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ARTIFICIAL INTELLIGENCE-BASED TRIAGE IN EMERGENCY DEPARTMENTS: PERFORMANCE, WORKFLOW OPTIMIZATION, AND IMPLEMENTATION CHALLENGES

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ABSTRACT

Background: Emergency department (ED) triage plays a central role in patient prioritization and resource allocation. However, increasing patient volumes and the growing complexity of clinical presentations have exposed important limitations of traditional triage systems. Artificial intelligence (AI) has emerged as a promising approach to enhance triage through data-driven decision-making.
Objective: This study aims to examine the application of AI in ED triage, with a particular focus on predictive performance, workflow efficiency, and implementation challenges.
Methods: A narrative review of literature published between 2018 and 2026 was conducted, including systematic reviews, comparative studies, and clinical research. The analysis encompasses machine learning models, natural language processing techniques, and large language models applied to triage tasks.
Results: AI-based models demonstrate increased accuracy in predicting clinical outcomes, including hospitalization risk and severity classification. Comparative studies indicate that advanced models—particularly large language models—can achieve performance comparable to clinical decision-making in selected scenarios. In addition, AI-driven tools, such as real-time decision support systems and voice-assisted technologies, contribute to improved workflow efficiency. Nevertheless, several important challenges persist, including data quality issues, model interpretability, bias, and integration into existing healthcare infrastructures.
Conclusions: AI demonstrates considerable potential to enhance ED triage by improving predictive accuracy and operational efficiency. However, it should be regarded as a supportive tool rather than a replacement for clinicians. Future research should prioritize scalable architectures, seamless system integration, and validation in real-world clinical environments.

KEYWORDS

Artificial Intelligence, Emergency Department, Triage, Machine Learning, Large Language Models

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1. Introduction

Emergency department (ED) triage is a critical component of acute care, enabling rapid patient prioritization and efficient allocation of limited healthcare resources. However, rising patient volumes and increasing case complexity have revealed significant limitations of traditional triage systems, including variability, constrained predictive performance, and limited scalability (Kachman et al., 2024; Berlyand et al., 2018).

Artificial intelligence (AI), particularly machine learning (ML), has emerged as a promising approach to address these challenges. Early studies highlighted the potential of intelligent clinical decision support systems to assist in patient prioritization and improve decision accuracy (Fernandes et al., 2020). Subsequent research demonstrated that ML models can effectively predict key clinical outcomes—such as hospitalization, disease severity, and mortality risk—often outperforming conventional triage approaches (Raita et al., 2019; Lee et al., 2021).

More recent systematic and scoping reviews further confirm that AI-based triage systems can substantially enhance both accuracy and efficiency in emergency care settings (Yi et al., 2025; Tyler et al., 2024; Almulihi et al., 2024; El Arab & Al Moosa, 2025).

Advancements in natural language processing (NLP) and large language models (LLMs) have further expanded the capabilities of AI in emergency medicine. Recent studies demonstrate that AI systems based on conversational data and language models can achieve performance comparable to clinicians in selected triage scenarios (Seo et al., 2025; Masanneck et al., 2024; Paslı et al., 2024; Lansiaux et al., 2026). In addition, emerging technologies such as voice-assisted systems and real-time decision support tools have shown

potential to improve workflow efficiency and reduce cognitive burden in emergency departments (Cho et al., 2022).

AI applications are also extending beyond hospital settings into prehospital care and virtual triage systems, enabling earlier decision-making and improved patient routing (Zarei et al., 2025; Nasser et al., 2025). These developments highlight the growing role of AI not only in clinical decision support but also in optimizing healthcare operations and system-level efficiency (Biesheuvel et al., 2024).

Despite these promising advances, several challenges remain. Issues related to data quality, algorithmic bias, model interpretability, and integration into existing healthcare infrastructures continue to limit widespread implementation (Da'Costa et al., 2025; Friedman et al., 2024; Masoumian Hosseini et al., 2023). Furthermore, healthcare professionals express concerns regarding trust, ethical implications, and accountability of AI systems in triage decision-making (Ahun et al., 2023), while expert commentaries emphasize that AI is not yet ready to fully replace clinicians (Lebold & Preiksaitis, 2024; Craca et al., 2023).

Therefore, this study aims to analyze the current state of artificial intelligence applications in emergency department triage, focusing on predictive performance, technological advancements, and implementation challenges. By synthesizing recent evidence, this work seeks to provide insights into the role of AI as a supportive tool for improving triage systems in modern emergency care.

2. Methods

This study was conducted as a narrative literature review focusing on the application of artificial intelligence in emergency department triage. Relevant publications from 2018 to 2026 were identified using academic databases and search engines, including PubMed and Google Scholar. Keywords such as "artificial intelligence," "machine learning," "emergency department," "triage," and "large language models" were used to retrieve relevant studies.

The inclusion criteria comprised original research articles, systematic reviews, scoping reviews, and expert commentaries related to AI applications in triage and emergency care. Studies focusing on predictive modeling, clinical decision support systems, natural language processing, and real-time AI-assisted triage were included (Fernandes et al., 2020; Masoumian Hosseini et al., 2023). Articles not directly related to emergency care or triage systems were excluded.

A total of 26 relevant studies were selected and analyzed. The extracted data included study type, AI methodology, application domain, and key findings related to triage performance, workflow efficiency, and implementation challenges (Da'Costa et al., 2025; El Arab & Al Moosa, 2025). The selected studies were qualitatively synthesized to identify major trends, benefits, and limitations of AI-based triage systems.

Study selection was performed through a manual screening process based on predefined inclusion criteria.

3. Results

A summary of key studies included in this review is presented in Table 1, highlighting the diversity of artificial intelligence approaches and their impact on triage outcomes.

Table 1. Summary of selected studies on artificial intelligence in emergency department triage

Study	Year	AI Method	Application	Key Findings
Yi et al.	2025	ML / AI	Triage outcomes	Improved prediction of clinical outcomes
Kachman et al.	2024	AI systems	Emergency care	AI enhances decision-making and workflow
Tyler et al.	2024	AI models	ED triage	Broad application of AI in triage systems
Almulihi et al.	2024	ML	Triage accuracy	Increased accuracy and patient prioritization
Raita et al.	2019	ML	Outcome prediction	AI outperforms traditional triage
Seo et al.	2025	NLP / AI	Severity triage	Conversational AI improves triage decisions
Da'Costa et al.	2025	AI systems	ED triage	Benefits and challenges identified
Masanneck et al.	2024	LLM	AI vs clinicians	Comparable or better performance than humans
Cho et al.	2022	Voice AI	Workflow support	Improved efficiency and triage performance
Lee et al.	2021	ML	Hospitalization prediction	Accurate prediction of patient outcomes
Paslı et al.	2024	LLM (ChatGPT)	Triage decisions	Promising accuracy in decision-making
Lansiaux et al.	2026	NLP / LLM	Predictive models	Advanced models improve triage prediction

Note. Abbreviations: AI – artificial intelligence; ML – machine learning; NLP – natural language processing; LLM – large language model. Own elaboration based on reviewed studies.

The analysis of the selected studies indicates that artificial intelligence has significant potential to improve emergency department triage across multiple domains. Machine learning models have been shown to accurately predict clinical outcomes such as hospitalization, severity classification, and mortality risk (Raita et al., 2019; Lee et al., 2021). Several studies report that AI-based systems outperform traditional triage methods in predictive accuracy, consistency, and decision reliability (Yi et al., 2025; Almulihi et al., 2024; El Arab & Al Moosa, 2025).

A technical comparison of selected AI approaches used in triage systems is presented in Table 2, illustrating differences in input data, model design, and predictive performance.

Table 2. Technical comparison of artificial intelligence approaches in emergency department triage

Study	Year	AI Technique	Input Data	Output Prediction	Performance / Outcome
Raita et al.	2019	Machine Learning	Vital signs, demographics	Clinical outcomes	High predictive accuracy (outperformed traditional triage)
Lee et al.	2021	Machine Learning	Clinical data	Hospitalization risk	Accurate prediction of admission
Cho et al.	2022	Voice AI + ML	Real-time voice input	Triage task performance	Improved workflow efficiency
Karlafti et al.	2023	Decision Support System	Clinical parameters	Triage decisions	Enhanced decision support
Masanneck et al.	2024	Large Language Model	Clinical scenarios	Triage classification	Comparable to clinicians
Paslı et al.	2024	ChatGPT (LLM)	Case descriptions	Triage decisions	Promising accuracy
Tortum et al.	2024	ML models	Patient data	Risk stratification	Improved prioritization
Seo et al.	2025	NLP + AI	Patient–doctor conversations	Severity assessment	Improved triage accuracy
Waligora et al.	2025	AI models	Clinical datasets	Triage performance	Increased efficiency and accuracy
Lansiaux et al.	2026	NLP + LLM + Hybrid Models	Multimodal data	Outcome prediction	Superior predictive performance

Note. Abbreviations: AI – artificial intelligence; ML – machine learning; NLP – natural language processing; LLM – large language model. Own elaboration based on reviewed studies.

The reviewed studies demonstrate clear differences between AI methodologies in terms of input data, model complexity, and clinical applicability. Traditional machine learning models, primarily based on structured clinical variables, provide stable and interpretable predictions, particularly for outcome forecasting such as hospitalization risk and patient prioritization (Raita et al., 2019; Lee et al., 2021). In contrast, approaches incorporating natural language processing and large language models enable the analysis of unstructured and conversational data, offering enhanced flexibility in early-stage triage and complex clinical scenarios (Seo et al., 2025; Lansiaux et al., 2026).

Across the analyzed literature, large language models and hybrid AI systems demonstrate promising performance in triage decision-making. Comparative studies suggest that these models can achieve results comparable to, and in some cases exceeding, clinician performance under controlled conditions (Masanneck et al., 2024; Paslı et al., 2024). However, variability in model performance across studies indicates that outcomes are strongly influenced by data quality, model design, and implementation context.

In addition to predictive performance, several studies highlight the impact of AI on workflow efficiency in emergency departments. Real-time decision support systems and voice-assisted technologies have been shown to improve documentation processes, reduce triage time, and decrease cognitive workload among healthcare professionals (Cho et al., 2022; Fernandes et al., 2020). These findings suggest that AI contributes not only to clinical accuracy but also to operational optimization.

Furthermore, the application of AI extends beyond hospital-based triage systems. Emerging evidence supports the use of AI in prehospital and virtual triage, enabling earlier patient assessment and more efficient allocation of healthcare resources (Zarei et al., 2025; Nasser et al., 2025). This broader application highlights the potential of AI to influence patient flow and healthcare system performance at multiple levels.

Despite these benefits, several limitations were consistently identified across studies. Key challenges include data quality issues, algorithmic bias, limited model interpretability, and difficulties in integrating AI systems into existing clinical workflows (Da'Costa et al., 2025; Friedman et al., 2024; Masoumian Hosseini et al., 2023). Additionally, heterogeneity in study design and outcome measures limits direct comparison of results and reduces the generalizability of findings.

4. Discussion

The findings of this review indicate that AI has considerable potential to transform emergency department triage across multiple dimensions, including predictive performance, workflow efficiency, and system-level optimization. Machine learning models consistently demonstrate superior performance compared to traditional triage systems in predicting key clinical outcomes, such as hospitalization, severity classification, and mortality risk (Raita et al., 2019; Lee et al., 2021).

Importantly, model performance appears to be closely linked to the type and structure of input data. Models based on structured clinical variables—such as vital signs and demographic data—offer high reliability and interpretability. In contrast, approaches incorporating natural language processing and large language models enable the analysis of unstructured and conversational data, thereby expanding the scope of triage in complex clinical scenarios (Seo et al., 2025; Masanneck et al., 2024).

Rather than competing approaches, these methodologies should be viewed as complementary, with their applicability depending on the clinical context and data availability.

Comparative studies indicate that large language models can achieve performance comparable to clinicians in selected triage scenarios (Masanneck et al., 2024; Paslı et al., 2024; Lansiaux et al., 2026). However, their effectiveness appears to be context-dependent and influenced by data quality, prompt design, and model architecture. This highlights the importance of cautious interpretation of AI-generated outputs and reinforces the need for human oversight (Lebold & Preiksaitis, 2024; Craca et al., 2023). Rather than replacing clinicians, AI systems are more appropriately positioned as decision-support tools that enhance clinical reasoning and reduce cognitive load.

Another key finding of this review is the potential of AI to improve operational efficiency in emergency departments. Real-time decision support systems and voice-assisted technologies have been shown to streamline documentation processes, accelerate triage decisions, and reduce workload for healthcare professionals (Cho et al., 2022; Fernandes et al., 2020). These improvements are particularly relevant in high-demand settings, where time pressure and resource constraints can negatively affect decision-making quality.

Beyond in-hospital applications, the expansion of AI into prehospital and virtual triage systems represents a significant development. Early patient assessment supported by AI can facilitate more accurate routing and prioritization, potentially reducing overcrowding in emergency departments and improving overall healthcare system performance (Zarei et al., 2025; Nasser et al., 2025). This system-level perspective underscores the broader impact of AI beyond individual clinical decisions and highlights its role in healthcare system optimization (Biesheuvel et al., 2024).

Despite these promising advantages, several critical challenges remain. Data quality and completeness are fundamental limitations, as AI models are highly dependent on the integrity of input data (Da'Costa et al., 2025; Masoumian Hosseini et al., 2023). Algorithmic bias represents another significant concern, particularly when models are trained on non-representative datasets (Friedman et al., 2024). In addition, the lack of transparency and interpretability of complex models, especially deep learning and large language models, may hinder clinical trust and acceptance (Ahun et al., 2023).

Furthermore, variability in study design and the absence of standardized evaluation frameworks limit the comparability of results across studies, complicating the translation of research findings into clinical practice (Masoumian Hosseini et al., 2023). Ethical considerations, including accountability, patient safety, and data privacy, also play a crucial role in shaping the implementation of AI in emergency care (Lebold & Preiksaitis, 2024).

Taken together, these findings suggest that the most effective future direction for AI in triage lies in hybrid approaches that integrate structured clinical data with unstructured and multimodal inputs. Such systems have the potential to combine the reliability of traditional machine learning models with the flexibility of advanced language-based architectures, thereby maximizing predictive performance and clinical applicability (Lansiaux et al., 2026; Seo et al., 2025).

Despite the growing body of evidence supporting the effectiveness of AI-based triage systems, further prospective and multicenter studies are needed to validate their performance in diverse clinical settings

(Da'Costa et al., 2025; Friedman et al., 2024). Standardized evaluation frameworks and reporting guidelines would also facilitate more reliable comparison across studies and support the translation of research findings into clinical practice (Masoumian Hosseini et al., 2023).

In addition, future research should focus on the development of explainable and transparent AI models, as improving interpretability is essential for increasing clinician trust and ensuring safe implementation in real-world environments (Ahun et al., 2023; Lebold & Preiksaitis, 2024).

Ultimately, artificial intelligence should be viewed as a complementary tool that supports, rather than replaces, clinical decision-making. Successful implementation will require not only technological advancements but also careful consideration of ethical, organizational, and human factors. Continued interdisciplinary collaboration between clinicians, data scientists, and policymakers will be essential to ensure the safe and effective integration of AI into emergency department triage systems.

5. Conclusion

Artificial intelligence represents a transformative approach to improving emergency department triage by enhancing prediction accuracy, decision-making, and operational efficiency. The findings of this review demonstrate that AI-based models, including machine learning algorithms, natural language processing techniques, and large language models, can significantly improve the identification of high-risk patients and support clinical prioritization (Raita et al., 2019; Lee et al., 2021; Masanneck et al., 2024).

Comparative analyses indicate that advanced AI systems can achieve performance comparable to, and in some cases exceeding, traditional triage methods and human decision-making (Paslı et al., 2024; Lansiaux et al., 2026). Furthermore, the integration of real-time decision support tools, voice-assisted systems, and multimodal predictive architectures has demonstrated strong potential to optimize clinical workflows and reduce cognitive burden in emergency settings (Cho et al., 2022).

Despite these advantages, several challenges must be addressed before widespread implementation can be achieved. Key limitations include data quality issues, algorithmic bias, lack of transparency, and difficulties in integrating AI systems into existing healthcare infrastructures (Da'Costa et al., 2025; Friedman et al., 2024). In addition, concerns related to trust, ethical considerations, and accountability highlight the need for cautious and responsible adoption (Ahun et al., 2023).

Future research should focus on improving model interpretability, validating AI systems in real-world clinical environments, and developing scalable and interoperable solutions.

Ultimately, artificial intelligence has the potential to fundamentally reshape emergency department triage; however, its success will depend on responsible integration, clinical validation, and maintaining the central role of human decision-making in patient care.

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