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Review
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ARTIFICIAL INTELLIGENCE IN MEDICINE; OPPORTUNITIES AND CHALLENGES

Tahmineh DARVISHMOHAMMADI[1], Ayşe ÖZKAL[2]*, Ahmet Selim ÖZKAL[3]

[1]*Pamukkale University, Faculty of Engineering, Department of Textile Engineering, 20070, Denizli, Türkiye*
[2]*Gazi University, Faculty of Medicine, Department of Internal Medicine, 06570, Ankara, Türkiye*

Abstract: Currently, artificial intelligence (AI) is used in many fields of medicine such as cardiology, endocrinology, neurology, and particularly gastroenterology where AI increases the quality of images obtained from related imaging techniques. Also, medical diagnosis is greatly affected by AI algorithms and deep learning techniques. AI shows potential for not only monitoring and managing treatment plans but also promises accurate diagnosis and prediction of diseases. This paper aims to review the future opportunities and challenges of AI applications in medicine. The results show a bright future with multiple opportunities in medical diagnosis, radiology, and pathology fields with increasing accuracy, image quality, and decreasing radiation dose. Additionally, AI will facilitate medical research studies which is a great contribution to the medical world. Challenges and ethical limitations will be mostly related to the validity and reliability of data, bias, responsibility issues, risks and unpredictable consequences, and equitable application which need establishing clear guidelines and regulations. This paper suggests a more extended educational program for both healthcare professionals and patients to achieve the best result.

Keywords: Artificial intelligence, Medical technologies, Medicine, Medical diagnosis

***Corresponding author:** Pamukkale University, Faculty of Engineering, Department of Textile Engineering, 20070, Denizli, Türkiye
E mail: aozkal@pau.edu.tr (A. ÖZKAL)
Tahmineh DARVISHMOHAMMADI https://orcid.org/0009-0000-7590-1004
Ayşe ÖZKAL https://orcid.org/0000-0003-1294-7106
Ahmet Selim ÖZKAL https://orcid.org/0009-0008-9667-7126

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1. Introduction

Artificial intelligence (AI) is a field that aims to fabricate machines that can perform human-like tasks such as decision-making, problem-solving, language processing and learning from data. A wide range of disciplines, including technology, psychology, neuroscience, biology, mathematics, social sciences and philosophy, fall within the scope of AI and AI aims to solve complex problems by imitating human cognitive abilities (Velagaleti, 2023).

The first use of the artificial intelligence (AI) concept (computers think as intelligent as humans) was raised as early as 1950. Although AI applications in medicine experienced a slow development trend compared to engineering, it has revolutionized medicine (Kaul et al., 2020). AI in healthcare can save time, reduce costs, and improve patient management, while also supporting recruitment and retention of healthcare professionals in rural areas rural health facility recruitment and retention. However, challenges include delayed adoption, a lack of ongoing implementation of technology within the healthcare system and insufficient consideration of user perspectives and feedback (Sunarti et al., 2021).

As a result, personalized medicine has emerged replacing the old version of algorithm-based medicine (Kaul et al., 2020). Generally, AI has the potential to predict diagnoses and therapeutic response in medicine. To mention some examples of AI in predicting and diagnosing diseases, we can refer to its potential to detect early-stage Alzheimer's disease using Support Vector Machines (SVM) and statistical tools. Other examples include analyzing retinal fundus images in diabetic patients using Convolutional Neural Networks (CNN), identifying brain lesion segmentation by multi-scale 3D CNN, and predicting ischemic stroke thrombolysis using a combined approach of CNN and Artificial Neural Networks (Kamdar et al., 2020). Although, it can increase the accuracy of diagnosis which leads to better efficacy of therapeutic processes (Ruffle et al., 2018), the development of AI in medicine has raised questions about how this technology might affect trustworthy relationships in clinical settings (McDougall, 2018).

The importance of this study lies in its potential to bridge the gap between emerging technologies in computer science and their applications in medical care systems, particularly in diagnosis, disease control, and management. As AI continues to reshape the medical landscape and shift decision-making processes towards data-centric insights (Filipp, 2019), understanding its implications and challenges is critical not only for patient care but also for informing medical education. Therefore, the broader impact of AI-based technologies on the medical community and patient outcomes underscores the significance of this review paper.

This paper aims to review the current applications of AI in various fields of medicine, particularly in medical diagnosis, and also to explore the opportunities, challenges, ethical implications, and future directions in this area.

1.1. Current Application of AI in Different Fields of Medicine

Artificial intelligence (AI) is transforming the healthcare industry through improvements in patient outcomes, therapeutic planning, diagnostic accuracy, and operational efficiency. Large volumes of medical data are analyzed using AI and machine learning (ML) technologies to find patterns and anomalies that can be used for personalized medication and early disease diagnosis (Kuwaiti et al., 2023). The use of these technologies enhances administrative efficiency, resource allocation, and patient engagement with virtual assistants and chatbots (Velagaleti, 2023). Additionally, AI helps healthcare practitioners by combining human knowledge with analytical skills, guaranteeing a human-in-the-loop strategy for high-quality and safe healthcare services. The transformative influence of artificial intelligence (AI) on healthcare delivery and patient outcomes is demonstrated by its use in medical imaging, diagnostics, virtual patient care, drug development, patient engagement, and rehabilitation. Incorporating AI into healthcare systems presents several ethical, social, and technical concerns that must be addressed through with effective governance (Sezgin, 2023).

Currently, AI is applied in multiple medical fields. In cardiology, AI is not only applied to FDA-approved ECG monitoring and atrial fibrillation applications but also can significantly predict the risk of cardiovascular diseases. It is shown that AI-based systems can identify incidents of atrial fibrillation more than routine clinical care and can subsequently impact the lower incidence of ischemic strokes (Halcox et al., 2017). In endocrinology fields, AI has been applied to glucose monitoring systems which helps the patients to obtain better control of their blood glucose (Christiansen et al., 2017). In addition, in neurology, AI plays an important role in disease management. For example, wearable technology can detect epilepsy seizures and report them on mobile applications (Regalia et al., 2019). Another example is the assessment of gait, posture, and tremors in multiple sclerosis, Parkinson's disease or Huntington's disease (Dorsey et al., 2018). AI also plays a crucial role in diagnostic medicine, particularly in increasing the accuracy of cancer histopathology. It is demonstrated that it is feasible to develop and deploy a robust computational decision support system for pathology that can scale to large datasets and integrate into clinical workflows, improving diagnostic efficiency and accuracy (Campanella et al., 2019).

There are great advancements in AI in different fields of medicine. However, special improvements in the field of gastroenterology were observed (Kaul et al., 2020). In this field, artificial intelligence and deep learning help increase the quality of images obtained from endoscopy (Yang and Bang, 2019) and colonoscopy in a way that can revolutionize gastroenterological practice for prediction, personalization, and automation in diagnostics and treatment (Ruffle et al., 2018). For example, AI successfully differentiates chronic pancreatitis from pancreatic cancer which has been a challenge in the field (Zhu et al., 2013). AI has particularly advanced AI-assisted endoscopy for more accurate detection of gastrointestinal polys or lesions (Hoogenboom et al., 2020). AI-assisted systems have gone beyond by predicting bleeding, increasing the survival rate of cancer, and metastasis in colorectal cancer and can significantly reduce the rate of unnecessary additional surgeries (Ichimasa et al., 2017). The summary of these studies on the application of AI in various medical fields, including aims, technology, and results is demonstrated in Table 1.

1.2. AI Application in Medical Diagnosis

The application of AI in medical diagnosis has been particularly successful. Specifically, multiple AI algorithms and deep learning techniques have been used successfully in diagnosing diseases such as Alzheimer's, Parkinson's, skin cancer, and stroke. Also, image analysis has had a significant impact on. For example, new techniques have been employed in analyzing medical images like mammograms, MRI scans, and anatomical images for stroke diagnosis. Additionally, Natural Language Processing (NLP) has been utilized to extract information from clinical notes and radiology reports for the identification, classification, and prediction of diseases (Kamdar et al., 2020). For example, the first NLP was introduced by Fiszman which was a device to read X-ray language on the chest (Fiszman et al., 2000). Also, in another study least square support vector machine (LSSVM) was introduced to detect cancer at an early stage (Sweilam et al., 2010). In 2017, NLP was used to differentiate between peripheral arterial diseases and other arterial diseases with more than 90% accuracy (Afzal et al., 2017). The three main domains of AI application in medical diagnosis are illustrated in Figure 1.

Table 1. Summary of studies on the application of AI in various medical fields, including aim, technology, and results. AI had a great impact on diagnosis and managing the treatment process in multiple fields of medicine such as cardiovascular, endocrinology, neurology, gastroenterology and oncology

Field of Medicine	Aim of the study	Technology	Result	Reference
Cardiovascular Diseases	Evaluating the effectiveness of monitoring using an AI-based electrocardiographic capture system, compared to routine clinical care in diagnosing atrial fibrillation (AF) in individuals over 65 years age with ≥1 additional stroke risk factor	AliveCor Kardia device, a smartphone/tablet-based single-lead electrocardiographic capture system	Screening with this method can significantly identify incidents of atrial fibrillation more than routine clinical care and can impact on AF detection and the lower incidence of ischemic strokes	Halcox et al. (2017)
Endocrinology	Evaluating the performance, safety, and accuracy of an AI based glucose sensor, particularly when used in conjunction with an insulin pump, mobile device application, or glucose sensor recorder (GSR), in individuals with type 1 or type 2 diabetes	Guardian Sensor 3 glucose sensor	Demonstrated accuracy and precision across a range of glucose levels (hypoglycemic, euglycemic, and hyperglycemic)	Christiansen et al. (2017)
Neurology	Evaluating the effectiveness of generalized tonic-clonic seizure (GTCS) detection and monitoring using AI-based wearable devices.	These devices use a machine learning algorithm to recognize the physiological signatures of GTCS events based on accelerometer (ACC) and electrodermal activity (EDA) data.	Showed effective with high sensitivity (over 92%) and a low false alarm rate (FAR), especially during rest, making them promising tools for seizure detection.	Regalia et al. (2019)
Diagnosis of Cancer in Histopathology	To develop a decision support system for pathology that overcomes the limitations of traditional methods using an AI-based system that only use the reported diagnoses as labels for training, so avoiding the time-consuming and expensive process of pixel-wise manual annotation.	A deep learning framework that combines convolutional neural networks with RNNs under a multiple-instance learning approach	Showed the feasibility to develop and deploy a robust computational decision support system for pathology that can scale to large datasets and integrate seamlessly into clinical workflows, improving diagnostic efficiency and accuracy.	Campanella et al. (2019)
Gastroenterology	A review to evaluate potential applications of AI and machine learning to improve predictive modelling, personalize medicine, and enhance diagnostic and therapeutic interventions in gastroenterology.	Machine learning (ML), deep learning and computer vision	Showed advanced tools can revolutionize gastroenterological practice for prediction, personalization, and automation in diagnostics and treatment.	Ruffle et al. (2018)
Colorectal Cancer	To Evaluate whether AI could predict the presence of lymph node metastasis in patients with T1 colorectal cancer after endoscopic resection, with the goal of reducing the need for unnecessary additional surgeries.	An AI model was developed using machine learning techniques to analyze 45 clinicopathological factors and predict the presence or absence of lymph node metastasis	The AI model showed better performance in predicting lymph node metastasis compared to existing guidelines, significantly reducing the rate of unnecessary additional surgeries.	Ichimasa et al. (2017)

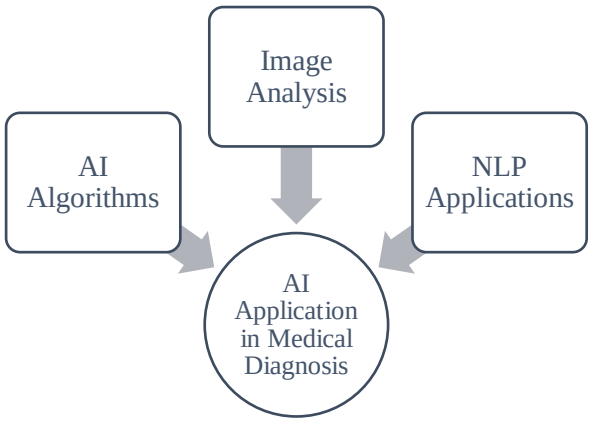

Figure 1. Three main domains of AI application in medical diagnosis.

As seen from Figure 1, the AI algorithm is used to diagnose multiple diseases, Image Analysis is also used to increase the accuracy of medical imaging techniques. Finally, Natural Language Processing NLP is used to extract data from medical notes and reports.

AI offers a wide range of opportunities for healthcare professionals to be involved in everyday practice. Al consultation is an example of an AI opportunity in medical practice. An AI system can easily use patients' medical records and databases to offer them the best medical care decisions (Tursunbayeva and Renkema, 2022). Another important use of AI is acting as a healthcare assistant to monitor patients' symptoms, manage their medication, and follow up on their compliance (Kim, 2018). Additionally, Al tools make it easier easy for untrained healthcare professionals to perform cardiac ultrasound imaging with high-quality images. In addition, AI can design treatment plans by analyzing medical records and guidelines to provide treatment options and plans (Zauderer et al., 2014). Moreover, AI-based technologies not only can be applied in doctors' practice, but also in helping pharmaceutical companies but they can also help pharmaceutical companies to develop new molecules at a higher speed compared to traditional methods. This can significantly affect the medical world in terms of time and cost (Mesko and Görög, 2020).

2. Review

Literature sources were Google Scholar, PubMed, and Scopus. The inclusion criteria were the relevancy to the topics of artificial intelligence, machine learning, and application in medicine. Also, new and most updated resources were preferred. Papers with poor citations and those published before 2000 were excluded from the sources. Mostly review articles were chosen as they were closer to the nature of the topic, but there was no limitation on the study design of the papers. The search strategy was mostly based on “relevancy” on topics and keywords “AI in medicine”, “AI in medical diagnosis” and, “AI opportunity in medicine” were used. Only papers published in journals were reviewed in this article and the book chapter was not used to obtain the more recent ideas of AI in medicine.

3. Findings

Out of the reviewed literature, 10 articles discussed the future opportunities and challenges of AI in different fields of medicine. The key results of the studies highlight the fact that AI can not only be applied to collecting medical records, follow-up, and managing treatment plans, but it is particularly the subject of study in the diagnosis field. Studies show the promising results of AI's potential for successful diagnosis with a high level of accuracy and reliability. Few articles were discussed about the question of whether AI can replace doctors or not. Lastly, other articles focused on the challenges and ethical limitations of AI applications in medicine. The key findings include the need to educate and train healthcare professionals, the great challenge of validity and reliability of AI outcomes, bias, responsibility, risks and unpredicted results, and equitable issues.

AI has been shown to assist in designing predictive models that use electronic health record data to generate accurate and scalable predictions for numerous medical events that can help with collecting medical records, follow-ups, and using neural networks to identify relevant information from the patient’s chart (Rajkomar et al., 2018). Also, articles reviewed machine learning and deep learning technologies and algorithms to assess whether they are patient-centric and improve the process of care (Kim, 2018). Additionally, medical diagnosis has been a major focus in articles discussing how AI could significantly improve accuracy and sensitivity. Papers provide technical knowledge on methods, algorithms, and applications in the medical diagnosis field, particularly in medical imaging systems such as endoscopic diagnosis (Kamdar et al., 2020). In endoscopy, AI has helped make the endoscopic process more efficient, leading to the more accurate categorization of risk in patients with common gastroenterology symptoms, such as bleeding (Kaul et al., 2020).

Furthermore, an issue raised in the literature is whether AI could replace doctors. The findings suggest that this is unlikely to happen. Instead, the technology is intended to assist medical professionals rather than replace them (Briganti and Moine, 2020).

In case of challenges, although AI offers many opportunities, the reliability of generative AI is under question. There are concerns about whether these systems are tailored to meet the needs and requirements of medical professionals and healthcare systems (Zhang and Boulos, 2023). Additionally, literature studies focus on ensuring that AI in medicine prioritizes patient care. It is essential to develop clear guidelines and regulations to address the ethical implications of AI, such as maintaining patient privacy (Canales, 2020).

Lastly, from the healthcare professional’s perspective, the need for designing AI-enabled jobs was highlighted to

ensure the contribution of healthcare professionals in this field. This includes better adaptation of doctors to their roles and learning skills that will be useful in the future, such as social and related soft skills, to ensure a smooth transition (Tursunbayeva and Renkema, 2022). Also, for this need, articles and educational materials are currently being written as guides for medical professionals including definitions of AI, various methods in practice, potential challenges, and insights into what the future may hold (Mesko and Görög, 2020).

3.1. Opportunities

In the field of medical diagnosis, a future trend discussed involves designing a method to assess the reliability of classifiers on a case-by-case basis which focuses on increasing the reliability of disease diagnosis considerably. Another discussed future scenario was the use of AI in complementary medicine. As this branch of medicine needs further evaluation and verification, AI can play an important role in facilitating the verification process (Kononenk, 2001).

In the radiology field, AI applications can result in increased image quality, decreased radiation dose, and MRI scanner time, and reduced cost. All of these could result in a higher technical quality of radiology examinations (Lakhani et al., 2018). To be more specific, possibilities and perspectives in the radiology field are anticipations of the diagnosis of cancerous lesions in oncologic patients using texture analysis, prediction of treatment response to therapies for tumors, such as intra-arterial treatment for hepatocellular carcinoma, and evaluation of the biological relevance of borderline cases (Abajian et al., 2018).

In the pathology field, there are challenges regarding quantifying and standardizing clinical results and AI shows a promising role in accurate grading, staging, classifying, and quantifying responses to treatment (Vamathevan et al., 2019). Also, as AI can learn from any kind of data, it can assist in clinical settings by collecting electronic health records and accurately predicting medical events (Rajkomar et al., 2018).

Additionally, employing the capability of AI in imaging techniques is also under-studied. There are promising developments related to using AI-based PET models to improve the monitoring and management of rare diseases (Hasani et al., 2022).

Lastly, AI will have an enormous effect on the biological and medical research field. Automation offers the opportunity to accelerate the drug discovery process which remains a great challenge (Filipp, 2019).

3.2. Can Artificial Intelligence Replace Doctors?

Despite all the developments, the question that has been raised is whether doctors be replaced by artificial intelligence or not. The answer to this question would be probably "No". There is no chance of replacing doctors and healthcare systems with AI. The technology-based AI is complementary to medicine, not the replacement of it (Briganti and Moine, 2020). Recently, the question and worries about removing radiologists from medicine after AI applications have been raised. The fact is that it is not possible to remove radiologists from medicine, particularly after AI application in medicine. Radiologists were the first medical professionals who adopt technology and computer science in their work, so radiologists will be further strengthened by emerging new technologies (Pesapane et al., 2018).

3.3. Challenges

One of the future trends of applying AI in medicine will likely be the need to have educated and trained healthcare professionals. Some medical universities have already started adding to add AI-technology-related courses to their curriculum to prepare the students for real practice of the future (Briganti and Moine, 2020). Additionally, academic papers and guides are being written to inform and educate healthcare professionals to fulfil this need (Mesko et al., 2020).

Another challenge with the use of AI in medicine is the clinical validation of AI applications in medical practice. Although a large number of articles have been published comparing the non-AI technology diagnosis with AI-driven diagnosis, they lack sufficient number, sample size, or proper study design (Briganti and Moine, 2020). For generative AI tools such as ChatGPT, the unpredictability seems to cause trust and validation problems because it is not exactly clear when the answers are completely correct, wrong incorrect, or even misleading. There is a phenomenon related to generative AI called "AI hallucinations" which refers to making up information, references, or academic papers that do not exist (Zhang and Boulos, 2023).

Moreover, Healthcare professionals have several concerns and resistance regarding AI integration. These include concerns about safety, particularly related to the risk of errors that could potentially endanger patient safety, leading to increased skepticism in healthcare settings. Additionally, fears of losing professional autonomy and difficulties integrating AI into existing workflows are widely reported barriers. To address these challenges, effective training programs and involving end-users in the development and technical processes of AI systems are essential (Lambert et al., 2023).

Lastly, studies frequently emphasize the clinical benefits of AI without adequately addressing the associated costs and technical requirements. This lack of transparency can lead to incomplete conclusions about the financial barriers and economic impact of AI in medicine. To gain a clearer understanding of AI's financial implications, future research should focus on detailing the investments required for AI technologies and evaluating the expected return on investment. By improving the reporting of these financial aspects, researchers can provide more accurate evaluations of AI's cost-effectiveness and its potential to enhance healthcare delivery. This will facilitate better decision-making and support more strategic investments in AI technology (Rossi et al., 2022).

3.4 Ethical Complications

The use of AI in medicine must aligned with ethical

principles to ensure that patient care remains the top priority. Achieving this requires the development of clear guidelines and regulations for the use of artificial intelligence in healthcare. Additionally, healthcare professionals must be trained to understand the ethical implications of artificial intelligence and how to use it responsibly. This includes understanding the limitations and potential biases of the technology, also the importance of maintaining patient privacy. Finally, transparency and accountability are crucial in ensuring that the use of artificial intelligence in medicine aligns with ethical and moral principles. This includes ensuring that patients are fully informed about the use of artificial intelligence in their care and that healthcare providers are held accountable for any errors or biases that may arise (Canales, 2020). Main challenges to AI algoritms in medicine are shown in Figure 2

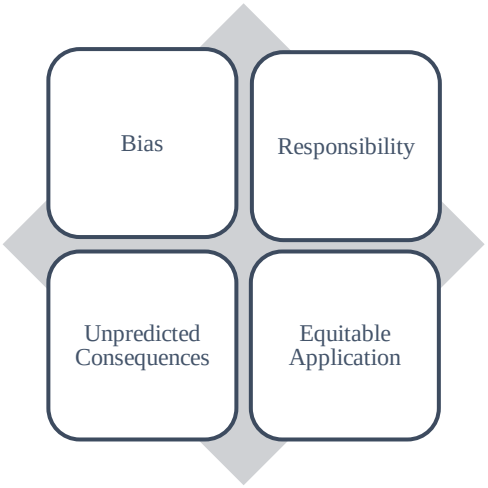

Figure 2. The key ethical challenges to AI algorithms in medicine.

From Figure 2, it is seen that the key limitations and ethical challenges related to the use of artificial intelligence in medicine include bias (artificial intelligence algorithms can inherit biases from the data they are trained on), responsibility (as artificial intelligence becomes more autonomous, determining responsibility for medical errors becomes more complex), unpredicted consequences (the introduction of artificial intelligence may lead to unpredicted results and new risks for patients, requiring constant monitoring of its proper functioning) and equitable application (there is a need to ensure that artificial intelligence is applied equitably across communities and healthcare systems to avoid further limiting access and outcomes for certain patient populations). These ethical limitations of AI application in medicine are illustrated in Figure 2. Addressing these limitations and ethical challenges is crucial to gaining the potential benefits of AI in medicine (McKinney et al., 2020).

4. Results and Suggestions

As the application of AI increases day by day, it is crucial to become more informed and discuss how AI is affecting the healthcare environment. It seems that engineering and computer science or technology-related fields are already advancing in integrating AI usage and despite the advancement in AI application medicine, a long journey remains.

Results of the studies performed by 2023 indicate that generally, the future of AI in medicine is very bright. Several promising studies show that clinical decision support is one of the most important opportunities for the application of AI in medicine. It is the process of making decision for healthcare professionals more effective and quick. The process is particularly important in emergency medicine where quick and accurate decisions can save lives. Soon, we expect that clinical decision-making will be more efficient, saving time, money, and energy with more accurate results. Furthermore, image analysis has been positively affected and continues its advancement in recent years. In recent years, imaging techniques have been influenced by computer science adopting many analysis software and applications. It is highly probable that AI will bring be a new revolution in image analysis fields producing not only high-quality and high-resolution images but also making them more accessible to patients.

Additionally, AI also contributes significantly to disease detection and diagnosis area which is a considerable advancement in the medical world. It is now clearly known that the key to treatment is diagnosis. This is why a large amount of research and science budget is dedicated to the diagnosis section. Predictive models have been the potential to facilitate the early detection and diagnosis of diseases. Lastly, personalized disease treatment and simplification of administrative tasks in the healthcare system are two other areas in which AI improves efficiency, leading to and leads to time and cost savings.

Regarding challenges in AI application in medicine, the main ones are related to the challenge of validation of data. Since well-designed studies are still limited in this area, the reliability and validity of data might need more information and data at this time.

Our suggestion for the future of AI in medicine would be to increase educational problems in universities, companies, and private training sessions. It is not possible to apply all the changes to the healthcare environment without having enough knowledge. This era is more than just using computer science in medicine, we are encountering fast-evolving technology that has no boundaries in advancement and innovation. To obtain the best result, more education is still needed for both healthcare professionals and patients.

5. Conclusion

This review highlights three critical takeaways for readers and researchers. First of all, AI shows great promise in enhancing medical diagnosis and treatment planning particularly in areas like radiology, pathology, and clinical decision support. However, AI is intended to augment rather than replace medical professionals. Secondly, significant challenges remain in validating AI systems, addressing ethical concerns, and ensuring equitable implementation across healthcare settings. These issues require future ongoing research and careful consideration. Thirdly, there is an urgent need for increased education and training on AI in healthcare, both for current professionals and future medical students.

These points are crucial from both scientific and practical perspectives. The potential of AI to improve patient outcomes and healthcare efficiency could revolutionize medical practice, but only if implemented responsibly. The challenges identified underscore the need for accurate validation studies and ethical guidelines to ensure patient safety and equitable care. The emphasis on education highlights the evolving nature of medical practice and the importance of preparing the healthcare workforce for technological integration.

Lastly, for medical students and their educators, this research highlights the importance of incorporating AI-related coursework into the medical curriculum. Students must develop not only technical skills but also critical thinking abilities to evaluate AI tools, their opportunities and ethical implications. Besides, Education policymakers should consider revising medical education standards to include AI competencies, ensuring future physicians are prepared for an increasingly tech-driven healthcare environment. On the other hand, practitioners should be aware of both the potential benefits and limitations of AI in their fields, actively seeking opportunities for continuing education to be updated with AI advancements. Furthermore, for data scientists and engineers, this research highlights the critical need for collaboration with healthcare professionals to develop clinically relevant AI solutions. It also emphasizes the importance of addressing issues like bias, transparency, and interpretability in AI systems. Last but not least, for patients and the public, this research suggests a future where AI could lead to more accurate diagnoses and personalized treatments and highlights the need for informed consent regarding AI use in their care. Addressing these implications across various stakeholders will lead to realizing the full potential of AI in medicine while reducing its risks and challenges.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	T.D.	A.Ö.	A.S.Ö.
C		100	
D	80	20	
S		100	
DCP	80	20	
DAI	30		70
L	80		20
W	20	20	20
CR	20	20	60
SR		100	
PM	20	80	

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management.

Conflict of Interest

The authors declared that there is no conflict of interest.

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