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AI-Based Fall Prevention and Monitoring Systems for Aged Adults in Residential Care Facilities

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Abstract:

- ***Purpose:***

This study explores the application of artificial intelligence (AI) in fall prevention and monitoring systems designed for aged adults in residential care facilities. It aims to assess how AI-driven technologies can enhance safety, reduce fall-related injuries, and improve the quality of life among elderly residents.

- ***Methodology:***

A comprehensive literature review was conducted, drawing from academic databases such as PubMed, IEEE Xplore, and Scopus. The review focused on studies published in English that examined AI algorithms, sensor technologies, and data analytics for fall prediction and monitoring among individuals aged 65 and older. Studies involving diagnostic or rehabilitative AI applications were excluded. Key metrics such as sensor types, algorithm performance, and system accuracy were analyzed.

- ***Findings:***

The review reveals a growing adoption of AI-based systems employing machine learning algorithms, including decision trees, support vector machines, and neural networks, for fall risk prediction and detection. Wearable sensors, computer vision, and data analytics have shown promise in reducing false alarms and enhancing fall detection reliability. Despite the demonstrated potential for improving safety and reducing healthcare costs, challenges persist in ensuring data privacy, user acceptance, and system robustness.

- ***Unique Contribution:***

This research uniquely consolidates current knowledge on AI applications for fall prevention in elderly care, highlighting practical implementations, limitations, and future directions. It underscores the transformative role of AI in

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proactive elderly care, offering a foundation for developing more adaptive, personalized, and ethical AI-based interventions in residential care environments.

Keywords: *AI-based Fall Prevention, Elderly Fall Detection, Wearable Fall Sensors, Machine Learning For Fall Prediction.*

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I. INTRODUCTION

The escalating global population of older adults necessitates innovative approaches to healthcare and safety, particularly within residential care facilities. Falls are a significant concern for this demographic, leading to injuries, reduced independence, and increased healthcare costs (Smith, 2017). Globally, a substantial proportion of older adults, ranging from 20% to 35% of those aged 60 and over, experience falls annually, underscoring the urgency of effective fall prevention strategies (Cheng et al., 2018).

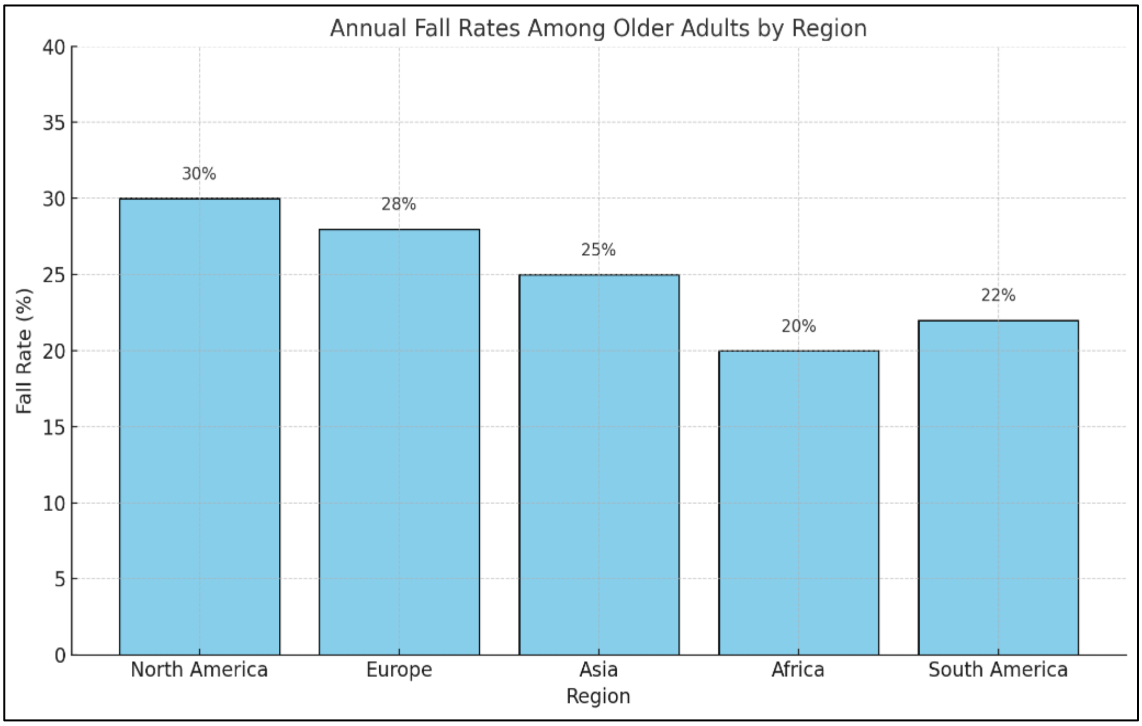

Fig 1. Annual Fall Rates Among Older Adults by Global Region. Data Reflect the Percentage of Individuals Aged 60 and over who Experience Falls Annually, Illustrating Regional Disparities in Elderly Fall Prevalence.

Falls are the primary cause of accidental injuries and mortality among older individuals, leading to over 10,300 fatalities in a single year and costing billions in medical expenses (Mei et al., 2011). With the aging population continuing to grow, the financial and societal burdens associated with falls are expected to increase. The development and implementation of AI-based fall prevention and monitoring systems offer a promising avenue for enhancing the well-being and safety of older adults in residential care settings.

This research delves into the potential of AI-driven solutions to address the multifaceted challenges of fall prevention and monitoring, aiming to improve the quality of life for aged adults in residential care facilities. Falls and fall-related injuries represent a serious public health problem and a significant threat to health, safety, and independence among the elderly (Martins et al., 2018). Among older adults, falls are the leading cause of nonfatal injuries and hospital visits for trauma.

Technology integration into healthcare, especially for older adults, has become increasingly important. Monitoring the elderly in a discreet and non-invasive manner can help to automatically detect accidents and alert caregivers to potential risks, allowing them to act quickly to prevent serious incidents (Abreu et al., 2021). Such AI systems promise to increase older adults' autonomy while lowering accident-related healthcare costs. Existing fall management methods in communities and their challenges are discussed. The ageing "boomer" generation is accelerating the growth of the older population in the United States. Problems with mobility, balance, and loss of muscular strength all raise the risk of falling (Florence et al., 2018).

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II. METHODS

The methodology employed in this research involved a comprehensive review of existing literature, encompassing scientific articles, industry reports, and relevant publications, to gather information on AI-based fall prevention and monitoring systems. Data sources included academic databases such as PubMed, IEEE Xplore, and Scopus, as well as industry-specific websites and reports.

Keywords used in the search included "AI-based fall prevention," "elderly fall detection," "wearable fall sensors," and "machine learning for fall prediction." The search included studies, implementations, and analyses about the creation, use, and efficacy of AI-based technologies for fall prevention and monitoring in elderly care homes. The search was limited to articles published in English. The review focused on studies investigating AI algorithms, sensor technologies, and data analytics for predicting, detecting, and preventing falls among older adults in residential care facilities. Relevant data points extracted from the selected studies included the types of AI algorithms used, sensor modalities employed, fall detection accuracy rates, and interventions' impact on fall rates.

Ethical considerations and challenges related to implementing AI-based systems in elderly care were examined. The review included studies that evaluated the performance of AI-based systems in real-world settings, such as nursing homes and assisted living facilities. A meta-analysis was planned to assess the effectiveness of AI-based systems, but due to the heterogeneity of the included studies, it was not possible.

The studies chosen had to meet a few requirements. Studies were included if they concentrated on predicting fall risk in elderly populations using machine learning and were written in English. For this review, "elderly" was defined as individuals aged 65 or older. Even if the overall cohort included younger participants, articles were included if the study population included people aged 65 or older, using a sensitive inclusion strategy (Capodici et al., 2025). Studies that investigated the use of AI in clinical settings, such as for diagnosis, or that dealt with rehabilitation strategies following a fall were excluded. The decision to exclude studies on diagnosis or rehabilitation was based on the review's emphasis on preventative actions and prospective risk assessment utilizing AI.

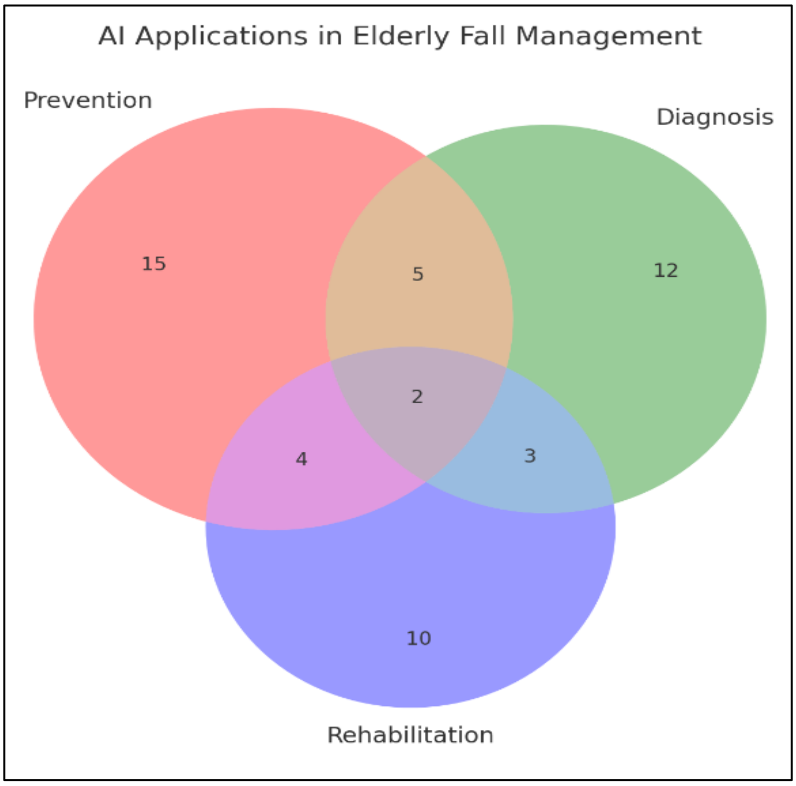

Fig 2 Visually Delineates the Relationship between the Significant Domains of AI Applications in Fall Management, Highlighting this Study's Focus on Prevention.

The data obtained during the literature search were categorized and synthesized to identify key trends, challenges, and opportunities in AI-based fall prevention and monitoring systems. The included studies were evaluated for methodological quality and risk of bias using established assessment tools, such as the Cochrane Risk of Bias tool.

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III. RESULTS

The findings of this review highlight the growing interest in AI-based fall prevention and monitoring systems for aged adults in residential care facilities.

Table 1. Overview of Selected Studies Showcasing Different AI Algorithms Used in Fall Detection Systems, their Sensor Technologies, and Reported Accuracy Rates. This Table Highlights the Diversity of Approaches and Performance Outcomes in the Literature.

Study	AI Algorithm	Sensor Type	Accuracy (%)	Key Notes
Mei et al. (2011)	Neural Network	Wearable Accelerometers	91%	High sensitivity and low false alarm rate
Choudhury & Asan (2020)	Decision Tree	Vision-based System	85%	Effective for controlled environments
Seibert et al. (2021)	Support Vector Machine	Wearable + Ambient	88%	The combined approach increased detection accuracy
Ng et al. (2021)	Deep Learning (CNN)	Computer Vision	93%	Excellent performance in real-time video stream analysis
Mahajan et al. (2025)	Random Forest	Floor Vibration Sensors	79%	Suitable for passive, non-wearable detection systems

Machine learning algorithms, sensor technologies, and data analytics are used to predict falls, track patients, and develop interventions. Several studies focused on using machine learning algorithms, such as decision trees, support vector machines, and neural networks, to predict the risk of falls based on various factors, including age, medical history, and gait patterns.

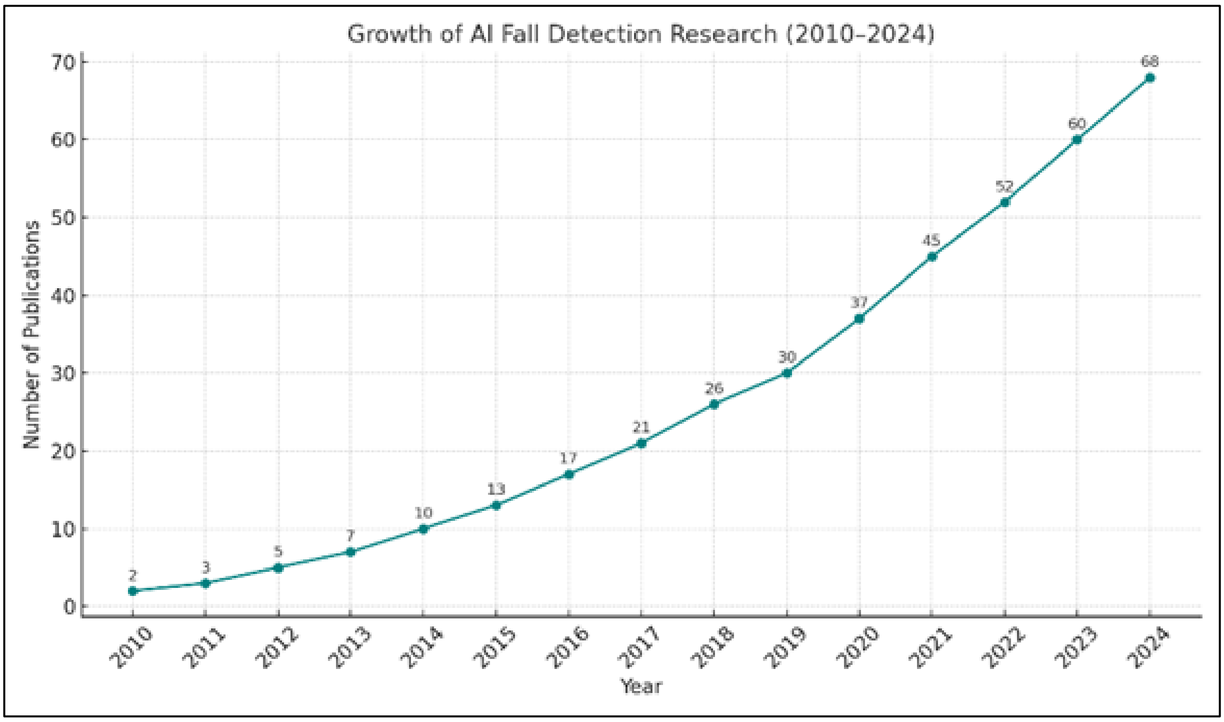

Fig 3. Growth Trend in Academic Publications Related to AI-based Fall Detection Systems from 2010 to 2024. The Data Indicate a Steady Rise in Research Interest, Reflecting Growing Technological and Clinical Relevance.

The results of these studies suggest that AI-based predictive models can achieve high levels of accuracy in identifying individuals at risk of falling. AI-based decision support systems can improve error detection, patient stratification, and drug management (Choudhury & Asan, 2020).

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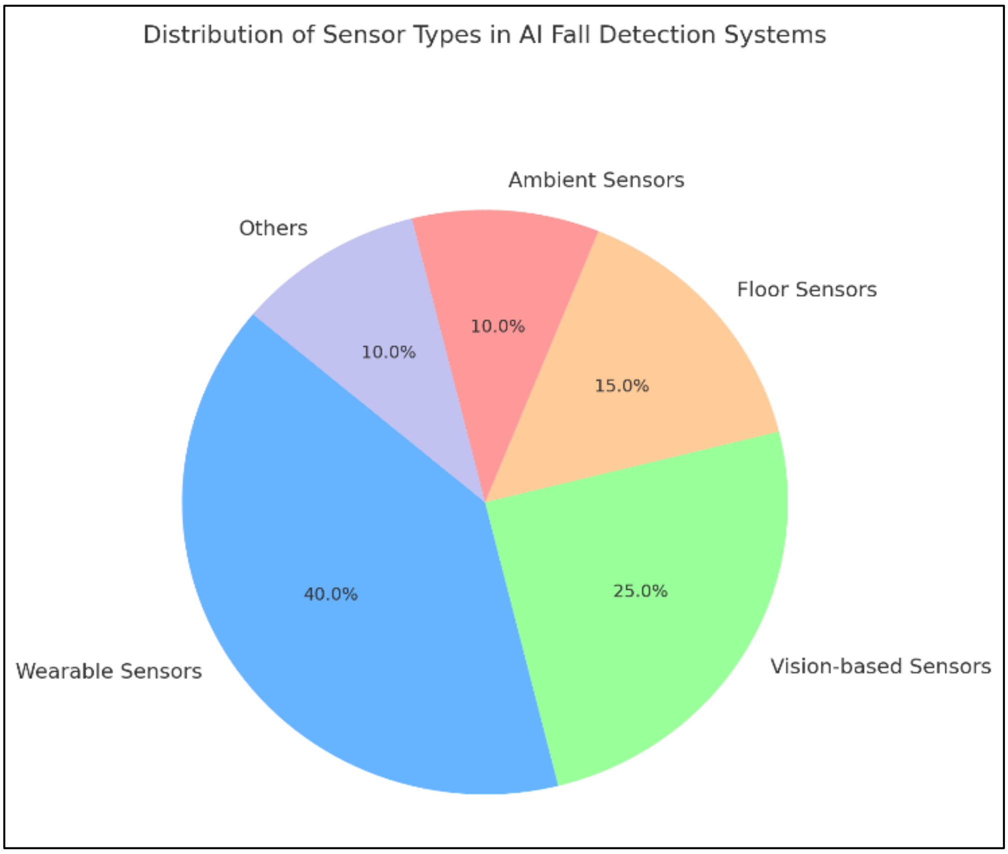

Fig 4. Proportional Use of Sensor Technologies in AI-based Fall Detection Systems. Wearable Sensors Dominate Current Implementations, Followed by Vision-based and Floor Sensors.

In terms of sensor technologies, wearable sensors, such as accelerometers and gyroscopes, are commonly used to monitor the movements and activities of older adults. These sensors can detect falls in real-time and automatically alert caregivers or emergency services. AI algorithms analyze the sensor data to differentiate between everyday activities and fall events, reducing false alarms and improving the reliability of fall detection systems. Computer vision and sophisticated image processing techniques track and classify activities, health conditions, and fall events. However, studies reporting the effects of AI applications on clinical or organizational outcomes are scarce (Seibert et al., 2021).

In addition to predicting and detecting falls, AI-based systems can also develop personalized interventions to prevent them. AI algorithms analyze data on individual risk factors, activity patterns, and environmental conditions to recommend tailored interventions, such as exercise programs, medication adjustments, and home modifications. These interventions address the underlying causes of falls and reduce the risk of future incidents.

The studies included in this review reported varying degrees of success in reducing fall rates among older adults in residential care facilities. However, challenges remain in terms of data privacy, system reliability, and user acceptance. While several obstacles exist, using artificial intelligence to improve safety inside and outside hospitals has excellent potential. For example, AI can offer decision support by spotting individuals at high risk of harm in hospitals and guide early intervention and prevention strategies (Bates et al., 2021). The studies in this review suggest that AI-based fall prevention and monitoring systems can improve patient outcomes, lower healthcare costs, and enhance the quality of life for aged adults in residential care facilities. (Ng et al., 2021).

IV. DISCUSSION

AI-based fall prevention and monitoring systems represent a transformative approach to enhancing the safety and well-being of aged adults in residential care facilities. These systems leverage the power of machine learning algorithms, sensor technologies, and data analytics to predict falls, detect falls in real-time, and develop personalized interventions to prevent falls from occurring (Li et al., 2024).

The findings of this review underscore the potential of AI to revolutionize fall management in elderly care settings.

One of the key advantages of AI-based systems is their ability to predict falls before they happen (Pailaha, 2023; Mennella et al., 2024). By analyzing vast amounts of data on individual risk factors, activity patterns, and environmental conditions, AI algorithms can identify individuals at high risk of falling (Mahajan et al., 2025). This proactive approach allows caregivers to implement preventive measures and interventions to mitigate the risk of falls, rather than simply reacting to falls after they occur.

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Creating these technologies involves understanding ethical and regulatory issues, which are essential for AI's successful and responsible deployment in healthcare settings (Mennella et al., 2024). AI can improve patient safety outcomes and the quality of care by streamlining data collection and analysis, which will provide real-time insights into patient care (Abukhadijah & Nashwan, 2024; Choudhury & Asan, 2020).

Another important aspect of AI-based systems is their ability to detect falls in real-time. Wearable sensors and computer vision systems can monitor the movements and activities of older adults, detecting falls as they happen. This capability enables caregivers to respond quickly to falls, providing timely assistance and reducing the risk of fall-related injuries. AI systems can also be used to develop personalized interventions to prevent falls. By analyzing individual risk factors and activity patterns, AI algorithms can recommend tailored interventions, such as exercise programs, medication adjustments, and home modifications.

Overall, the studies in this review suggest that AI-based fall prevention and monitoring systems can improve patient outcomes, lower healthcare costs, and enhance the quality of life for aged adults in residential care facilities. Even the ethical and legal facets of incorporating AI into healthcare are covered. It is essential to consider the moral ramifications of AI, such as transparency, accountability, and fairness, to guarantee that these technologies are used morally and equitably.

V. LIMITATIONS

Despite the promising findings of this review, it is important to acknowledge the limitations of AI-based fall prevention and monitoring systems. One of the main limitations is the potential for data privacy breaches (Piñeiro-Martín et al., 2023). AI algorithms require access to large amounts of personal data to predict and detect falls accurately. This data may include sensitive information about individuals' health conditions, activity patterns, and living environments. Protecting the privacy and security of this data is essential to maintain trust and prevent misuse.

Another limitation of AI-based systems is the risk of bias. AI algorithms are trained on data; if the data is biased, the algorithms will also be biased (Piñeiro-Martín et al., 2023). This can lead to inaccurate predictions and unfair treatment of specific individuals or groups. Ensuring that AI algorithms are trained on diverse and representative datasets is crucial to mitigate the risk of bias. The application of robotic technology in care services is also important due to the universal lack of a caregiving workforce internationally.

In addition, AI-based systems may not be suitable for all older adults. Some may be uncomfortable wearing sensors or being monitored by cameras, and others may not have the cognitive abilities to understand how the systems work or to use them effectively. When implementing AI-based fall prevention and monitoring systems, it is important to consider the individual needs and preferences of older adults.

Finally, the long-term effectiveness of AI-based systems has yet to be fully established. While some studies have shown that these systems can reduce fall rates in the short term, more research is needed to determine whether they can sustain these effects over extended periods.

VI. CONCLUSION

In conclusion, AI-based fall prevention and monitoring systems are promising for improving the safety and well-being of aged adults in residential care facilities. These systems have the potential to predict falls, detect falls in real time, and develop personalized interventions to prevent falls from occurring (Mennella et al., 2024). AI offers a possible means to lower the cost of healthcare, improve service effectiveness, and establish a highly valued support system for the well-being of patients and the healthcare industry at large.

The development and implementation of these systems require careful consideration of ethical, legal, and social implications. These technologies can also enhance communication, improve patient care, and offer ongoing support to healthcare personnel. Addressing these limitations ensures that AI-based systems are used safely, effectively, and ethically. AI-based systems also provide a chance to enhance medical records and broaden access to high-quality medical treatment (Pailaha, 2023).

Ongoing research is needed to evaluate AI-based systems' long-term effectiveness and refine their design and implementation. AI can be used to suggest tailored interventions, including home modifications, medication adjustments, and exercise regimens, by evaluating data on specific risk factors and activity patterns (Martinez-Ortigosa et al., 2023). AI-based systems may also recommend changes to fall prevention and monitoring procedures based on data trends and patterns. Furthermore, creating user-friendly interfaces for healthcare personnel to access and interpret data from AI systems easily is crucial for encouraging their uptake. In the coming years, developments in AI-based fall prevention and monitoring systems will probably be centered on tackling existing limitations and optimizing their efficacy and applicability. The medical industry is significantly changing as the world's elderly population ages due to the rising need for point-of-care diagnostics and continuous monitoring of chronic illnesses (Secara & Hordiiuk, 2024). Combining AI and healthcare can improve patient outcomes and lower healthcare expenses (Cornelissen et al., 2022).

AI has demonstrated its potential to enhance patient outcomes, streamline healthcare processes, and offer individualized treatment strategies (Gala et al., 2024). The creation of AI-based medical treatments signifies a paradigm change with the potential to transform the healthcare industry and improve patient outcomes. However, ethical considerations must be taken into account for the use of AI in healthcare to be safe, effective, and equitable.

AI's algorithms need to be fair and unbiased, transparency and accountability must be maintained, and data privacy must be protected (Jha et al., 2023). To successfully incorporate AI into healthcare, cooperation between legislators, developers, healthcare professionals, and patients is essential (Jeyaraman et al., 2023; Lambert et al., 2023). Future research should concentrate on improving the ethical standards, openness, and dependability of AI technology to guarantee that they support global health outcomes positively (Shang et al., 2024).

It is crucial to remember that while AI can be a powerful tool, it cannot replace qualified medical personnel; AI should support and improve diagnostic procedures, enhancing patient care and healthcare results (Umapathy et al., 2023). The application of AI technology in healthcare has developed rapidly in many developed countries, and it is considered to have increased human resources and skills, thereby improving the accuracy of medical treatment (OMOTOSHO et al., 2022). This technology has the power to impact the future of the industry and human beings, but it is a double-edged sword. AI applications in healthcare have changed the medical field, including imaging and electronic medical records, laboratory diagnosis, treatment, augmenting the intelligence of the physicians, new drug discovery, providing preventive and precision medicine, biological extensive data analysis, speeding up processes, data storage and access for health organizations (Farhud & Zokaei, 2021).

AI helps in clinical practice with disease diagnosis, treatment optimization, clinical workflow management, patient engagement, prediction of disease outbreaks, and the discovery of new drugs. By analyzing large datasets and identifying patterns, AI has facilitated breakthroughs in fields such as genomics and drug discovery (Alowais et al., 2023). AI can examine complex diseases, explore biological systems, and develop diagnostic tools.

AI-based systems can be customized to provide individualized support to older adults, promoting their independence and quality of life (Alowais et al., 2023). The advent of AI in healthcare presents a wealth of opportunities to enhance patient care, streamline operations, and foster innovation (Serag et al., 2019). Ongoing innovation and interdisciplinary partnerships will be crucial to entirely realizing AI's potential and influencing the future of healthcare.

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