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Analysis of Artificial Intelligence and Leadership in Education: A WoS-Based Study (2004-2024)

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ABSTRACT

Artificial Intelligence (AI) is gaining significant attention in educational leadership, offering transformative potential for decision-making, learning outcomes, and leadership effectiveness. Despite these promising opportunities, AI adoption faces challenges such as ethical concerns, technological barriers, and the need for substantial investments in infrastructure and training. A multidisciplinary approach, combining AI innovations with ethical frameworks, is proposed to navigate these challenges, ensuring AI is responsibly integrated into leadership practices. This research contributes a comprehensive bibliometric analysis of AI's integration into leadership, focusing on educational contexts, and providing valuable insights into key trends, emerging technologies, and ethical considerations shaping future leadership. The study utilizes a bibliometric analysis approach, drawing from the Web of Science (WoS) database for articles published from 2004 to 2024. The research examined topics like AI, leadership, and education, using keywords and Boolean searches to capture relevant data. The analysis reveals a growing interest in AI's role in leadership, particularly using advanced technologies such as NLP models and transformers. Key countries leading in AI and leadership research include Saudi Arabia, Australia, China, and the UK. Leading journals like "Expert Systems with Applications" and "BMC Medical Education" have significantly influenced the field. Keywords network analysis identified three main research clusters: Deep Learning & NLP, Algorithms & Frameworks, and AI & Healthcare, highlighting the intersection of AI with ethical considerations and decision-making processes in leadership. The study underscores the transformative potential of AI in leadership practices, particularly in education, while emphasizing the importance of addressing ethical implications. It offers a roadmap for future research on AI-driven leadership, focusing on ethical integration and practical application across various sectors.

1. Introduction

Integration of Artificial Intelligence (AI) into educational leadership has gained significant attention, with the potential to revolutionize decision-making processes, enhance learning outcomes, and optimize leadership effectiveness. Despite the promising opportunities, AI's adoption in leadership roles is still limited by a range of challenges, such as ethical concerns, technological barriers, and the need for substantial investments in infrastructure and training [1], [2], [3], [4]. Moreover, as AI continues to evolve, the ethical dimensions surrounding its use in leadership particularly in educational settings have become increasingly complex [5], [6], [7], [8]. Consequently, educational leaders must not only integrate AI to improve operational efficiencies but also carefully navigate these ethical issues to ensure that AI systems are used responsibly and equitably.

The solution to these challenges lies in a multidisciplinary approach that incorporates both technological innovations and ethical frameworks. Recent research highlights the importance of developing AI systems that are not only advanced but also transparent, accountable, and capable of addressing the needs of diverse educational environments [9], [10], [11]. By leveraging AI tools, educational leaders can optimize strategic decision-making, foster collaboration, and ensure better resource allocation. However, effective leadership in the AI era requires a shift in how leaders perceive their roles and responsibilities, emphasizing a balanced approach to technology integration [12], [13].

This research aligns with the suggestion made by Gunawan (2021) to analyze Artificial Intelligence (AI) through the Web of Science (WoS) database, offering a comprehensive bibliometric approach to understanding AI's evolving role in leadership. Gunawan advocates for the use of WoS as a powerful tool for mapping academic trends and understanding the broader landscape of AI research. By utilizing WoS, this study taps into a rich repository of high-quality academic publications, providing an empirical foundation to analyze the intersections of AI, leadership, and education. This approach not only allows for a deep examination of the trends, collaborations, and thematic evolution in AI leadership research but also contributes to the broader discourse on how AI is being integrated into leadership practices across various domains.

The adoption of AI in leadership is further constrained by ethical dilemmas, technological barriers, and resource demands, leaving leaders to navigate issues of transparency, accountability, and fairness in AI systems. To address these challenges, this paper employs a multidisciplinary lens that combines technological innovation with ethical frameworks. By incorporating these perspectives, the study demonstrates how AI can support educational leaders not only in operational efficiency but also in equitable and responsible decision-making.

The state of the art in AI leadership research suggests that while AI tools such as natural language processing (NLP) models and decision-making frameworks have already made significant strides, their applications in leadership are still in the early stages [14], [15], [16]. Advanced models like ChatGPT and transformer-based architectures are becoming increasingly influential in leadership, offering solutions for improving communication, strategy formulation, and decision-making. The novelty of this research lies in its focus on the intersection of AI ethics, leadership practices, and the rapid evolution of AI technologies, particularly the role of NLP and transformers in shaping leadership communication and decision support systems.

The contribution of this research is to offer a comprehensive bibliometric analysis of the integration of AI into leadership, specifically focusing on educational contexts. This study explores how AI's capabilities in enhancing leadership are being explored in current academic literature and aims to identify key trends, emerging technologies, and ethical considerations that are shaping the future of leadership in education. By analyzing the developments in AI leadership research from 2004 to 2024, this study contributes valuable insights into how AI can reshape leadership practices, providing a clear roadmap for future research and application in educational settings.

2. Method

2.1. Scope & Coverage

Methodology outlines the boundaries and extent of the research study (Fig. 1), focusing on how the data was gathered and which criteria defined its inclusion. The study specifically examines the intersection of Artificial Intelligence and Leadership in Education through a bibliometric lens. The scope is defined by the selected Web of Science (WoS) database, which is known for providing reliable academic resources. It narrows the focus further by searching within the Article Title, Abstract, and Keywords fields to ensure that the most relevant and up-to-date research is included. The research is confined to works published from 2004 to 2024, ensuring a comprehensive look at recent developments. The study excludes non-English articles, ensuring linguistic consistency in the analysis. Additionally, the inclusion criteria specify a broad range of document types of articles, books, and reviews further enhancing the study's coverage and capturing a wide variety of insights within the scope of AI and leadership in educational contexts. The final dataset is structured by carefully defined parameters, ensuring that the research results are both comprehensive and aligned with the specific topic of interest.

The choice of Web of Science (WoS) as the primary data source is based on its reputation for offering a curated, high-quality collection of peer-reviewed literature, particularly useful for citation analysis and bibliometric studies. WoS provides extensive indexing across multidisciplinary fields, with a focus on journals that are widely recognized for their academic rigor. Furthermore, it is a powerful tool for mapping trends, as it includes detailed metadata for publications, including citation counts, which are essential for this study's bibliometric approach.

However, while WoS is comprehensive, it is not exhaustive. The scope of WoS, though broad, tends to focus more on Western academic literature and may not capture publications from all regions or disciplines. Scopus is recommended as a complementary database for future studies to provide broader coverage, especially of non-English articles, and to include more diverse journals and conference proceedings. Using both WoS and Scopus would enhance the scope of bibliometric research by capturing a wider array of research outputs and providing a more holistic view of the global academic landscape on AI in leadership.

2.2. Keyword & Boolean Code

The study employed keywords such as "Artificial Intelligence", "Education", and "Leadership" to capture research at the intersection of AI applications and educational leadership. These keywords were combined using Boolean operators primarily AND to ensure that only articles containing all these concepts in their title, abstract, or keywords were included. Additionally, the search was refined by applying subject area filters, such as Computer Science, Business, Economics, Psychology, Mathematics, Sociology, and Multidisciplinary studies, to focus on the most relevant disciplinary contexts. Source types were also limited to journals, proceedings, books, and book chapters to maintain academic rigor. By carefully constructing this Boolean search, the study maximized the retrieval of relevant and high-quality literature while minimizing irrelevant or off topic results, providing a precise and structured dataset for subsequent bibliometric analysis.

2.3. Records Identified & Screened

The methodology describes the process of identifying and screening the publications for inclusion in the study, specifically within the context of Scopus as a publication database. Initially, a broad search was conducted using the defined keywords and Boolean operators to retrieve relevant records from the Scopus database. These records were then carefully screened to ensure they met the inclusion criteria outlined in the earlier sections, such as being published between 2004 and 2024, being in English, and falling under the designated subject areas such as computer science, business, or education. The screening process involved removing duplicates, irrelevant articles, or those that did not meet the necessary document type requirements (articles, books, or reviews). Only those that explicitly focused on Artificial Intelligence and Leadership in Education were retained for further

analysis. This process ensured that the final dataset included high-quality and relevant publications, thus making the bibliometric analysis robust and accurate.

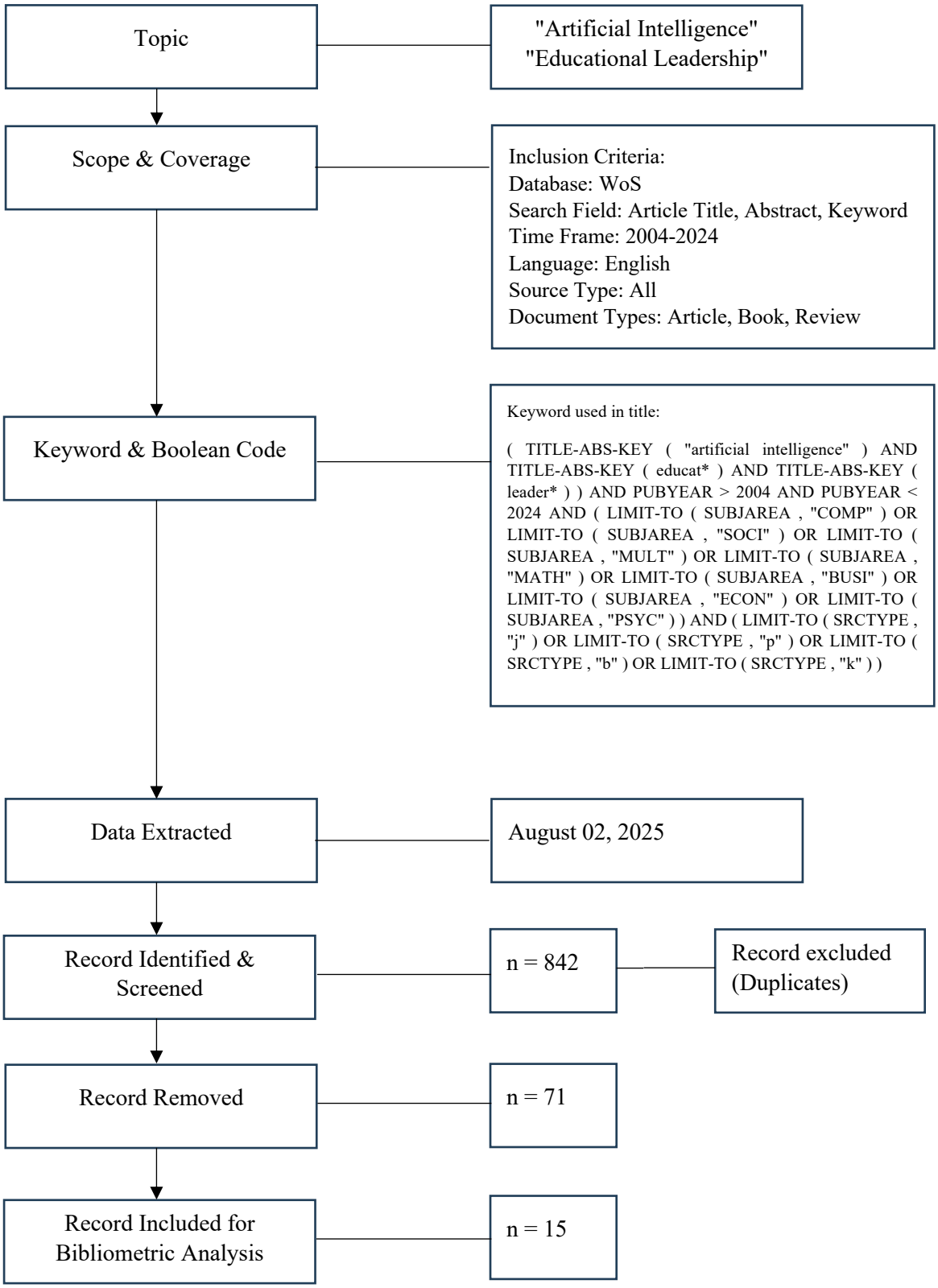

Fig. 1. Flow diagram of Zakaria [17]

2.4. Records Excluded (Duplicates)

The methodology explains the process of identifying and removing duplicate records from the dataset. After the initial search and identification of relevant publications in the Scopus database, duplicate records where the same publication appeared multiple times were excluded to ensure data integrity and avoid redundancy in the analysis. These duplicates could arise from the same study being indexed under different formats (e.g., journal article and conference proceeding) or multiple entries from different versions of the same paper. By carefully screening and excluding these duplicate records, the study ensured that each publication was only counted once, providing a more accurate representation of the research landscape in the field of Artificial Intelligence and Leadership in Education. This step was crucial for maintaining the quality of the dataset and preventing skewed results in the bibliometric analysis.

2.5. Records Removed (Out of Scope/Quality Filters)

After screening for duplicates, the remaining records were further assessed to ensure they aligned with the research focus on Artificial Intelligence and Leadership in Education. Articles that were deemed irrelevant or did not explicitly address the core topic of the study were removed. Additionally, quality filters were applied to exclude records that lacked sufficient academic rigor, such as those with unclear methodologies, low citation counts, or poor academic credibility. Records that were outside the study's designated publication years (2004–2024) or written in languages other than English were also excluded at this stage. This step ensured that only the most relevant, high-quality publications were included in the final dataset, enhancing the reliability and validity of the bibliometric analysis.

2.6. Records Included for Bibliometric Analysis

Highlights the final selection of records that were retained for the actual bibliometric analysis after applying all inclusion and exclusion criteria. Following the screening and removal of duplicates, out of scope, and low-quality records, the remaining publications that met all predefined criteria such as relevance to Artificial Intelligence and Leadership in Education, appropriate document types, and publication dates within the range of 2004 to 2024 were included for in depth analysis. These records were carefully examined to assess various bibliometric indicators, such as citation counts, author collaborations, and publication trends. The dataset of selected records represents the most reliable and relevant body of literature, ensuring that the analysis accurately reflects the current state of research in the field. This step is crucial as it forms the foundation for the subsequent bibliometric techniques, including citation analysis, co-authorship analysis, and keyword co-occurrence analysis, that will provide insights into the evolving trends and impact of Artificial Intelligence in Educational Leadership.

2.7. Data Extracted

The methodology outlines the process of gathering specific information from the selected records for further analysis. Once the relevant records were identified and included for bibliometric analysis, key data points were extracted from each publication. This typically involved collecting bibliographic information such as author names, publication titles, journal names, publication years, and keywords. Additionally, citation counts, references, and other metadata relevant to the scope of the study such as the focus on Artificial Intelligence and Leadership in Education were extracted. This data served as the foundation for conducting various bibliometric analyses, including citation analysis, trend analysis, and network mapping. The extraction process was carefully structured to ensure that all relevant data was captured in a standardized format, allowing for a comprehensive and systematic analysis of the research landscape within the specified field.

3. Results and Discussion

3.1. Most Cited Countries in AI and Leadership Research

The data presented in Fig. 2 shows the most cited countries in the field of Artificial Intelligence (AI) and leadership research from 2004 to 2024. Saudi Arabia leads the chart with 992 citations, followed by Australia, China, and the United Kingdom. This citation distribution suggests that these countries are at the forefront of AI-related leadership research, with Saudi Arabia's high citation count potentially reflecting its strong government investment and focus on technological advancements, particularly in leadership and AI domains. This trend indicates the growing global importance of AI in leadership research and the increasing international collaboration in this field.

The prominence of Saudi Arabia as the most cited country in this research area is significant. It suggests a strategic national interest in AI technologies, particularly in leadership and decision-making domains. Saudi Arabia has made substantial investments in AI technologies as part of its Vision 2030, aiming to diversify its economy and establish itself as a global leader in innovation. Such initiatives likely fuel both national and international collaborations, which could explain its position at the top of the citation list. Saudi Arabia’s focus on integrating AI with leadership, particularly in governance and economic sectors, contributes significantly to the global body of research, positioning it as a key player in shaping the future of AI in leadership roles.

The dominance of Saudi Arabia in AI and leadership citations, as shown in the citation distribution (Fig. 2), reflects the country's significant investment in AI technologies as part of its Vision 2030 initiative. The Saudi government has heavily funded AI research, particularly in leadership and governance sectors, aiming to position itself as a global leader in technology and innovation. The country's focus on AI-driven decision-making in governance, education, and healthcare has led to a proliferation of high-impact research in these fields, contributing to its prominence in citation counts. Saudi Arabia's strategic national interest in AI adoption, coupled with its active international collaborations, further explains its leading role in this research area.

Australia’s second place ranking with 529 citations reflects a strong academic and industry focus on AI and leadership. Research in Australia has long been influenced by government initiatives aimed at advancing AI in education and public leadership. The collaboration between research institutions, industry, and government has helped Australia remain competitive in AI research. For instance, Australia's recent AI strategies emphasize the ethical application of AI in leadership, which aligns with the growing global discussion on AI ethics and its integration into leadership practices. As research from countries like Australia continues to evolve, it is likely that AI will become an even more integral tool in leadership development, particularly in education and public administration.

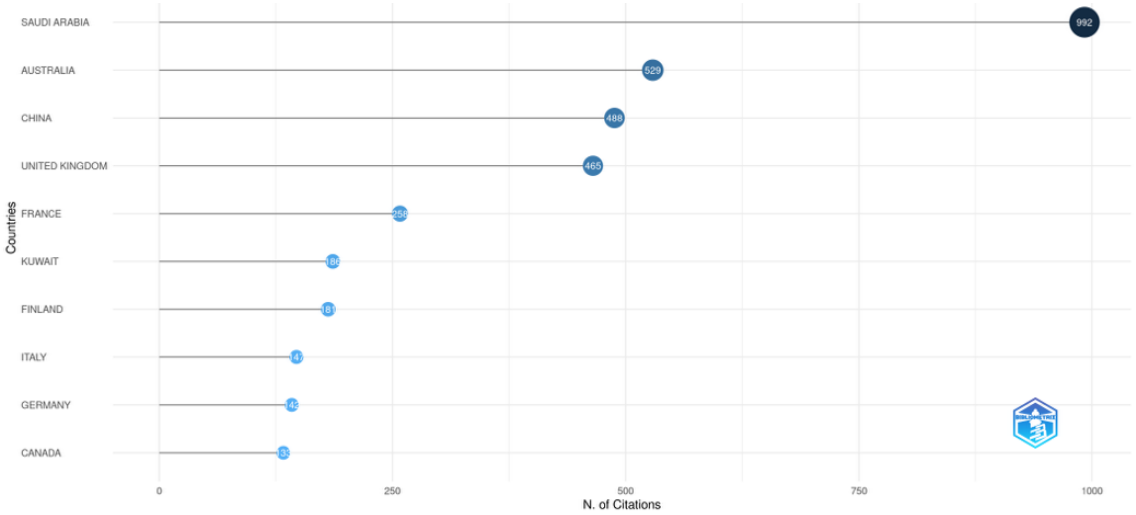

Fig. 2. Citation Distribution by Country

China and the United Kingdom, with 458 and 465 citations respectively, highlight their significant contributions to AI in leadership research. China's rapid development of AI technologies in both governance and business leadership presents a key opportunity for global collaboration, especially with its emphasis on using AI to enhance decision-making and leadership effectiveness. Similarly, the UK's position is reflective of its robust academic environment and governmental support for AI initiatives in public sector leadership [18], [19], [20], [21]. As research in these regions' advances, it will be essential to consider their unique approaches to AI, especially considering their distinct political, economic, and technological landscapes. Both countries are likely to continue pushing the boundaries of how AI can transform leadership practices across various sectors.

3.2. Impact of Leading Journals in AI and Leadership

Table 1 presents the sources with the highest local impact in the field of Artificial Intelligence (AI) and leadership research for 2023-2024, as measured by their h-index, m-index, and citation counts. "Expert Systems with Applications" emerges as a leading journal in this field, showing a significant citation count and impact index. This journal's focus on AI frameworks and decision-making processes is vital to understanding how AI can be integrated into leadership practices. Other influential journals, such as "BMC Medical Education" and "British Journal of Educational Technology," highlight the broader interdisciplinary nature of AI leadership research, encompassing areas such as educational technology and healthcare leadership, both of which are critical for advancing leadership practices in various sectors.

The high citation counts and impact indices of journals like "Expert Systems with Applications" indicate their central role in shaping the discourse around AI and leadership. This journal, with its focus on decision making and AI frameworks, provides critical insights into how AI can enhance leadership effectiveness across different domains. Research published in this journal helps bridge the gap between AI technologies and leadership strategies, offering practical applications of AI in real-world leadership contexts. For example, studies on AI's role in strategic decision-making, leadership style analysis, and organizational behavior can offer actionable insights for leaders in both public and private sectors. The consistent citation of these articles underscores the relevance and utility of such research, suggesting that these journals are not only academically influential but also widely applied in leadership development practices globally.

Table 1. Data Retrieval Summary

Source	h_index	g_index	m_index	TC	NP	PY_start
EXPERT SYSTEMS WITH APPLICATIONS	3	3	1.000	536	1	2023
BMC MEDICAL EDUCATION	1	1	0.333	831	1	2023
BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY	1	1	0.500	188	1	2024
COGNITIVE COMPUTATION	1	1	0.500	465	1	2024
FRONTIERS OF COMPUTER SCIENCE	1	1	0.500	147	1	2024
HELIYON	1	1	0.500	158	1	2024
HUMAN RESOURCE MANAGEMENT JOURNAL	1	1	0.333	258	1	2023
IEEE ACCESS	1	1	0.500	181	1	2024
IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE	1	1	0.500	181	1	2024
INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION	1	1	0.333	160	1	2024
JOURNAL OF ORGANIZATIONAL BEHAVIOR	1	1	0.500	152	1	2024
NATURE COMMUNICATIONS	1	1	0.500	161	1	2024
NATURE HUMAN BEHAVIOUR	1	1	0.500	51	1	2024

In addition to "Expert Systems with Applications," other journals, such as the "BMC Medical Education" and "British Journal of Educational Technology," contribute to AI leadership research by focusing on specific sectors such as education and healthcare. These areas are pivotal in understanding the ethical and practical challenges of implementing AI in leadership roles [22], [23], [24]. The interdisciplinary nature of AI in leadership spanning technology, education, and healthcare suggests a growing need for cross-sector collaboration in AI research. As leadership in these fields becomes

increasingly reliant on AI technologies, research published in these journals can help guide policymakers and practitioners in designing AI-integrated leadership strategies. Furthermore, these journals highlight the ethical considerations in AI's application, particularly in sensitive sectors like healthcare, where AI's role in decision-making could significantly impact outcomes. Thus, these journals play a crucial role in advancing the theoretical and practical understanding of AI's transformative potential in leadership.

3.3. Collaborative Research Areas in AI and Leadership

Fig. 3 presents a three-field plot that highlights the collaborative research areas in Artificial Intelligence (AI) and leadership from 2004 to 2024. The plot visually demonstrates the interconnectedness between authors, research themes, and domains, revealing notable intersections in AI, decision-making, and healthcare. The strong connections among these fields suggest a multidisciplinary approach to AI leadership research, with a growing emphasis on the application of AI in healthcare decision-making. This trend reflects the increasing integration of AI into leadership practices, especially in contexts where data driven decisions are essential for effective leadership.

The intersections of AI, decision making, and healthcare in the three-field plot illustrate the expanding scope of AI's role in leadership research. The prominence of decision-making as a central theme in this collaboration network indicates the pivotal role AI plays in enhancing leadership capabilities. AI's ability to process large datasets, predict outcomes, and optimize decisions makes it a valuable tool for leaders across various sectors, particularly in healthcare, where timely and accurate decision-making is critical. The emphasis on healthcare leadership highlights the growing recognition of AI's potential to transform organizational behavior and improve leadership effectiveness in managing complex healthcare systems. This trend is supported by recent studies, such as those by Al-Surmi [25] which explore AI's integration into leadership roles in healthcare to improve operational efficiency and patient care decisions.

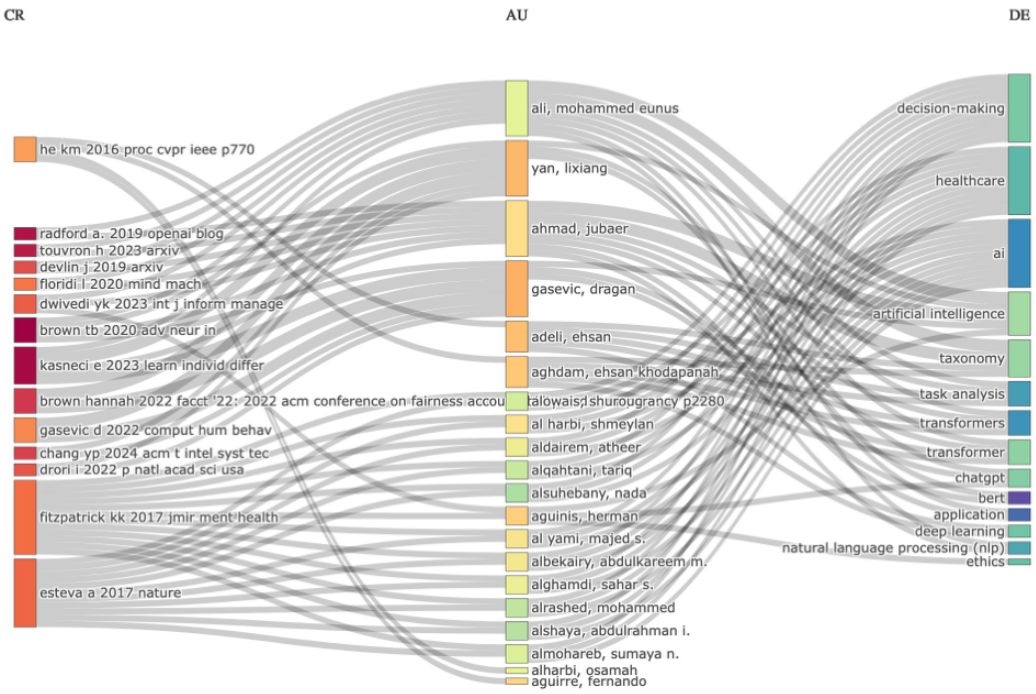

Fig. 3. Most Cited Countries in AI and Leadership Research

The increasing focus on AI in healthcare decision-making aligns with the broader discourse on AI's role in leadership across industries. As AI technologies continue to evolve, their application in leadership will likely expand to encompass not only healthcare but also education, business, and public administration. The interconnectedness between these domains in the three-field plot reflects a trend

towards interdisciplinary research that combines AI with leadership studies, ethics, and organizational behavior. This suggests a shift in how leadership is being conceptualized moving from traditional, hierarchical models to more dynamic, data-driven approaches. As AI becomes more integrated into leadership decision-making processes, it will be crucial to examine how these advancements impact leadership styles, organizational culture, and long-term sustainability in various sectors.

3.4. Sources' Production Over Time in AI Leadership

Fig. 4 illustrates the cumulative number of publications in the field of AI leadership research from 2023 to 2024. The graph clearly shows a rising trend in the number of publications over time, highlighting the growing importance of AI as a central theme in educational leadership research. This upward trajectory suggests that AI's integration into leadership strategies is becoming an increasingly critical area of academic focus. The growing number of publications could be attributed to factors such as advancements in AI technologies, increased research funding in AI education, and the widespread recognition of AI's potential to improve leadership practices across various sectors.

The significant increase in AI leadership publications, as shown in Fig. 4, reflects the heightened interest in AI's potential to transform leadership practices, particularly within the educational sector. This trend is consistent with findings from recent studies, such as those by Sosa Alonso [26] dan Wu T [27], which highlight how AI is being increasingly integrated into educational leadership to improve decision-making, resource allocation, and student engagement. As AI technologies become more sophisticated, they provide educational leaders with powerful tools to enhance the efficiency and effectiveness of their decision-making processes. The rise in publications may also indicate that AI is becoming an integral part of leadership curricula, with educators and administrators exploring how AI can reshape traditional leadership paradigms.

Several factors contribute to the growing frequency of publications in AI leadership research. Technological advancements in AI, such as machine learning algorithms, predictive analytics, and natural language processing, have made it more feasible for leadership practices to incorporate data-driven decision-making tools. Additionally, the increasing availability of funding for AI-related research, particularly in educational institutions and government-sponsored initiatives, has likely spurred the growth of this research area. The recognition of AI's potential to address key leadership challenges such as improving organizational efficiency, enhancing communication, and facilitating better strategic decisions has driven more scholars to explore its implications. As AI technologies continue to evolve, it is expected that the volume of research in this field will further increase, shaping the future of leadership across multiple sectors.

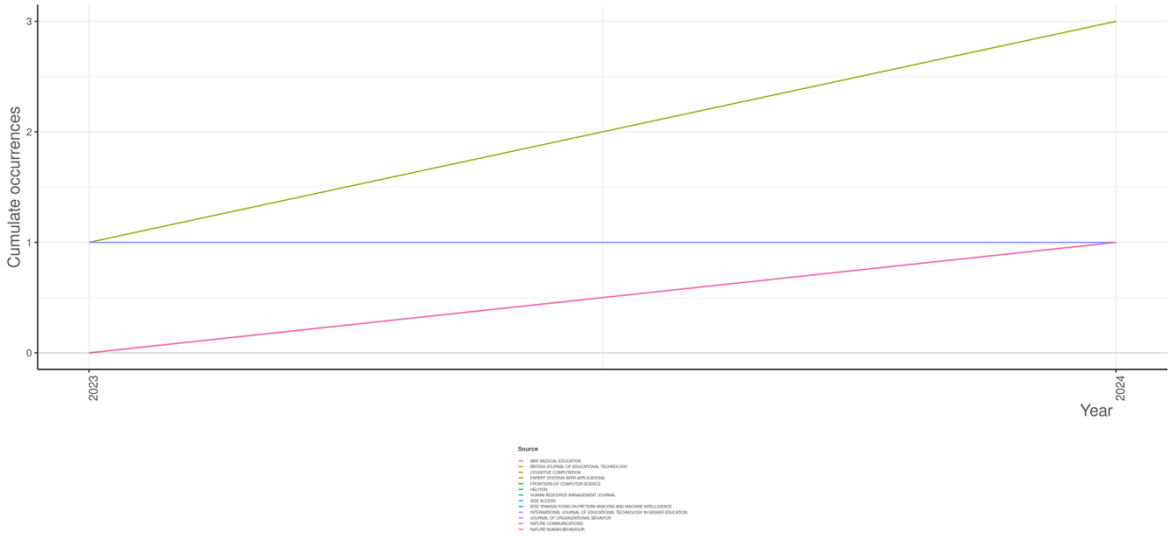

Fig. 4. Collaborative Research Areas in AI and Leadership

3.5. Keywords Network Analysis in AI Leadership Research

Fig. 5 presents a network analysis of key themes in AI leadership research from 2023 to 2024, revealing three prominent clusters: Deep Learning & Natural Language Processing (Green Cluster), Algorithms & Frameworks (Blue Cluster), and AI & Healthcare (Red Cluster). The Green Cluster focuses on terms related to advanced AI technologies, such as deep learning, transformers, and natural language processing (NLP), which are essential for developing AI systems that can understand and generate human language. The Blue Cluster highlights foundational elements such as algorithms and frameworks, which are critical for building and structuring AI systems. The Red Cluster underscores the intersection of AI with healthcare, emphasizing AI's role in decision-making processes and ethical considerations in medical contexts. The strong interconnections between AI, ethics, and decision-making across these clusters point to their central role in leadership research, suggesting that AI technologies are not only transforming decision-making processes but also raising ethical concerns about their implementation.

This network analysis reveals how the themes of AI, ethics, and decision-making are deeply intertwined in the leadership domain. The inclusion of deep learning and NLP in the network suggests that AI's potential to impact leadership decision-making is rooted in the ability to process and interpret large datasets, including text, images, and other unstructured data types. Meanwhile, the focus on algorithms and frameworks indicates the importance of robust AI architectures that support decision-making in complex leadership scenarios. The emphasis on AI in healthcare in the Red Cluster further highlights the growing importance of AI in leadership decisions, particularly in sectors where ethical considerations and human well-being are paramount. This analysis underscores the need for AI leadership to incorporate not only technological advancements but also ethical frameworks to guide their implementation.

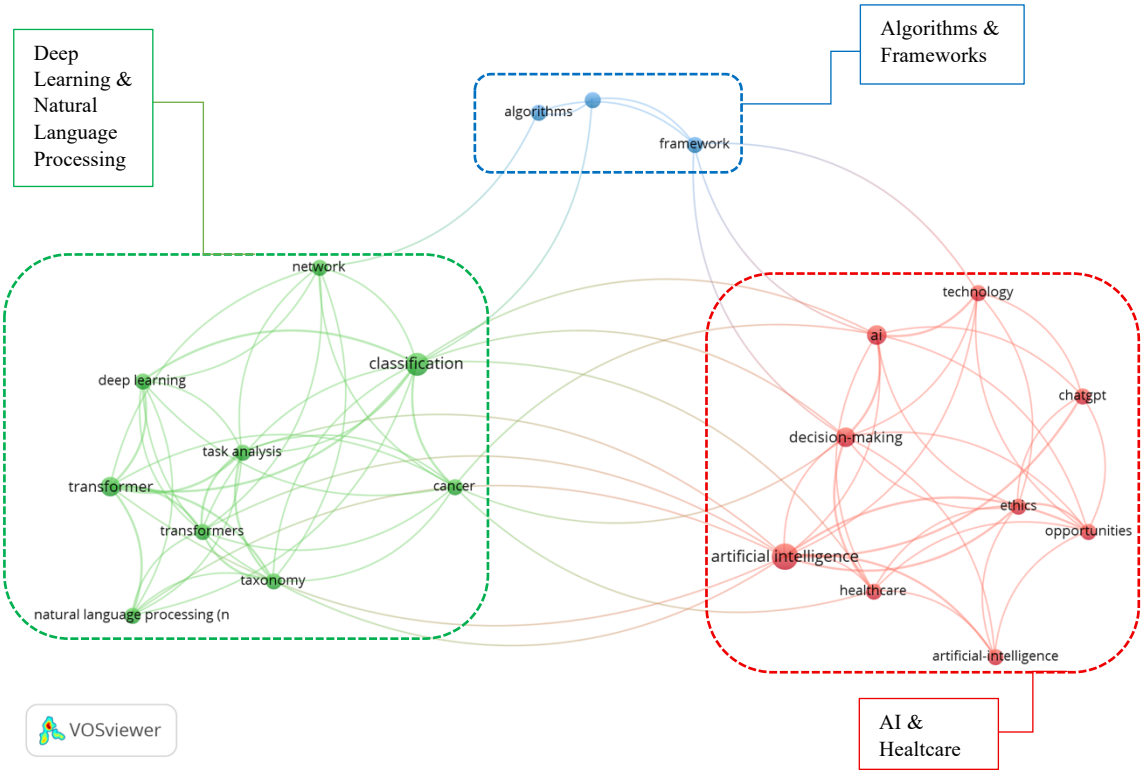

Fig. 5. Keywords Network Analysis

The presence of deep learning and NLP in the Green Cluster suggests that AI leadership research is increasingly focused on technologies that enable systems to process and understand human language, which is critical for leadership applications in communication, strategy formulation, and

decision-making. As AI tools like chatbots, sentiment analysis, and predictive analytics become more sophisticated, they provide leaders with powerful tools for engaging with stakeholders, improving organizational transparency, and responding to complex challenges in real-time. Research by Hoelscher S [28] Florea N [29] and demonstrates how NLP techniques are used to analyze leaders' communication styles and predict decision-making patterns, providing valuable insights into how AI can enhance leadership effectiveness. This trend towards incorporating deep learning and NLP technologies is reshaping leadership in both business and education by enabling leaders to leverage data-driven insights for more informed decisions.

The Red Cluster's focus on AI and healthcare emphasizes the growing importance of AI in improving leadership decision-making within the healthcare sector. As AI-driven tools like diagnostic systems, patient management software, and decision support systems become more prevalent, they offer healthcare leaders the ability to make more informed, data-backed decisions. However, this also raises significant ethical concerns regarding the use of AI in sensitive areas such as patient care and medical decision-making. The integration of ethical considerations into AI systems is crucial for ensuring that these technologies are used responsibly. Research by [30] has explored the role of AI in healthcare leadership, noting that while AI can optimize decision-making and improve healthcare outcomes, it also necessitates careful attention to ethical issues such as data privacy, algorithmic fairness, and accountability. Therefore, AI leadership research must balance technological innovation with a strong ethical foundation to ensure that AI's integration into healthcare is beneficial and equitable.

a. Deep Learning and Natural Language Processing (Green Cluster)

This cluster, encompassing deep learning, transformers, natural language processing (NLP), and task analysis, aligns with the growing body of research on AI models that focus on understanding and generating human language. Previous studies have shown that transformer-based models, such as BERT, GPT, and T5, have revolutionized the field of NLP by achieving state-of-the-art results in tasks like text classification, sentiment analysis, and machine translation. Notably, the prominence of task analysis in this cluster suggests an increasing interest in model explainability and the interpretability of deep learning systems, an area gaining significant attention in contemporary AI research. Researchers, such as Patwardhan N [31], have highlighted the effectiveness of transformer models for contextual understanding in NLP, thus contributing to the expansion of AI's capabilities.

b. Algorithms and Frameworks (Blue Cluster)

The focus on algorithms and frameworks represents a key pillar of AI research and development. This cluster is supported by foundational work in algorithmic theory and AI frameworks that drive innovations across various applications. Research such as [32] on deep learning frameworks and [33] on the Keras framework emphasizes the role of advanced algorithms in optimizing model performance and application deployment. The evolution of frameworks like TensorFlow and PyTorch has accelerated AI research by providing powerful tools that simplify the creation and scaling of machine learning models. The algorithm-centric nature of this cluster may also reflect ongoing efforts to develop more efficient algorithms capable of reducing the complexity and cost of AI models.

c. AI and Healthcare (Red Cluster)

The intersection of AI, healthcare, and decision-making has garnered increasing interest in research due to AI's transformative potential in the medical field. AI's role in diagnosis, treatment recommendations, and healthcare decision support systems is well-documented, with studies like [34] showing how deep learning models can outperform human experts in diagnosing diseases such as skin cancer and pneumonia. This cluster's emphasis on ethics and opportunities underscores a crucial area of concern for AI in healthcare. As AI's capabilities grow, researchers and policymakers alike have stressed the importance of addressing ethical issues, such as bias in AI systems, privacy concerns, and the potential for AI-driven inequities in healthcare access. The literature, including [35] discusses how biased training data may disproportionately affect certain groups, highlighting the need for fair and transparent AI systems.

3.6. Evolution of Keywords in AI and Leadership

Fig. 6 presents the evolution of keywords in AI and leadership research from 2023 to 2024, highlighting the dynamic nature of the field. Key terms such as "AI ethics," "ChatGPT," and "transformers" have emerged and gained prominence, reflecting a shift towards more advanced AI technologies and their ethical implications in leadership contexts. The inclusion of "AI ethics" signals a growing concern about the responsible use of AI, particularly in leadership roles where decision-making can have significant societal and organizational impacts. The rise of "ChatGPT" and "transformers" emphasizes the increasing relevance of natural language processing models and their application in leadership, facilitating communication, decision support, and strategic planning in educational and organizational leadership. This shift in keyword trends illustrates how AI is evolving from a purely technical domain to a more socially and ethically oriented field of study.

As these keywords evolve, AI leadership research is moving beyond basic AI technologies and exploring more sophisticated applications. The increasing prominence of "AI ethics" indicates that researchers are increasingly concerned with the moral and societal implications of AI. The inclusion of "ChatGPT" and "transformers" in the research discourse underscores the growing application of advanced AI models in leadership, particularly for tasks such as communication, decision-making, and knowledge sharing. These developments suggest that AI is not only reshaping leadership in terms of operational efficiency but also transforming how leaders interact with their teams, stakeholders, and broader society.

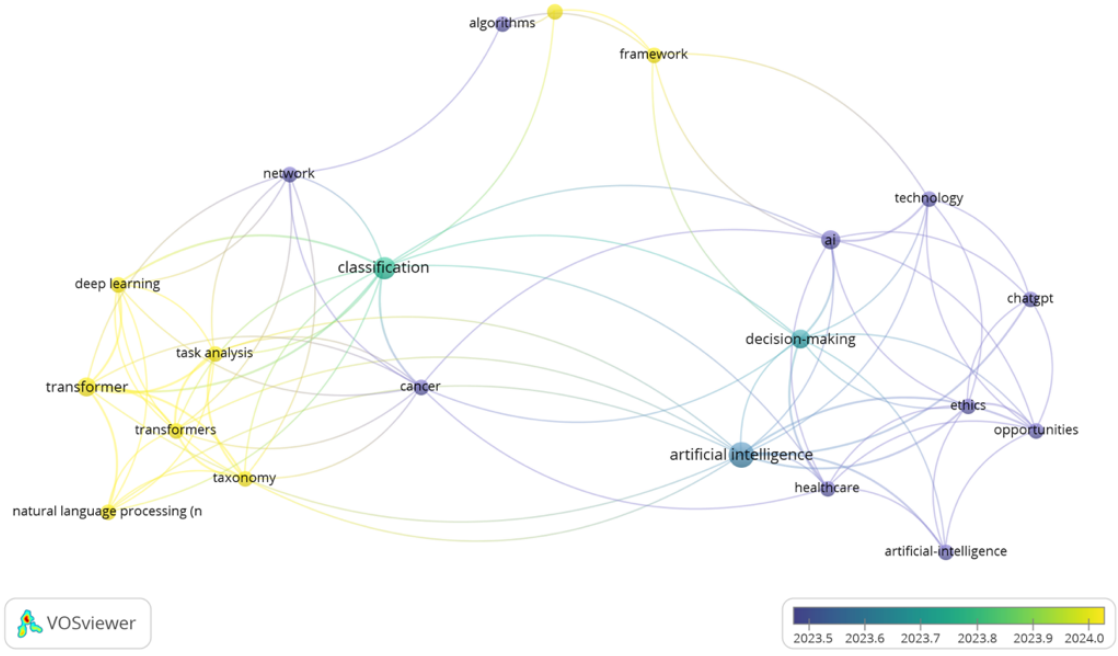

Fig. 6. Keywords Evolution Over Time

The emergence of "AI ethics" as a significant keyword reflects the increasing need for ethical frameworks in AI leadership research. As AI technologies become more integrated into leadership processes, particularly in sensitive areas such as healthcare, education, and governance, the ethical implications of these technologies are becoming a major area of focus. Research by [36] has highlighted that AI technologies, when not properly regulated, can lead to unintended consequences such as biased decision-making, a lack of transparency, and accountability gaps. As such, AI ethics is becoming a key consideration for leaders in these sectors, as they are tasked with implementing AI solutions that are not only effective but also fair, transparent, and responsible. This evolution signifies that AI leadership research is shifting towards a more interdisciplinary approach, integrating

technology, leadership theory, and ethics to better address the challenges posed by AI in leadership roles.

The increasing frequency of terms like "ChatGPT" and "transformers" suggests that advanced AI models are significantly influencing leadership practices. These technologies, which excel in natural language understanding and generation, are becoming integral to leadership roles, particularly in communication and decision-making. ChatGPT, for example, offers leaders a powerful tool for automating communication, enhancing customer service, and even assisting in decision-making by providing data-driven insights. Similarly, the use of transformers for tasks like text generation, sentiment analysis, and strategic forecasting is becoming more prevalent in leadership contexts, enabling leaders to make informed decisions based on a broader range of inputs. As AI models continue to evolve, their application in leadership will likely expand, further transforming how leaders engage with their teams and manage organizations. Research by [37] emphasizes the role of AI in enabling leaders to process vast amounts of information and make decisions more effectively, particularly in fast-paced environments where timely and accurate decisions are crucial.

a. AI Ethics

The emergence of "AI ethics" as a significant keyword signals a growing recognition of the moral and ethical implications of AI in leadership roles. This reflects a shift from purely technical discussions of AI to considerations of how AI impacts society, governance, and organizational decision-making. This is a recent trend, as AI ethics has only gained prominence in the past few years due to the increased application of AI in sensitive areas such as healthcare, education, and finance.

b. ChatGPT

The appearance of "ChatGPT" as a keyword is novel because it highlights the rapid advancement and application of conversational AI models in leadership. ChatGPT, based on GPT-3.5 and GPT-4, represents a new era in natural language processing (NLP) and is now being explored for its potential to assist leaders in communication, decision-making, and knowledge dissemination. The novelty lies in how leaders can use AI models like ChatGPT for strategic discussions, content generation, and interactive leadership styles.

c. Transformers

The term "transformers" refers to the specific AI architecture that powers advanced NLP models like ChatGPT. Its increased mention reflects the growing importance of this technology in AI leadership, especially in applications related to communication, automated decision-making, and knowledge management. While transformers were initially discussed primarily in NLP and machine learning communities, their growing presence in leadership research indicates their broader relevance in organizational leadership.

This study's findings align with broader global trends in AI leadership research, particularly in AI ethics and the application of NLP technologies. Countries such as Australia, China, and the UK have also made significant contributions to AI in leadership research, with strong academic and industry collaborations driving advancements in AI applications across various sectors. However, Saudi Arabia's dominance in citation counts and AI leadership research highlights a regional disparity in research output and influence, driven largely by its government's investments and strategic initiatives.

While AI in leadership is gaining momentum globally, the application of AI tools in education and healthcare leadership is still in its infancy. Many countries, particularly in developed regions, are exploring the integration of AI in leadership roles, but challenges related to infrastructure, policy development, and workforce readiness remain prevalent. As AI technologies mature, it is expected that global research on AI leadership will continue to evolve, with a growing emphasis on ethical frameworks, cross-sector collaboration, and the responsible use of AI in decision-making.

3.7. Three Main Contributions

Comprehensive Bibliometric Analysis: This study provides a comprehensive bibliometric mapping of AI's integration into leadership practices, specifically in the educational context. It identifies key trends, influential journals, and leading countries in AI leadership research, offering valuable insights into the state of the art and emerging technologies.

Ethical Integration of AI in Leadership: A key contribution of this research is its focus on AI ethics in leadership. The study highlights the importance of integrating ethical considerations into AI systems to ensure their responsible use in leadership practices, particularly in education and healthcare. It provides a framework for future research on how AI can be ethically integrated into leadership practices across various domains.

Technological Advancements in Leadership: The study explores the role of advanced AI technologies, such as ChatGPT and transformers, in shaping leadership communication, decision-making, and strategy. These technologies are transforming leadership practices by providing tools that enhance communication, optimize decision-making processes, and support more informed leadership practices.

4. Conclusion

This study has explored the integration of Artificial Intelligence (AI) in leadership, specifically within educational contexts, over the past two decades. The findings highlight the transformative potential of AI, particularly in enhancing decision-making processes, communication strategies, and leadership effectiveness. However, as AI continues to evolve, it becomes clear that its ethical implications must be addressed to ensure responsible and equitable use, especially in sensitive sectors like education and healthcare.

For Policymakers: Policymakers must prioritize the development of comprehensive AI policy frameworks that address ethical considerations in AI deployment. This includes establishing standards for transparency, accountability, and fairness in AI systems used in leadership roles. Ensuring that AI technologies are ethically integrated into governance, education, and healthcare will be critical to maintaining public trust and preventing bias or discrimination in decision-making processes.

For Researchers: Future research should focus on natural language processing (NLP)-driven leadership tools and their applications in leadership roles, especially in educational and healthcare sectors. Investigating the intersection of AI technologies like ChatGPT and transformers with leadership communication, decision support systems, and ethical frameworks can provide deeper insights into how these tools can reshape leadership practices. Additionally, researchers should explore cross-disciplinary approaches, combining AI, leadership theory, and ethics, to better understand the societal impacts of AI in leadership.

For Educators: Educators must adopt AI responsibly by integrating AI tools into leadership roles with a clear focus on their ethical implications. Professional development programs should be introduced to train educational leaders in effectively leveraging AI technologies while ensuring that they adhere to ethical standards. Educators should also advocate for policies that promote AI literacy in leadership contexts, ensuring that AI is used to enhance educational outcomes without compromising fairness or equity.

This study positions AI-driven leadership as a transformative trend in education but emphasizes the urgent need for ethical frameworks and cross-disciplinary collaboration. As AI technologies evolve, it is essential for stakeholders across all sectors to work together in developing policies, conducting research, and implementing practices that ensure AI's responsible and impactful integration into leadership roles.

Declarations

Supplementary Materials: Supplementary materials of this study include the full dataset retrieved from Scopus and visualizations generated using VOS viewer.

Author Contributions: MBS: Conceptualization; RNG: Writing-Initial Draft, Editing and Visualization, Methodology and Review & Editing, Conceptualization, Formal analysis, Methodology and Review; MBS: Editing; ATO & USJ: Validation and Monitoring. All authors have read and approved the published version of the manuscript.

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