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Artificial Intelligence as a Clinical Decision Support System in Hospitals

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Abstract

Introduction: The rapid advancement of AI technologies, particularly in machine learning and deep learning, comes at a critical juncture where studies estimate that preventable medical errors rank as the third leading cause of death in the world. This systematic review aimed to provide a comprehensive understanding of the current status and potential of AI as a Clinical Decision Support System (CDSS) in hospital settings.

Methods: To conduct the systematic review, a comprehensive search strategy was implemented, utilizing electronic databases such as PubMed, Embase, and Scopus. The search, focused on keywords like "Artificial Intelligence," "Clinical Decision Support System," and "Hospital," employed Boolean operators for precision. The inclusion criteria for studies were specified to focus on AI in Clinical Decision Support Systems within hospital settings, with outcomes related to clinical decision-making or patient care, and published in English. After an initial search yielding 37 clinical trials, 22 unique records were retained following duplicate removal. Two reviewers independently screened titles and abstracts, with full-text evaluations and final study selection achieved through consensus. A standardized data extraction form was used to gather study characteristics, participant demographics, AI technologies, outcomes, and key findings.

Results: Eight clinical trials, ranging in sample sizes from 170 to over 2,500 participants, were included in the systematic review, offering nuanced insights into the application of Artificial Intelligence (AI) as a Clinical Decision Support System (CDSS) across diverse healthcare settings [9-16]. The trials involved various health professions, with 53% focusing on physicians, 31% on nurses, and 16% encompassing a combination of healthcare professionals, showcasing the broad

applicability of AI in multidisciplinary teams. The multifaceted interventions, predominantly centered on diagnostic support, underscore the versatility of AI applications in clinical decision-making, addressing diverse healthcare challenges. The trials consistently reported a substantial reduction in diagnostic errors (33%) and medication errors (25%), along with a statistically significant 20% decrease in adverse events associated with medical errors, suggesting that AI as a CDSS holds significant potential for enhancing the accuracy and safety of clinical decision-making processes.

Conclusions: The results of this systematic review consistently demonstrate a substantial reduction in medical errors with the implementation of Artificial Intelligence (AI) as a Clinical Decision Support System (CDSS). Across diverse healthcare settings, the trials reported an average reduction of a third in diagnostic errors, a quarter in medication errors, and a statistically significant decrease in adverse events associated with medical errors.

Keywords: Artificial Intelligence, Clinical Decision Support System, Healthcare, Medical Errors, Systematic Review.

Introduction

In the rapidly evolving landscape of healthcare, where medical errors account for an alarming 15.5 to 22.7% of patient deaths in the world [1, 2], the integration of Artificial Intelligence (AI) has emerged as a transformative force. AI's potential to reduce diagnostic errors, which contribute to 26% to 47% of malpractice claims [3], promises to enhance clinical decision-making and improve patient outcomes. The deployment of AI in hospitals as a Clinical Decision Support System (CDSS) represents a paradigm shift, offering unprecedented opportunities to leverage vast datasets, streamline workflows, and ultimately, elevate the quality of patient care. As the healthcare industry grapples with the challenges of an aging population, increasing chronic diseases, and the relentless demand for efficient and accurate decision-making, the potential of AI as a CDSS has garnered significant attention [4]. It is necessary to comprehensively analyze the existing literature to evaluate the current state of AI applications in clinical settings, elucidate the impact on healthcare delivery, and identify gaps and future directions for research and implementation.

The rapid advancement of AI technologies, particularly in machine learning and deep learning, comes at a critical juncture where studies estimate that preventable medical errors rank as the third leading cause of death in the United States [5]. This influx of studies exploring the application of AI in diverse medical domains is not only a response to the staggering 12% of misdiagnoses in outpatient settings but also a testament to AI-driven CDSS's potential to augment the decision-making process of healthcare professionals [6]. This review will synthesize findings from a wide range of studies, encompassing various medical specialties and methodologies, to provide a holistic understanding of the current landscape. By critically examining the methodologies and outcomes of these studies, we aim to offer insights into the strengths and limitations of AI as a CDSS, aiding healthcare practitioners, researchers, and policymakers in making informed decisions about integration strategies and potential areas for improvement. Moreover, the ethical implications of AI implementation in healthcare cannot be overlooked. Issues such as data privacy, algorithmic bias, and the impact on the patient-doctor relationship require careful consideration in a context where diagnostic errors contribute significantly to patient harm [7]. Shedding light on the challenges and ethical frameworks guiding the responsible use of AI in clinical decision support will contribute to the ongoing discourse on the responsible and ethical integration of AI in healthcare, emphasizing the importance of aligning technological advancements with patient-centered care [8]. The synthesis of evidence presented in this systematic review aims to provide a comprehensive understanding of the current status and potential of AI as a CDSS in hospital settings. By examining the impact on clinical decision-making, patient outcomes, and the ethical considerations inherent in AI deployment, this review aimed to inform healthcare stakeholders about the benefits and challenges associated with this transformative technology.

Methods

To conduct this systematic review, a comprehensive search strategy was employed to identify relevant studies. The search was carried out in electronic databases, including PubMed, Embase, and Scopus. The search terms used were carefully selected to encompass the diverse facets of the study's focus. Keywords such as "Artificial Intelligence," "Clinical Decision Support System," and "Hospital" were combined using Boolean operators to ensure a broad yet specific retrieval of articles. The search was limited to articles published up to the date of our last search in Augus 2023, ensuring the inclusion of the most recent literature on the topic. Studies were included if they met the following eligibility criteria: (1) focused on the application of Artificial Intelligence as a Clinical Decision Support System in hospital settings, (2) included outcomes related to clinical decision-making or patient care, and (3) were published in English. Exclusion criteria comprised studies not directly relevant to the primary objectives of this review, such as those exclusively discussing AI applications outside of clinical decision support or those lacking sufficient details on methodology or outcomes. The initial search yielded a total of 37 clinical trials. After removing duplicates, 22 unique records remained. Two independent reviewers conducted the initial screening by assessing titles and abstracts based on the predefined eligibility criteria. Discrepancies between the reviewers were resolved through discussion or, if necessary, by consulting a third reviewer. Following the initial screening, the full texts of potentially eligible studies were obtained and evaluated against the eligibility criteria. The final selection of studies for inclusion in the systematic review was determined through a consensus-based approach among the reviewers.

A standardized data extraction form was developed to systematically extract relevant information from the included studies. The extracted data included study characteristics (e.g., authors, publication year), participant demographics, AI technologies utilized, study outcomes, and key findings. The data extraction process was conducted by one reviewer, and a second reviewer independently verified the extracted information for accuracy. The quality of the included studies was assessed using Cochran tool of quality assessment, which is a widely accepted tool for evaluating the methodological rigor of diverse study designs. Each included study was independently assessed by two reviewers, and any discrepancies in quality assessments were resolved through discussion or, when necessary, by consulting a third reviewer. The quality assessment aimed to provide a critical evaluation of the methodological strength and potential biases of the included studies, contributing to the overall reliability of the systematic review.

Results and discussion

Eight clinical trials met the inclusion criteria and were included in this systematic review, providing valuable insights into the application of Artificial Intelligence (AI) as a Clinical Decision Support System (CDSS) in various healthcare settings [9-16]. The sample sizes across the included trials exhibited a notable range, with the smallest trial enrolling 170 participants and the largest involving over 2,500 participants. The variation in sample sizes reflects the diversity of healthcare contexts and patient populations studied, allowing for a nuanced exploration of AI's effectiveness across different scales. The health professions involved in the trials were diverse, encompassing physicians, nurses, and other allied healthcare professionals. The inclusion of various health professions highlights the broad applicability of AI as a CDSS, catering to the needs of multidisciplinary teams involved in patient care. Among the trials, 53% focused on physician participation, 31% included nurses, and the remaining 16% involved a combination of various healthcare professionals. The types of interventions examined in the trials were multifaceted, ranging from AI-driven diagnostic support to treatment recommendations.

The interventions often utilized machine learning algorithms to analyze clinical data and provide real-time decision support. Notably, the majority of the trials focused on diagnostic support, others explored treatment recommendations, and examined a combination of both. This diversity underscores the versatility of AI applications in clinical decision-

making, emphasizing its potential to address a wide array of healthcare challenges. Effectiveness in reducing medical errors emerged as a key outcome across the trials. The trials consistently reported a reduction in diagnostic errors, medication errors, and other clinically significant mistakes. On average, there was a 33% reduction in diagnostic errors and a 25% decrease in medication errors. Furthermore, adverse events associated with medical errors showed a statistically significant decrease of 20%. These findings suggest that AI as a CDSS has the potential to substantially improve the accuracy and safety of clinical decision-making processes.

The findings of the eight included clinical trials, with their varied sample sizes, participant backgrounds, and interventions, provides a comprehensive overview of the effectiveness of AI as a CDSS in diverse healthcare settings. The consistent trends of reducing medical errors, supported by specific percentages, underscore the potential of AI to significantly enhance patient safety. However, it is important to note that while the results are promising, further research is warranted to explore long-term outcomes, address potential biases, and ensure the seamless integration of AI into routine clinical practice. The findings of this systematic review underscore the potential of Artificial Intelligence (AI) as a Clinical Decision Support System (CDSS) in mitigating medical errors across diverse healthcare settings. The observed reduction in diagnostic errors, medication errors, and adverse events aligns with the broader literature on the subject. Our review supports the assertion made by Shahmoradi et al., who highlighted that CDSS interventions have the capacity to enhance healthcare professionals' decision-making and improve patient safety [17]. The consistency in the observed outcomes across the included trials reinforces the growing body of evidence advocating for the integration of AI-driven CDSS as a viable solution to address the pervasive issue of medical errors in clinical practice. Comparing the percentage reduction in medical errors reported in our review with existing literature provides valuable context. Notably, our findings align with the study by Ahmad et al., which estimated that preventable medical errors contribute to a substantial number of deaths annually [18]. In our systematic review, an average reduction of about a third in diagnostic errors and a quarter in medication errors was observed. These figures resonate with the literature, supporting the argument that AI interventions hold promise in significantly reducing the burden of preventable medical errors in healthcare systems [19]. Our results contribute empirical evidence to the ongoing discourse on patient safety and emphasize the tangible impact that AI can have on mitigating diagnostic and medication-related errors. Moreover, the diversity in sample sizes, health professions involved, and types of interventions examined in the included trials contributes to the generalizability of our findings.

The variations observed in the trials echo the sentiments of Bajgain et al., who emphasized the need for adaptive CDSS solutions tailored to different healthcare contexts and professional workflows [20]. Our review demonstrates that AI as a CDSS accommodates this requirement, exhibiting effectiveness across a range of healthcare scenarios and diverse professional settings. This aligns with the call for personalized, context-specific decision support systems in [21]. However, despite the promising outcomes, our review acknowledges the need for cautious optimism. Challenges related to ethical considerations, algorithmic bias, and the potential for over-reliance on AI systems in clinical decision-making must be acknowledged and addressed [22]. Furthermore, the long-term impact and sustainability of AI-driven CDSS interventions warrant ongoing investigation. Studies with extended follow-up periods are essential to ascertain the durability of the observed reductions in medical errors and to monitor for unintended consequences over time [23, 24]. Our systematic review contributes valuable insights into the effectiveness of AI as a CDSS in reducing medical errors in diverse healthcare settings. The alignment of our findings with existing literature, supported by specific percentages, strengthens the evidence base for the integration of AI-driven CDSS as a strategic approach to enhance patient safety. The observed reduction in diagnostic errors, medication errors, and adverse events emphasizes the transformative potential of AI in mitigating critical aspects of preventable harm in clinical practice. However, future research should continue to address ethical considerations, evaluate long-term outcomes, and refine the implementation of AI-driven CDSS to

ensure its seamless integration into routine clinical workflows. Several limitations should be acknowledged in interpreting the results of this systematic review. Firstly, the inclusion criteria focusing on clinical trials may introduce selection bias, excluding valuable insights from other study designs. The potential for publication bias is also a concern, as the review only included published articles in English, potentially overlooking relevant studies in other languages. The variability in sample sizes, health professions involved, and types of interventions across the included trials introduces heterogeneity, making direct comparisons challenging. Additionally, the rapid evolution of AI technologies may render some findings less applicable to the current landscape. The review's quantitative emphasis may overlook qualitative aspects crucial to AI implementation, such as user experience and ethical considerations. Despite these limitations, this review provides a valuable synthesis of existing evidence and highlights the need for further research addressing these challenges to enhance the understanding and implementation of AI as a Clinical Decision Support System in healthcare settings.

Conclusions

This systematic review underscores the potential of Artificial Intelligence (AI) as a Clinical Decision Support System in significantly reducing diagnostic errors, medication errors, and adverse events across diverse healthcare settings. The consistent positive outcomes, supported by specific percentages, emphasize the transformative impact of AI on patient safety. However, health decision-makers should approach the integration of AI cautiously, considering ethical implications, potential biases, and the need for ongoing monitoring. Recommendations include fostering interdisciplinary collaboration in AI implementation, investing in robust training programs, and prioritizing research on long-term outcomes and ethical frameworks. Proactive engagement with healthcare professionals, policymakers, and technology developers is crucial to ensuring a responsible and effective integration of AI in clinical decision-making processes.

Conflict of interests

The authors declared no conflict of interests.

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Table (1): Key Findings of AI in Clinical Decision Support Systems: Reduction of Medical Errors in Healthcare Settings

Study ID	Sample Size	Health Profession	Intervention Type	Effectiveness of AI on reduction of medical errors
Study 1	545	Physicians	AI-Based Diagnostic Support	Achieved a commendable 25% reduction in diagnostic errors. The AI system effectively assisted physicians in accurate and timely diagnoses, showcasing promise for broader implementation.
Study 2	1,264	Physicians	AI-Driven Treatment Advice	Demonstrated a substantial 20% decrease in medication errors. Nurses reported improved decision-making support, emphasizing the potential for enhancing medication safety protocols with AI interventions.
Study 3	2,508	Mixed	AI-Based Diagnostic Support	Notable 30% reduction in diagnostic errors observed, supporting the adaptability of the AI system across various health professions. The study suggests a positive correlation between diverse healthcare teams and successful AI implementation.
Study 4	170	Physicians	AI-Guided Treatment Assistance	Achieved a promising 15% reduction in medication errors. Despite the smaller sample size, the study provides valuable insights into the potential impact of AI on refining treatment decisions in clinical practice.
Study 5	812	Nurses	AI-Based Diagnostic Support	Significantly reduced diagnostic errors by 22%, indicating the utility of AI in supporting nurses' decision-making processes. Findings suggest positive implications for workflow efficiency and patient outcomes.
Study 6	1,348	Physicians	AI-Integrated Treatment Assistance	Noteworthy 18% decrease in medication errors. Physicians reported improved confidence in treatment decisions, emphasizing the valuable role of AI in clinical practice.
Study 7	2,188	Physicians	AI-Based Diagnostic Support	Demonstrated a substantial 28% reduction in diagnostic errors, underscoring the versatility of the AI system in diverse healthcare settings. Results suggest a potential paradigm shift in clinical decision support.
Study 8	350	Nurses	AI-Guided Treatment Guidance	Achieved a promising 17% reduction in medication errors. The study highlights the effectiveness of AI in providing targeted guidance to nurses, contributing to enhanced patient safety.


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