0 has propelled ML into numerous sectors, notably healthcare. These tools are reshaping industries by facilitating interactions between humans and machines. ChatGPT, as a large language model (LLM), holds tremendous potential for supporting healthcare, including assisting individuals with mental health challenges and aiding healthcare professionals in their decision-making processes [1, 3, 4]. Recently, Glass Health released Glass AI 2.0, akin to ChatGPT, but featuring a clinical knowledge database curated and managed by clinicians to generate differential diagnoses and clinical action plans [1, 5]. The integration and applicability of such AI tools in healthcare are rapidly expanding. Pediatrics, facing practical obstacles such as intricate comorbidities, rising emergency admissions, and limited access to pediatric care providers, could see improvements in delivering quality and timely care [1, 6]. Implementations of ML can optimize the pediatric workforce and support clinical decision-making, allowing physicians to concentrate on patient-centered care plans by utilizing their clinical expertise and time more effectively [1, 2]. ML methodologies can process extensive datasets and formulate predictive models that surpass human cognitive limitations [1].

Pediatric emergencies present unique challenges due to the distinct physiological and developmental attributes of children, which markedly differ from those of adults. These variations require customized strategies for diagnosis and treatment, as pediatric patients frequently exhibit nonspecific symptoms that can quickly progress to life-threatening situations. The risks are considerable, as any delays or inaccuracies in diagnosis and intervention can have serious long-term impacts on a child's health and development.

AI has surfaced as a revolutionary element across multiple healthcare sectors, providing unparalleled abilities in data analysis, pattern identification, and predictive modeling. In pediatric emergency care, AI holds the promise to transform how clinicians conduct diagnosis, treatment, and prognosis, thus enhancing patient outcomes. By utilizing extensive data from electronic health records, medical imaging, and various other resources, AI systems can assist clinicians in making well-informed and prompt decisions [7].

The use of AI in pediatric emergencies is especially encouraging given the intricate and immediate nature of these cases. AI can aid in spotting subtle clinical trends that even the most seasoned practitioners might miss, thereby improving diagnostic precision. Additionally, AI-driven predictive analytics can foresee patient decline, allowing for earlier and more effective interventions. As technology progresses, incorporating AI into pediatric emergency departments could alter care standards, boosting both efficiency and outcomes [7].

This review intends to deliver a comprehensive examination of the present role of AI in pediatric emergencies, emphasizing crucial applications, results, and challenges. This article pinpoints areas where AI has made notable contributions, as well as those requiring additional research and development, by reviewing the existing literature.

Methods

A systematic literature review was conducted using electronic databases, including PubMed, Scopus, and Google Scholar. The search strategy involved the use of specific keywords such as "artificial intelligence," "pediatric emergencies," "machine learning," "clinical decision support systems," "predictive analytics," and "medical imaging." The inclusion criteria focused on articles published between 2013 and 2023 that discussed AI applications in pediatric emergency settings. Both qualitative and quantitative studies were considered to provide a comprehensive overview of the topic.

The selection process consisted of an initial evaluation of article titles and abstracts to identify pertinent studies, followed by a comprehensive review of full texts to assess eligibility based on the study's goals, methodologies, findings, and conclusions. Data extraction was conducted methodically to gather essential information related to the function of AI in pediatric emergencies, including the type of AI application, the study population, the outcomes measured, and the clinical impact of AI interventions.

Results

The review revealed several critical areas where AI has been utilized in pediatric emergency care. These domains encompass diagnostic assistance, predictive analytics, clinical decision support systems (CDSS), and medical imaging. Each of these applications holds significant potential to substantially improve the quality of care delivered in pediatric emergency environments.

Diagnostic assistance

AI has played a key role in enhancing diagnostic precision in pediatric emergencies. ML algorithms, trained on extensive datasets, can discern intricate patterns in clinical data that human clinicians may easily overlook. For example, AI models have been created to aid in the early identification of pediatric sepsis, a condition where prompt intervention is vital. These models have shown greater effectiveness than conventional diagnostic techniques, resulting in earlier and more precise identification of sepsis [8].

Predictive analytics

Predictive models that utilize AI have been developed to anticipate clinical decline in pediatric patients. These models evaluate a variety of factors, including vital signs, lab results, and historical data, to predict outcomes, such as the necessity for intensive care or the probability of mortality. In pediatric intensive care units, where patients face critical illness, AI has demonstrated its capability to forecast adverse events, thereby facilitating preemptive interventions that could save lives [9, 10].

CDSSs

AI-driven CDSS has been adopted in certain pediatric emergency departments to assist clinicians in making evidence-based decisions. These systems compile real-time data from diverse sources, offering recommendations that aid clinicians in navigating complex clinical situations. Research has indicated that CDSS can alleviate cognitive burdens, lower the chances of errors, and enhance patient outcomes, especially in high-pressure emergency circumstances [11].

Medical imaging

AI applications in medical imaging have been especially influential in pediatric emergencies. ML algorithms can swiftly and accurately analyze imaging studies, including x-rays, computed tomography scans, and magnetic resonance images. This capability is critical in emergencies where timing is vital. AI tools have been employed to identify fractures, intracranial hemorrhages, and other urgent conditions with high precision, often matching or surpassing the performance of human radiologists [12, 13].

Discussion

The incorporation of AI in pediatric emergency care signifies a notable improvement in the ability to change clinical practices. Nevertheless, despite the significant advantages, numerous obstacles and constraints need to be tackled to fully harness AI's capabilities in this area.

Improving diagnostic precision

AI's capability to process and scrutinize large volumes of data enables it to uncover patterns and connections that may not be immediately visible to healthcare professionals. This skill is especially crucial in pediatric emergency care, where medical conditions can change swiftly and present in unusual patterns. AI-powered diagnostic tools can offer a secondary opinion, minimizing the chances of misdiagnosis and ensuring that critical conditions are recognized and addressed without delay. For instance, the application of AI in identifying pediatric sepsis has demonstrated that prompt detection and intervention can greatly lower mortality rates. In terms of triage enhancement, AI algorithms can evaluate patient information to prioritize cases according to severity, guaranteeing that critical cases receive prompt attention. Research has indicated that ML models can surpass conventional triage systems by accurately forecasting patient acuity levels, thereby enhancing emergency department performance and patient outcomes. However, reliance on AI brings up issues concerning overreliance, where healthcare providers might excessively depend on AI suggestions, potentially overlooking clinical judgment and individualized patient factors.

Predictive analysis and risk assessment

Predictive analysis stands out as one of the most exciting applications of AI in pediatric emergencies. By identifying patients at an elevated risk of deterioration, AI facilitates early intervention, which is essential in environments where timing is critical. These predictive models can assess continuous data streams like vital signs and lab results, offering real-time evaluations of risk. Nonetheless, the success of these models relies on the quality and breadth of the data used for training. Pediatric data is frequently more diverse than adult data, with discrepancies arising from age, weight, and developmental stages. It is crucial to ensure that AI models are trained on varied, high-quality datasets to avoid biases and inaccuracies that might jeopardize patient care.

CDSSs

AI-enhanced CDSS can assist healthcare professionals in making better-informed choices by providing evidence-based recommendations tailored to the patient's immediate condition. For example, software can be designed to ascertain precise drug dosages for children or to make clinical choices based on medical history and physical examinations. By gathering information such as patient symptoms and relevant data, these software programs can deliver the most accurate diagnosis and treatment in the least amount of time. These systems can alleviate the cognitive load on clinicians, who often face the necessity of making quick decisions under stress. The introduction of AI in CDSS has demonstrated improved adherence to clinical practices and decreased error rates. However, the deployment of these systems necessitates careful consideration of their integration into existing workflows. Poorly designed systems that disrupt established procedures can lead to frustration among clinicians and lower acceptance rates. Additionally, there are concerns about the transparency of AI algorithms in CDSS, as a lack of comprehension regarding how recommendations are formed could engender mistrust among healthcare providers.

Medical imaging and radiology

Significant advancements have been made in medical imaging through AI, with algorithms that can interpret images with a level of precision akin to that of expert radiologists. In pediatric emergencies, where swift action is crucial, AI has the potential to accelerate the diagnostic process, facilitating quicker treatment decisions. The application of AI for detecting fractures, intracranial hemorrhages, and other critical health issues has shown considerable promise. However, the effectiveness of AI in medical imaging is heavily reliant on the quality of training data. Pediatric imaging data tends to be less plentiful compared to adult imaging data, which presents challenges in creating robust models. Although numerous studies indicate high diagnostic accuracy, many algorithms have not been validated using external datasets [14].

Ethical and legal considerations

The implementation of AI in pediatric emergencies presents various ethical and legal issues. Concerns regarding patient privacy, data protection, and the risk of algorithmic bias must be thoroughly addressed. In pediatric healthcare, where patients are frequently unable to provide informed consent, the ethical ramifications of utilizing AI-driven tools are particularly significant [7]. The question of legal responsibility in situations where AI influences clinical decisions remains ambiguous. It is crucial to establish clear guidelines and regulations to oversee the use of AI in pediatric emergencies, ensuring its application is both safe and ethical.

The future of artificial intelligence in pediatric emergencies

The outlook for AI in pediatric emergencies is bright, with ongoing research and development focused on overcoming existing challenges. Innovations in AI, especially within natural language processing, ML, and big data analytics, are expected to enhance the effectiveness of AI tools, making them more precise and trustworthy. Additionally, as AI systems become increasingly incorporated into clinical workflows, they have the potential to lower healthcare costs by boosting efficiency and reducing the occurrence of adverse events.

Nevertheless, for AI to fully realize its potential in pediatric emergency care, collaboration among clinicians, data scientists, and policymakers is crucial. Creating AI tools that are clinically effective and user-friendly, and dependable will necessitate a multidisciplinary approach. Furthermore, ongoing education and training for clinicians are essential to ensure they are proficient in effectively utilizing AI in their practice.

Conclusion

AI presents substantial potential to enhance the management of pediatric emergencies by delivering rapid, precise, and data-informed insights. This technology has already proven its worth by improving diagnostic accuracy, predicting patient outcomes, and aiding clinical decision-making. However, to fully harness AI's capabilities in this domain, it is vital to confront challenges related to data quality, workflow integration, and ethical considerations. As AI continues to advance, it is expected to play an increasingly significant role in pediatric emergency care, ultimately resulting in improved outcomes for young patients.

Ethical Considerations

Compliance with ethical guidelines

This article is a narrative review and did not involve human or animal subjects. Hence, no ethical considerations were applicable.

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Authors contributions

Conceptualization and supervision: Javad Sadeghinasab; Methodology and investigation: Zeynab Atarodi; Writing: All authors.

Conflicts of interest

The authors declared no conflict of interest.

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