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THE FUTURE OF AI IN PREHOSPITAL EMERGENCY CARE: A REVIEW OF EMERGING TECHNOLOGIES AND TRENDS

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Abstract:
The integration of artificial intelligence (AI) into prehospital emergency care is significantly transforming patient management and enhancing outcomes within emergency medical services (EMS). This literature review explores emerging AI technologies and trends, focusing on their diverse applications, such as improving decision-making, optimizing triage processes, and enabling remote diagnosis. While the potential benefits of AI are substantial, several challenges remain, including variability in technology adoption, concerns about data reliability, and the need for adequate training among emergency personnel. These challenges highlight the critical need for comprehensive frameworks that facilitate the effective integration of AI into prehospital care settings. This review aims to provide valuable insights into the transformative role of AI in prehospital emergency care and outlines recommendations for future research and implementation strategies. By addressing these factors, we can better harness AI's potential to improve patient outcomes and operational efficiency in EMS.

Keywords: *Artificial Intelligence, Prehospital Emergency Care, Emergency Medical Services, Triage Optimization, Decision Support Systems*

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1.INTRODUCTION:

The integration of artificial intelligence (AI) into prehospital emergency care represents a transformative shift in how medical professionals approach patient management. With the increasing prevalence of out-of-hospital emergencies, timely and accurate decision-making is critical for improving patient outcomes. AI technologies are emerging as powerful tools for enhancing the efficiency and effectiveness of emergency medical services (EMS) by providing real-time data analysis, predictive analytics, and decision support systems (Toy et al., 2023; Chee, 2023). Recent studies highlight the potential of AI to optimize triage processes, assess patient conditions, and facilitate remote diagnosis in prehospital settings. For instance, systems that utilize machine learning algorithms to analyze patient data and symptoms can significantly improve triage accuracy, ensuring that patients receive appropriate care promptly (Hedderson et al., 2023). Moreover, the application of AI in processing imaging data, such as ocular images in eye emergencies, showcases the potential for AI to assist in primary diagnosis, ultimately leading to more effective treatment strategies (Chen et al., 2023). As AI technologies continue to evolve, understanding their implications for prehospital emergency care is crucial. This literature review aims to explore emerging AI technologies and trends within the field, focusing on their applications, effectiveness, and future directions. It seeks to provide insights into how AI can reshape the landscape of prehospital emergency care.

1.1. Statement of the problem

The integration of artificial intelligence (AI) into prehospital emergency care represents a transformative shift in how medical professionals approach patient management. With the increasing prevalence of out-of-hospital emergencies, timely and accurate decision-making is critical for improving patient outcomes. AI technologies are emerging as powerful tools for enhancing the efficiency and effectiveness of emergency medical services (EMS) by providing real-time data analysis, predictive analytics, and decision support systems (Toy et al., 2023; Chee, 2023).

Despite these advancements, the implementation of AI in prehospital settings faces several challenges, including variability in technology adoption, concerns about data reliability, and the need for training among emergency personnel. Additionally, there is a lack of comprehensive understanding regarding the specific AI applications that would most benefit prehospital care and how these technologies can be integrated into existing workflows.

This literature review aims to address these gaps by exploring emerging AI technologies and trends within the field, focusing on their applications, effectiveness, and future directions. The specific objectives of the study are to:

- To review existing literature on the application of AI in prehospital emergency care.
- To identify and categorize emerging AI technologies relevant to EMS.
- To propose recommendations for the successful integration of AI into EMS practices.

2. METHODOLOGY:

2.1. Research Design

This study utilized a literature review methodology to examine the emerging technologies and trends concerning artificial intelligence (AI) in prehospital emergency care. This approach facilitates a comprehensive exploration of published articles, academic studies, and relevant sources, aiming to provide insights into the role of AI in enhancing decision-making processes and improving patient outcomes in emergency services.

2.2. Search Strategy

A comprehensive search was conducted across several electronic databases, including PubMed, CINAHL, ScienceDirect, and MEDLINE. The search terms utilized included "artificial intelligence," "prehospital emergency care," "emergency medical services," "emerging technologies," and related keywords. The review was limited to articles published in English between January 2000 and 2024, while also considering foundational studies from earlier years that remain relevant to current practices. This review aims to establish a foundation for recommendations that support the integration of AI technologies in prehospital emergency care.

2.3. Inclusion and Exclusion Criteria

To be included in the review, studies had to meet specific criteria: they needed to focus on the application of AI technologies in prehospital emergency care settings, be published in peer-reviewed journals, and be available in full-text format. Studies were excluded if they concentrated solely on hospital-based factors, did not present original research (such as reviews or commentaries), or were not written in English.

2.4. Study Selection and Data Extraction

The initial search results were screened by title and abstract to identify relevant studies. The full texts of potentially eligible studies were then evaluated against

the established inclusion and exclusion criteria. Data extraction concentrated on study design, setting, sample characteristics, key findings, and factors pertinent to the implementation of AI technologies in prehospital contexts. The researchers filtered primary studies, excluding those that did not align with the focus of the review.

2.5. Quality Assessment

The methodological quality of the studies included in the review was assessed using the Newcastle-Ottawa Scale for observational studies. This 9-point scale evaluates studies based on participant selection, group comparability, and outcome ascertainment, ensuring that the literature reviewed adheres to rigorous quality standards.

2.6. Data Synthesis

A narrative synthesis was performed to summarize the key findings from the included studies. Factors influencing the adoption and effectiveness of AI technologies in prehospital emergency care were categorized and described, alongside an assessment of the strength and consistency of the evidence. In instances where applicable, a meta-analysis may be conducted to pool quantitative estimates of effect sizes across studies, offering a clearer understanding of AI's impact in this critical area.

2.7. Ethical Considerations

As this study involved a review of existing literature, no ethical approval was required. All included studies adhered to ethical standards for research involving human subjects.

2.8. Limitations

This review acknowledges potential limitations, including publication bias and the variability in study designs and methodologies across the included articles. Future research should aim to address these limitations by conducting empirical studies that further validate the effectiveness of AI technologies in prehospital emergency care.

3. RESULTS:

3.1. Search Results

After performing the comprehensive database search, 738 relevant citations were found since 2000 to 2024. Endnote was used to remove all potential duplicates and managed to find and exclude 357 duplicates among the different databases. After title/abstract screening of the remaining citations (n = 96), the full texts of relevant articles (n = 71) were also reviewed. Finally, 25 articles were included. These steps are summarized in the PRISMA flow chart in Figure 1

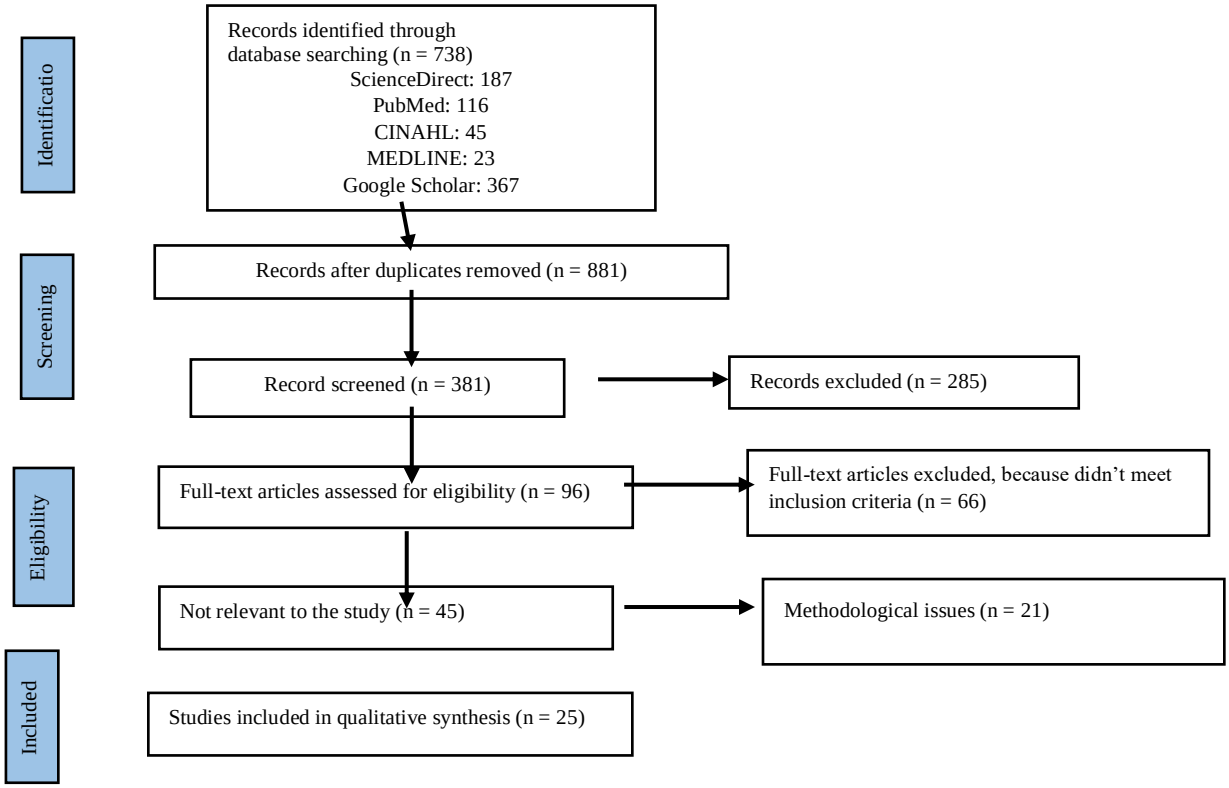

Figure 1:Figure 1: the PRISMA flow Chart

3.2. Integrate Research Results

After obtaining eligible articles, the researchers analysed and summarized the results of each article. Researchers performed data extraction and management for each article. Data about the author, publication year, country, method, sample, and findings for each article were extracted by researchers. All article evaluations used the PRISMA guidelines. Next, the researchers grouped the results of the study based on groups Prehospital Time (PT) and Influence Factors (see Table 1)

Table 1: Findings from Recent Studies on the Future of AI in Prehospital Emergency Care

Author(s) & Year	Aim of the Study	Research Methodology	Findings	Recommendations
Kang et al. (2020)	Develop and validate an AI algorithm for predicting the need for critical care in EMS.	Analysis of a large dataset (8.9 million visits) from the Korean National Emergency Department Information System.	AI algorithm achieved an AUC of 0.867, outperforming traditional triage tools.	Suggests enhancing decision-making in prehospital settings using AI.
Shimada et al. (2024)	Evaluate the integration of AI in perioperative anesthetic management.	Systematic review and meta-analysis of 8 RCTs involving 568 patients.	AI-assisted interventions showed promise but no significant differences in hypotension-related outcomes.	Calls for comprehensive approaches to integrate AI into clinical practice.
Cimino and Braun (2023)	Discuss the evolving landscape of clinical research in prehospital care.	Narrative review analyzing existing literature.	Identifies challenges like limited resources, ethical concerns, and the need for collaboration.	Advocates for further research to develop evidence-based guidelines.
Chee et al. (2023)	Analyze AI applications in prehospital emergency care.	Scoping review of 106 studies.	AI outperformed traditional methods, but most studies lacked rigorous prospective validation.	Emphasizes the need for explainable AI for clinician trust.
Masoumian Hosseini et al. (2023)	Explore AI applications and ethical concerns in emergency medicine.	Comprehensive literature search and thematic analysis.	Rapid increase in AI research, but decision-making lacks transparency.	Proposes an ethical framework for AI integration in emergency departments.
Toy et al. (2024)	Investigate AI applications in prehospital care for traumatic injuries.	Systematic review of 49 publications.	Most studies aimed to predict critical care needs; significant gaps in external validation and pediatric focus.	Recommends further research to standardize models and explore real-time implementation barriers.
Kim et al. (2020)	Assess the role of 5G technology in enhancing prehospital emergency care.	Review discussing the benefits and challenges of 5G implementation.	Highlights advantages like real-time data transmission but notes challenges such as regulatory limitations.	Calls for collaboration among stakeholders to maximize 5G benefits in emergency care.
Hedderson et al. (2025)	Explore the use of speech recognition technology in paramedicine documentation.	Scoping review of studies published from 2014 to March 2024.	Identifies potential for SR technology to enhance report efficiency but highlights the need for real-world testing.	Recommends user-centered design for effective SR technology integration.
Toy et al. (2023)	Examine AI's role in supporting EMS personnel during out-of-hospital cardiac arrest care.	Comprehensive search of databases, analyzing 54 studies.	Identified trends in AI applications for OHCA care but noted limited research overall.	Suggests further studies to enhance AI's role in resuscitation efforts.

Chenais et al. (2023)	Explore AI's current applications and challenges in emergency medicine.	Review of existing AI systems in emergency settings.	AI can improve diagnosis and triage but requires rigorous evaluation for safety and efficacy.	Advocates for comprehensive integration of AI in routine clinical care.
Meyer et al. (2024)	Review AI integration in acute care settings.	Systematic review focusing on patient journey and AI applications.	Research largely overlooks patient perspectives; only a small percentage focus on real-world clinical settings.	Urges exploration of AI's impact on both staff and patient experiences.
Ahmadzadeh et al. (2024)	Protocol for a living review on AI's impact on ED wait times.	Living systematic review methodology with biannual updates.	Initial literature search identified significant articles addressing AI's potential to reduce wait times.	Emphasizes the need for continuous monitoring of new evidence.
Jentzer et al. (2023)	Explore AI applications in cardiac intensive care units.	Review of AI and ML applications in CICUs.	AI has potential to improve patient outcomes but faces challenges in data management and model training.	Calls for robust datasets and careful methodological design in future studies.
Piliuk and Tomforde (2023)	Systematic review of AI applications in emergency medicine.	Review of 116 studies sourced from various databases.	AI technologies enhance clinical decision-making but face challenges in implementation and dataset generalizability.	Advocates for integrated approaches combining human expertise with AI.
Lee et al. (2023)	Develop an AI model to predict trauma mortality in the ED.	Retrospective cohort study using NEDIS dataset with over 6.5 million patients.	AI model achieved an AUROC of 0.9974, identifying key mortality predictors.	Suggests further validation using larger datasets to mitigate overfitting.
Chen et al. (2023)	Develop a multimodal AI system for triaging eye emergencies.	Diagnostic validity assessment involving 2038 patients.	Triage model showed high accuracy, outperforming triage nurses.	Recommends further testing in diverse healthcare settings.
Chan et al. (2023)	Examine prediction models' implementation in EDs.	Review of 36 reports on prediction model implementations.	Highlights challenges in integrating models into practice and the need for stakeholder engagement.	Advocates for frameworks to better understand implementation outcomes.
Shlobin et al. (2022)	Review AI applications in managing large-vessel occlusion strokes.	Synthesis of findings from 40 studies on AI in LVO management.	AI shows promise in triage and diagnosis but needs further exploration in management.	Encourages continued research in advanced AI applications for stroke care.
Murray et al. (2019)	Explore AI's role in diagnosing ischemic strokes caused by large vessel occlusions.	Review of studies on AI methodologies in acute stroke diagnostics.	Identifies advantages of AI over traditional methods in LVO detection but calls for standardization in performance assessment.	Recommends standardized performance metrics for reliable clinical application.

Weisberg et al. (2020)	Examine AI's role in triage within emergency radiology.	Review of FDA-approved AI applications for patient triage in imaging.	AI can enhance workflow efficiency and improve patient care in triage processes.	Suggests further studies on integrating AI into clinical practice.
de Koning et al. (2023)	Develop an AI model to predict acute coronary syndrome in EMS.	Retrospective cohort study analyzing data from 7,458 patients.	AI model showed improved specificity in identifying low-risk patients, alleviating ED overcrowding.	Calls for prospective validation before clinical implementation.
Myall et al. (2020)	Explore experiences of prehospital practitioners regarding death and dying outside hospitals.	Scoping review of 51 studies published from 2000 to 2019.	Identifies emotional challenges faced by practitioners and gaps in support for families and bystanders.	Recommends further empirical research to inform policy and practice in end-of-life care.
Stewart et al. (2021)	Discuss the integration of AI into echocardiography in emergency departments.	Perspective review on advancements in AI-enhanced echocardiography.	AI can improve image acquisition and analysis but faces challenges in validation and ethical implications.	Urges for further validation of AI algorithms across diverse patient populations.
Chiasakul et al. (2023)	Evaluate AI's efficacy in predicting venous thromboembolism (VTE).	Review of 20 studies assessing AI models vs. traditional risk assessment models.	AI models outperformed conventional models but had a high risk of bias and limitations in generalizability.	Calls for transparent reporting and external validation of AI models for clinical practice.
Lee et al. (2021)	Develop an AI model for predicting hospitalization for urgent ED patients.	Retrospective analysis of 282,971 ED visits using machine learning methodologies.	AI model demonstrated good predictive power, particularly for nontraumatic patients, optimizing patient management.	Recommends further research to enhance AI applications in urgent care settings.

3.3. Results regarding the AI in EMS

3.3.1. Current Applications of AI in Prehospital Care

Current research underscores the potential of artificial intelligence (AI) in enhancing prehospital emergency care (PEC). Kang et al. (2020) developed an AI algorithm that achieved an area under the receiver operating characteristic curve (AUC) of 0.867, surpassing traditional triage tools, thus improving decision-making for critical care needs. Chee et al. (2023) conducted a scoping review that highlighted AI's role in prognostication, demand prediction, and resource optimization, noting that AI often outperforms conventional methods. Moreover, Lee et al. (2023) demonstrated an AI model's efficacy in predicting trauma mortality with an impressive AUC of 0.9974, emphasizing the urgent need for timely assessments in trauma care. These studies indicate that AI technologies are not only enhancing diagnostic capabilities but also supporting clinical decision-making processes in PEC.

3.3.2. Historical Context and Evolution of AI Technologies

The evolution of AI in healthcare has been marked by technological advancements and increasing data availability. The integration of AI technologies into prehospital care has progressed from early applications to sophisticated predictive models. For instance, Meyer et al. (2024) highlighted that while AI applications in emergency medicine are emerging, many studies remain isolated and lack robust methodological frameworks. Historical reviews, such as those by Murray et al. (2019) and Shlobin et al. (2022), illustrate how AI methodologies, particularly machine learning (ML) algorithms, have evolved to improve diagnostic accuracy for conditions like large-vessel occlusion strokes and ischemic strokes. This historical context provides a foundation for understanding how AI technologies have matured and their current applications in PEC.

3.3.3. Challenges in Implementing AI in EMS

Despite the promising advancements, several challenges hinder the effective implementation of AI in emergency medical services (EMS). Shimada et al. (2024) noted that AI-assisted interventions in anesthetic management demonstrate limited clinical application, revealing a gap between AI research and practical use. Ethical concerns, such as data privacy and accountability in AI decision-making, have been highlighted by Masoumian Hosseini et al. (2023), who advocated for structured ethical frameworks to guide AI integration in emergency departments. Furthermore, as indicated by Hedderson et al. (2025), the need for user-centered design in technologies like speech recognition remains crucial for adoption. These challenges must be addressed to foster the effective integration of AI technologies in EMS.

3.4. Emerging AI Technologies

3.4.1. Predictive Analytics in Patient Outcomes

Predictive analytics using AI can significantly enhance patient outcomes by identifying high-risk patients and optimizing resource allocation. Chee et al. (2023) and Lee et al. (2023) both emphasized the role of predictive models in improving triage and diagnosis processes. Additionally, Peng et al. (2023) highlighted the potential of AI in managing hemorrhagic trauma by predicting outcomes and guiding treatment decisions, which underscores the value of predictive analytics in PEC.

3.4.2. AI-Driven Decision Support Systems

AI-driven decision support systems are increasingly being developed to assist EMS personnel in high-stakes environments. Studies by Chen et al. (2023) and Ahmadzadeh et al. (2024) illustrate how AI can streamline decision-making processes in emergency situations, particularly in predicting critical care needs and managing wait times in emergency departments. These systems not only enhance clinical efficiency but also improve patient safety through timely interventions.

3.4.3. Robotics and Autonomous Systems

While still in the nascent stages of development, robotics and autonomous systems are poised to transform prehospital care. Toy et al. (2024) discussed the potential of AI to assist EMS clinicians in making rapid decisions based on real-time data. As technology advances, the integration of robotics in PEC could facilitate automated patient assessments and interventions, thereby enhancing care delivery.

3.4.4. Telemedicine and Remote Patient Monitoring

Telemedicine and remote patient monitoring are critical components of modern healthcare, particularly in prehospital settings. The integration of AI into these technologies can enhance patient monitoring and facilitate timely interventions. The work of Kim et al. (2020) on the role of fifth-generation (5G) technology in EMS highlights how improved connectivity can support telemedicine applications, allowing for real-time data sharing and better patient management.

3.5. Trends Influencing the Future of EMS

3.5.1. Integration of AI with Internet of Things (IoT)

The convergence of AI with IoT technologies is a significant trend that promises to enhance prehospital emergency care. As IoT devices proliferate in healthcare settings, their integration with AI can provide real-time insights and predictive capabilities. This trend is supported by the findings of Lu et al. (2021), which discuss the potential of AI and IoT in improving healthcare delivery.

3.5.2. Data Privacy and Ethical Considerations

As AI technologies become more prevalent, data privacy and ethical considerations will remain paramount. The ethical implications of AI in healthcare, including bias management and transparency in decision-making, are crucial areas that need ongoing attention. Research by Chenais et al. (2023) emphasizes the need for robust ethical frameworks to govern AI applications in emergency settings.

3.5.3. Training and Education for EMS Personnel

Training and education for EMS personnel are essential for the successful adoption of AI technologies. As AI tools become integral to emergency care, workforce development will be necessary to equip professionals with the skills needed to leverage these technologies effectively. Ongoing education initiatives will help bridge the gap between technological advancements and practical application in the field.

3.5.4. Policy and Regulatory Frameworks

Policy and regulatory frameworks play a critical role in shaping the future of AI in prehospital emergency care. As highlighted by Ahmadzadeh et al. (2024), the establishment of guidelines and standards will be essential to ensure the safe and effective implementation of AI technologies. Collaborative efforts among policymakers, healthcare providers, and technology developers will be necessary to navigate the complexities of integrating AI into EMS.

4. DISCUSSION:

The integration of artificial intelligence (AI) into prehospital emergency care represents a significant advancement that has the potential to transform patient management and outcomes. This review highlights the various applications of AI technologies, emphasizing their role in enhancing decision-making processes, improving triage accuracy, and supporting emergency medical services (EMS) through predictive analytics and decision support systems.

Several studies underscore the efficacy of AI in improving triage processes. For instance, Kang et al. (2020) demonstrated that an AI algorithm achieved an area under the receiver operating characteristic curve (AUC) of 0.867, thereby outperforming traditional triage tools. This finding aligns with Chee et al. (2023), who conducted a scoping review and noted that AI often surpasses conventional methods in prognostication and resource optimization. Such advancements are crucial in the context of increasing out-of-hospital emergencies, where timely interventions can significantly impact patient outcomes.

Moreover, the potential of AI in predictive analytics is reinforced by Lee et al. (2023), who reported an impressive AUC of 0.9974 for an AI model predicting trauma mortality. This capability to deliver accurate assessments in real time is vital for emergency care, as it allows EMS personnel to make informed decisions quickly. However, despite these promising results, the implementation of AI technologies in prehospital settings faces challenges, including variability in technology adoption and concerns regarding data reliability (Masoumian Hosseini et al., 2023). Addressing these challenges is essential for the successful integration of AI into existing workflows.

The ethical implications of AI deployment in emergency care cannot be overlooked. As highlighted by Hedderson et al. (2025), user-centered design is crucial for promoting the adoption of technologies like speech recognition, which can streamline documentation processes for EMS personnel. Furthermore, the need for robust ethical frameworks, as advocated by Masoumian Hosseini et al. (2023), is paramount in ensuring that AI applications in emergency departments adhere to standards of accountability and transparency.

Emerging technologies such as robotics and telemedicine also represent significant trends in prehospital emergency care. Toy et al. (2024) emphasize the potential of AI to assist EMS clinicians in making rapid decisions based on real-time data. Similarly, Kim et al. (2020) discuss how 5G technology can enhance telemedicine applications, facilitating real-time data sharing and ultimately improving patient management. These advancements illustrate the ongoing evolution of AI in healthcare and its potential to reshape the landscape of emergency care. Thus, while the integration of AI in prehospital emergency care offers promising opportunities for enhancing patient outcomes and operational efficiency, addressing the associated challenges and ethical considerations is critical. Future research should focus on empirical studies that validate the effectiveness of AI technologies in real-world settings, ensuring that they are not only theoretically sound but also practically applicable in the dynamic environment of emergency care.

5. Recommendations

To effectively integrate AI technologies into emergency medical services (EMS), several best practices should be considered:

- Develop AI applications with input from EMS personnel to ensure usability and relevance in real-world scenarios.
- Implement comprehensive training programs for EMS staff on AI tools and technologies. Continuous education will enable personnel to leverage AI effectively in their decision-making processes.
- Establish robust data governance frameworks to ensure data quality, security, and compliance with privacy regulations.
- Conduct pilot studies to assess the functionality and impact of AI technologies in real-world emergency scenarios before widespread implementation. This allows for identification of potential challenges and refinements.
- Foster collaboration between AI developers, healthcare providers, and regulatory bodies to ensure that AI applications meet clinical needs and ethical standards.

6. Future Research Directions

Future research should focus on the following areas to further explore the integration of AI in prehospital emergency care:

- Conduct long-term studies to evaluate the effectiveness and safety of AI technologies in diverse emergency settings. This will provide insights into their real-world impact on patient outcomes.
- Investigate the ethical implications of AI use in EMS, focusing on accountability, transparency, and bias mitigation.

Developing comprehensive ethical guidelines will be essential for responsible AI deployment.

- Explore the potential of integrating AI with Internet of Things (IoT) devices in prehospital care. Research can assess how real-time data from IoT can enhance AI decision-making capabilities.
- Work towards standardizing AI models and performance metrics to facilitate comparisons across studies and applications, ensuring consistent evaluation methods.
- Study the effects of AI technologies on patient experiences and outcomes, emphasizing the need for patient-centered care in the adoption of AI tools.

7. CONCLUSION:

In conclusion, the integration of artificial intelligence (AI) into prehospital emergency care holds significant promise for transforming patient management and outcomes. This review has highlighted how AI technologies enhance triage accuracy, improve decision-making efficiency, and facilitate timely interventions, thereby addressing the critical needs of emergency medical services (EMS). However, the successful implementation of AI is contingent upon overcoming challenges such as data reliability, ethical considerations, and the need for comprehensive training among EMS personnel. As the landscape of AI in emergency care continues to evolve, future research must focus on empirical validation of these technologies in real-world settings, ensuring that they are both effective and ethically sound. Ultimately, by addressing these factors, the potential of AI to revolutionize prehospital emergency care can be fully realized, leading to better patient outcomes and more efficient healthcare delivery.

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