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Application of Artificial Intelligence in Cancer - A Comprehensive Review

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ABSTRACT

Cancer remains a significant cause of morbidity and mortality globally. While there has been improvement in cancer diagnosis, prognosis, and therapy, providing tailored and data-driven care remains a problem. Researchers have created AI methods to improve cancer imaging, making it faster, more accurate, and more informative. Artificial intelligence (AI), which is familiar with forecasting and automating numerous malignancies, has arisen as a viable solution for increasing healthcare precision and patient outcomes. AI applications in cancer encompass risk assessment, early diagnosis, patient prognosis, and therapy selection based on comprehensive data. It has been proven that the method is highly effective in detecting various kinds of cancer. This paper summarizes the role of AI in predicting cancer to enable early diagnosis. This review is based on secondary sources accessible through various internet databases, like Scopus, Google Scholar, Web of Science, and PubMed. This study reviewed English language books, journal articles, and other published resources to meet its aims. This review offers valuable insights into the use of AI in cancer treatment. AI application will be achieved through data intelligence, greater tumor understanding, more accurate therapeutic alternatives, and improved decision-making processes. AI can accurately predict outcomes and inform clinical decisions for cancer. With AI's vast potential in oncology, including applications in diagnosis, prognosis, and treatment, more patients can receive timely and effective cancer management. Early detection, prediction, and prognosis are crucial for combating cancer effectively.

INTRODUCTION

Artificial intelligence (AI) is a branch of computing science concerned with the development of intelligent computer systems. This intelligent system is a system with human-like behavioral intelligence. AI can be used to create systems with human-like reasoning abilities [1]. The healthcare industry is rapidly evolving in reacting to cutting-edge technology such as artificial intelligence, machine learning and deep learning. Machine learning (ML) is a subfield of artificial intelligence that focuses on the development of algorithms and statistical models that can enable computers to learn from and make predictions on data without being explicitly programmed. These include neural networks of various architecture kinds (eg. Recurrent neural networks, convolutional neural networks and long-term short memory are all types of neural networks used in machine learning and artificial intelligence.) [2]. These technologies have significantly impacted several elements of the hospital. Cancer is difficult to detect in its early stages and can quickly recur following therapy. Furthermore, making precise forecasts about illness prognosis is quite challenging. Early detection of certain malignancies might be challenging due to ambiguous symptoms and unclear signals on mammography or scans. Thus stronger prediction models incorporating multivariate data and high-resolution diagnostic techniques are critical in clinical cancer research. The literature on cancer analysis has seen a significant increase in the use of AI techniques and big data sets with historical clinical cases to train models. AI outperforms traditional approaches like statistical and multivariate analysis, according to the literature. Combining AI with advanced bioinformatics tools can considerably enhance diagnostic, prognostic, and predictive accuracy. ML is a part of AI that uses historical data to create prediction models for patient survival rates and has been extensively utilized to improve prognosis. Prognostication is a crucial ability for doctors working with cancer patients. ML improves cancer susceptibility, recurrence and survival forecasts, which are crucial for early detection and prognosis in research. ML can effectively handle patients in clinical settings. Researchers in biomedical and bioinformatics are developing ML algorithms to categorize cancer patients as high- or low-risk for recurrence, leading to improved prognostic treatment [3]. Many exact tasks, such as image identification, identifying skin biopsy lesions, evaluating cancer severity and detecting brain cancers may be accomplished using engineering science and modern technology known as artificial intelligence. There has been significant interest in developing AI diagnostic solutions for cancer detection and treatment due to advancements in technology. With the current need for AI systems, there will be a significant change in the healthcare industry. This modern and remarkable technology will play a significant part in halting the rapid rise of tumors and poor awareness [4].

1. MATERIALS AND METHODS

This narrative review is based on secondary sources gathered from multiple electronic databases, including Scopus, Google Scholar, Web of Science, and PubMed between October 10, 2023 and January 15, 2024. The search term used included "Artificial intelligence", "cancer", "deep learning", "machine learning", "challenges", "future scope", "breast cancer", "lung cancer", "ovarian cancer", "prostate cancer", "cervical cancer". This study reviewed the English language published resources, including books and journal articles, to meet its aims. This review included both theoretical and empirical publications that were relevant to its topic. Figure 1 shows the schematic flow of how the articles used in this narrative review were obtained.

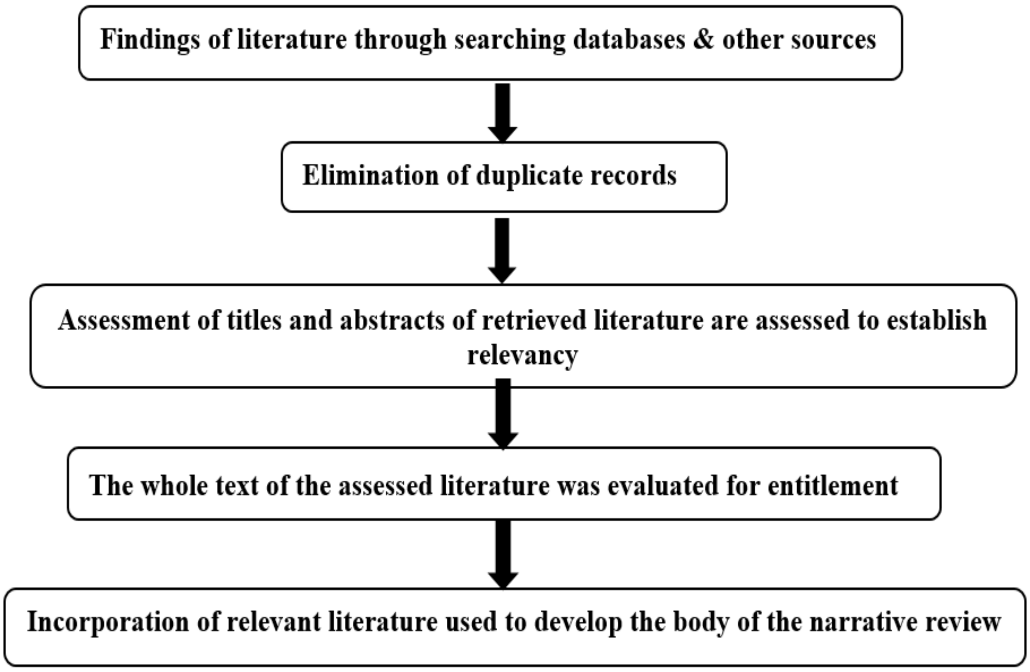

Figure 1. Schematic flow of how the literature included in this narrative review was gathered.

2. ARTIFICIAL INTELLIGENCE IN CANCER

AI is the term for machines that simulate human intellect. Machine Learning (ML) a subgroup of AI, is the process of training computer algorithms to make speculate based on experience. A deep learning (DL) is a part of ML in which complex structures similar to the linked neurons of the human brain are created [5]. The groups of AI are shown in figure 2. The use of AI in pathology and medical diagnosis has the potential to significantly advance cancer disease risk assessment, diagnosis, and prediction of therapy outcomes in patients. The clinical applications of AI and ML will speed up the mapping of personalized treatments for various types of cancer in the future of medicine. Researchers may collaborate in real-time and share information digitally with AI, potentially treating millions of individuals [6]. The wide approaches of AI in cancer research are shown in figure 3.

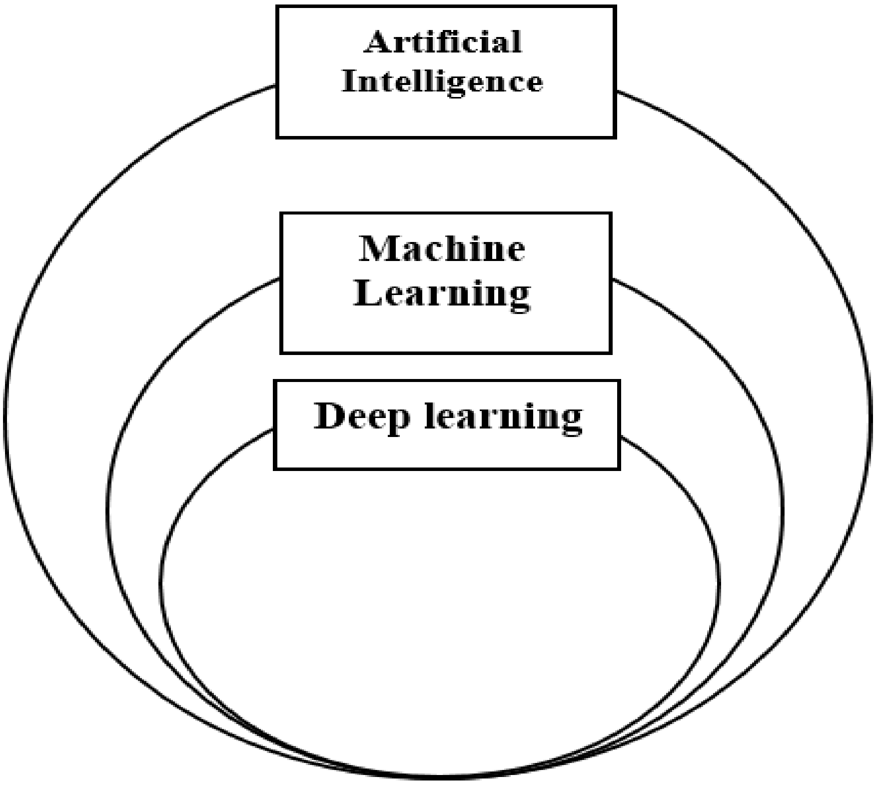

Figure 2. Schematic flow of Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL)

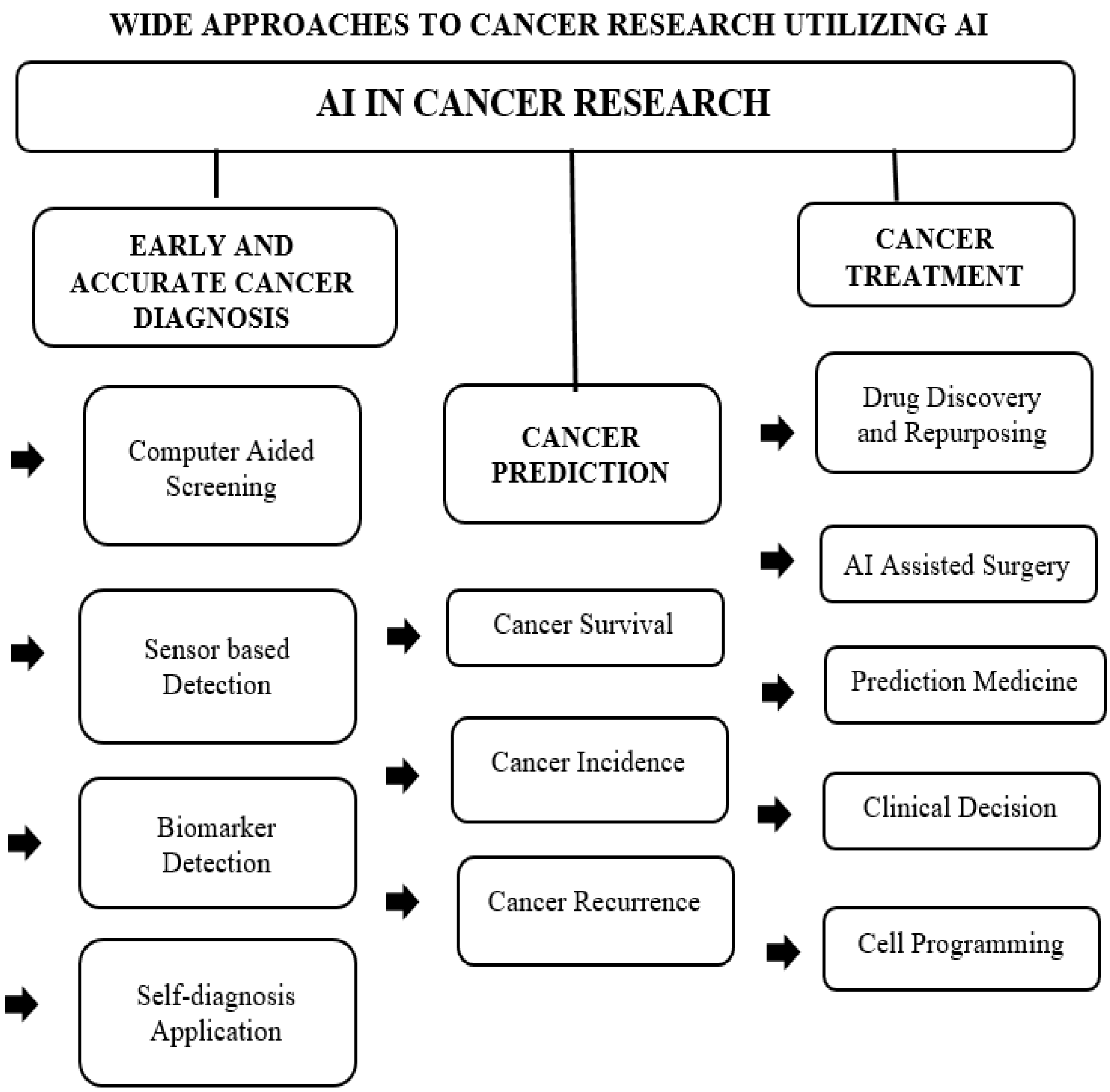

Figure 3. Wide approaches of AI in cancer research

3.1 AI in lung cancer

In Lee's study, a deep learning model can detect malignant from benign lung tumors based on chest radiographs outperformed radiologists, with accuracy, sensitivity, and a false positive rate as high [7]. Deep convolutional neural networks could aid pathologists in the detection of cancer subtypes or gene alterations, assisting in the classification of patients sensitive to targeted drugs [8, 9]. Another study found that a deep learning architecture based on Computed tomography (CT) images could distinguish between high tumor mutational burden and low tumor mutational burden, which could aid in the treatment of patients with advanced malignancies [10, 11].

AI-based imaging algorithms are being utilized in clinical practice to pinpoint and track possibly malignant tumors, in addition to guiding care. For example, a U.S. Food and Drug Administration-approved software tool now allows for the thorough diagnosis and monitoring of pulmonary nodules, the estimation of lung malignancy among identified lesions on low-dose CT scans, and the inclusion of therapy guidelines [12, 13].

3.2 AI in cervical cancer

Deep learning algorithms have received a lot of attention in cervical cancer precancer screening because they can reduce the requirement for colposcopies and function well in a completely vaccinated population [14, 15]. Meanwhile, several large-scale research has looked into AI-assisted diagnosis of cervical intraepithelial lesion (CIN) or cancer. Heling et al demonstrated that AI-assisted detection outperformed cytologists in a study of sensitivity and specificity [16, 17]. As a result, AI could play a significant role in cervical screening while also reducing unnecessary colposcopies.

3.3 AI in colon and gastric cancer

There are over 100 distinct varieties of cancer in the globe, however, colorectal cancer is the third most frequent and also a preventable disease. Prompt recognition and careful management of patients may improve incidence rates and clinical outcomes. AI implementation in screening could improve polyp detection diagnosis accuracy [18]. Furthermore, colorectal cancer therapy has entered a new age with the opening statement of robotic surgery, which is both cost-effective and time-consuming [19]. Deep neural networks have also been designed to detect enlarged lymph nodes or colonic polyps in CT images and to improve colon polyp identification during colonoscopy using a real-time DL computer-aided detection system authorized by the US Food and Drug Administration (GI Genius, Medtronic) [20, 21]. AI-augmented interpretation of endoscopic images has also been proven to increase esophageal cancer diagnosis accuracy [22].

3.4 AI in breast cancer

Deep dilated residual network (DD-ResNet) was used in auto-segmentation of the clinical target volume for breast cancer as AI in radiation progressed. The result showed that it could precisely segment clinical target volume (CTV) without a difficult method, improve target delineation consistency and safety, and help expedite the process [23]. Patients with breast cancer who are diagnosed early may have a higher chance of survival. AI-based technologies have outperformed traditional strategies in the categorization of malignant tumors [24, 25].

Mammography has been a 2D technique for detecting breast cancer that can increase early detection. However, mammography may be unable to detect many cancers due to breast density, tumor size, or unusual indications that are devoid of easily noticed when metastases develop. Convolutional neural networks were successful at identifying breast masses, equivalent to an experienced radiologist [26- 28].

AI is being used to detect and diagnose cancer through oncologic radiographic imaging. In the past, computer-aided detection was used for breast cancer imaging, but it was not found to be useful in a clinical setting. As a result, breast cancer imaging has been a primary focus for AI-based cancer diagnosis. AI-based models, for example, are now standard in breast imaging and are utilized therapeutically in a variety of professions. There are at least five breast-imaging detection and diagnostic algorithms authorized by the United States Food and Drug Administration [29].

3.5 AI in prostate cancer

Multi-parametric MRI in prostate cancer has been shown to improve the identification of clinically significant malignancy, however, obstacles such as inter-observer variability remain [30]. AI-based detections can solve these issues using ML algorithms and there are commercially available algorithms for prostate segmentation, lesion identification, and workflow integration [31].

4. FUTURE PROSPECTS

Cancer therapy is likely to develop significantly in the next years, with a 40 % increase in demand. At the same time, the American Society of Clinical Oncology predicts a shortfall of almost 2200 oncologists in the United States by 2025 [32]. Although novel mechanisms for bringing more healthcare professionals into the field have been put forward, even a strong mix of tactics cannot supply the ever-increasing need with human labor alone [33]. This means that AI and other technology tools will play an increasingly crucial role in cancer care, automating basic procedures and freeing up doctors to focus on more difficult patients and individualized treatment regimens. Finally, a combination of human experience and technical tools will be required to offer high-quality and personalized cancer care to all patients in need.

Since 1995, the FDA has accredited more than 500 AI-enabled medical application medical applications, with medical imaging accounting for 75 % of the total [34, 35]. However, AI still has enormous potential to expand into domains other than radiology. AI has already shown potential in a variety of healthcare disciplines, including drug discovery, genomics, and clinical decision-making. For example, AI may be familiar with evaluating enormous amounts of genetic data to find possible drug targets or create individualized treatment regimens for patients. Additionally, AI can support physicians in making more accurate diagnoses by processing and analyzing data from various sources, including electronic health records, medical imaging, and laboratory testing. ML algorithms have shown significant promise for simplifying radiologic information extraction and analysis, allowing data from magnetic resonance imaging scans to be automatically converted into 3-dimensional representatives. This not only saves radiologists time on repetitive activities but also allows them to focus more on connecting with other physicians or patients. In a study of nearly 3000 radiologists, AI was identified as having the greatest influence on breast, neuro, oncologic, and thoracic imaging. Notably, 55 % of survey respondents said that AI-only reports would be unacceptable to patients [36]. Pew research found that 60 % of patients are concerned with their clinician depending on AI to steer their treatment [37].

AI techniques in medicine, like any new technology, confront significant problems in ensuring precision and consistency. Model and prognostic advice are only as effective as the facts on which they are based. As new therapy response data sets become available, relevant recommendations will shift to better reflect these cutting-edge developments and while AI can support in identifying the optimal treatment regimen for a given patient, it must be constantly updated and retained to maintain accuracy [38].

AI allows for more informed decision-making, which benefits patients, but this system must adhere to ethical norms and morals. For example, AI has shown biases in healthcare caused by human language usage and historical societal structures, which must be addressed by intentional effort [39-41]. Despite these challenges, AI has previously been utilized effectively in medical imaging analysis, both diagnostically and to forecast outcomes. There are various FDA-approved AI implementations in pulmonary and cardiology, notably for predicting areas of blood flow restriction, perfusion, impairment, and clot formation [42].

ML approaches provide significant benefits and efficiency over arduous manual data curation [43]. Moving forward in natural language processing allows machines to contextualize language and form sophisticated links between words (ideas) and the facts they convey. The current development of generative AI employs computer "neural networks" that operate in a manner conceptually similar to the human brain. When fully implemented across the healthcare landscape, the fluidity and adaptability of generative AI will be critical for extracting the trove of medical information that lies within the estimated 80 % of unstructured medical data, making it inaccessible to current computational data analysis tools [44].

Generative AI algorithms analyze and integrate existing observational patient data to issue a recommended treatment plan [45]. Recent upgrades in "transformers" which power ever larger models without the requirement to manually label that data in advance, have made it feasible to integrate multiscale data sets into the patient treatment pipeline. Transformers have also introduced a new concept known as "attention" which allows models to monitor features across photos as they develop over time in reacting to treatment. These generative AI capabilities are well suited for medical applications, as long as the queries asked fall within a range of known or closely relevant medical knowledge [46, 47].

AI-based models will be implemented into all parts of healthcare after challenges are overcome and "AI algorithms" are validated for future research. In the future years, "oncology AI application" will be achieved through 'data intelligence", greater tumor understanding, more accurate therapeutic alternatives, and improved decision-making processes. Oncology will become a more unique discipline with more people receiving treatment than ever before.

Furthermore, risk assessment technologies integrated into smartphone applications will give the general public an instantaneous cancer risk estimate. The publication of high-risk estimations can encourage individuals to seek medical assistance and follow medical recommendations. Furthermore, risk reduction evaluation may encourage people to adopt better behaviors such as quitting smoking or exercising more. Algorithms will help clinicians decide whether to refer patients to high-complication healthcare institutions in primary care settings. Algorithm integration with the HER system can benefit healthcare facilities by giving an option for enhanced resource allocation based on information about particular subgroups at higher risk of cancer development or cancer-related effects [48]. The introduction of ChatGPT by open AI has been acknowledged for its extensive understanding of various disciplines. Researchers discovered that ChatGPT has the prospective to transform colorectal surgery by giving individualized and accurate medical information, lowering mistakes and problems, and enhancing patient outcomes [49]. Furthermore, Neuro-oncology was used as an example to investigate the ChatGPT response. ChatGPT may assist clinicians in diagnostic methodology by providing a fast review of radiographic images as well as predicting outcomes based on tumors [50].

5. CONCLUSION

AI has developed in our period thanks to technological advancements. Previously, these revolutionary ideas were only employed for nonmedical objectives, but they are now being used to enhance healthcare worldwide. This paper highlights the expanding importance of AI in several types of cancer. To design new development strategies, it's important to first grasp the organization's history and current accomplishments. AI has had a significant influence on healthcare and will persist in transforming the industry. AI is currently being used in oncology, but further efforts are needed to fully realize its potential The potential for oncology is enormous, with application in practically every facet of cancer research, including diagnosis, prognosis, and therapy. Cancer is one of the most lethal diseases, and there may soon be a cure; nonetheless, because prevention is better than therapy, early and rapid detection, cancer prediction, and disease prognosis prediction are crucial.

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Author contributions

N. Vanitha: Conceptualization; data curation; formal analysis; writing draft and validation. B. Kumudhaveni: Project administration; resources; supervision; review editing. S. Pooja and A. Monoj: Formal analysis; writing draft and validation. R. Radha: Resources; supervision; review editing.

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