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Cancer Diagnosis Accuracy using Artificial Intelligence Technology

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Abstract

The risk of death can increase by 13 percent with even a four-week delay in cancer treatment, according to Cancer Treatment Centers of America. The drastic increase in deaths, as treatment and diagnoses are prolonged, demands a modern alternative to the older system. The process of physical examination, to lab and imaging tests, to pathology reports, to the beginning of treatment requires time; a measure that most people do not have. To accelerate the process and introduce efficiency while remaining accurate, artificial intelligence (AI) technology must be integrated into the cancer diagnosis system. This paper reviews current applications of artificial intelligence (AI) in cancer diagnosis and treatment, focusing on breast and pancreatic cancer, highlighting gaps in clinical integration. The central research question guiding this review is: How can AI technologies improve the accuracy and efficiency of cancer diagnosis and treatment while addressing real-world limitations? Overall patient outcomes are expected to improve positively with the integration of AI systems, harnessing the combined power of humans and AI to deliver the best possible healthcare service for patients while maintaining the accuracy required for successful treatment outcomes.

Keywords: AI, Cancer diagnosis, Healthcare, Technology, Machine learning

1. Introduction

Cancer diagnosis and the following treatment planning rely heavily on pathology reports, which provide a comprehensive understanding of the disease at a microscopic level. The reports cover a gross description, a microscopic description, and a final diagnosis, helping medical professionals when determining the extent of cancer within the body and guiding treatment strategies (Surgical Pathology Reports, 2022). Pathology reports are necessary to stage the cancer and search for the most effective course of action in treatment.

Over time, pathological reports have been crafted by pathologists using knowledge and limited data to be stored in hospitals. However, with the recent discovery of artificial intelligence technology, the orthodox system is being updated and adapted to this rapidly developing software. The new arrangement would not be difficult to create and integrate into the current medical procedures, like the use of other methods that support the creation of a digital pathology system with databases and graphic displays (Rubin, 2024).

The integration of artificial intelligence (AI) holds promise in revolutionizing cancer diagnosis and prognosis. Recent advancements in AI algorithms have significantly supplemented the accuracy of models for cancer detection, treatment, and survival rates. By harnessing the power of machine learning and data analytics, AI systems can make the diagnostic process efficient, leaving the medical community with a method for quick diagnosis, initiation of treatment, and an overall better outcome in patient status (Huang et al., 2019).

Despite advancements, gaps remain in the literature regarding AI's comparative effectiveness across different cancer types, practical implementation challenges, and limitations in clinical adoption. This review addresses these gaps by synthesizing findings from existing studies, evaluating the effectiveness of AI tools in breast and pancreatic cancer, and discussing real-world limitations, including training data requirements, cost, accessibility, bias, and privacy concerns.

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2. Methodology

This review was conducted by selecting AI technologies, studies, and tools directly referenced in the existing literature on cancer diagnosis and treatment. Studies and tools were included if they provided specific examples of AI applications in breast or pancreatic cancer, focusing on diagnostic accuracy, treatment planning, or patient outcome prediction. Exclusion criteria included studies not available in full text or those that did not provide measurable outcomes related to AI performance.

Each AI technology or tool was evaluated based on its reported accuracy, implementation in clinical settings, and potential to enhance patient outcomes, as documented in the cited studies. Examples from both breast and pancreatic cancer were synthesized to compare effectiveness across cancer types. Challenges and limitations noted in the studies, such as data requirements, cost, access, bias, and privacy concerns, were also considered to provide a balanced assessment.

By following these criteria, the review summarizes current AI applications in cancer care, highlights differences in effectiveness across cases, and identifies areas where further research or practical improvements are needed.

3. The Current Method of Cancer Diagnosis

The traditional pathway for diagnosing cancer involves a prolonged process (Figure 1). During an initial physical exam, a medical professional will most likely begin by acquiring the medical and family history of the patient to learn more about their background and assess the plausibility of cancer. From there, a doctor will determine which lab and imaging tests are necessary to determine where the tumor is. Using lab tests, such as blood and urine samples, assists in learning more about the cancer. Tumor marker tests are another lab test that helps diagnose cancer by measuring the substances that cancer cells produce. The tumor markers can be a result of both cancer cells and normal cells; however, cancer cells produce them at a higher level.

To support lab results, CT scans, MRI scans, and PET scans are commonly used to further view the tumor and locate the cancer's presence in the body. CT scans require an X-ray machine that captures all angles of the body, sometimes using contrast material to highlight specific areas. An MRI uses magnets and radio waves to locate the tumor by capturing pictures of the body in slices. PET scans are a variant of nuclear scanning that creates 3-D, detailed images showcasing areas where glucose is lacking. Following all the scans and lab tests, to ensure that the cancer is present, a biopsy is conducted, where a piece of abnormal tissue is viewed under a microscope and the results are formatted within a pathology report for the patient to view (Tests and Procedures Used to Diagnose Cancer, 2023; Cancer, 2022).

When the cancer has been located within the patient's body, a doctor will work to determine the stage of the cancer to properly treat it and understand the danger. The pathology report helps both the doctor and patient better view the tumor and its characteristics. From here, the report is placed into a digital record system, also known as a computer-based patient record (CPR). The CPR system has just recently been implemented, following the era of paper patient records. The paper records were not easily accessible and were usually inaccurate. With the CPR system, medical professionals can access organized data, such as studies and patient records, efficiently (Institute of Medicine (US) Committee on Improving the Patient Record, 1997). Once the information has been placed into the CPR, under HIPAA, patient records must only be sent to the patient or provider, and under no circumstances should the information be used without the knowledge of the patient (Boop, M, n.d). The data pipeline continues through the patient being assessed again for each hospital visit to update treatment progress and cancer status.

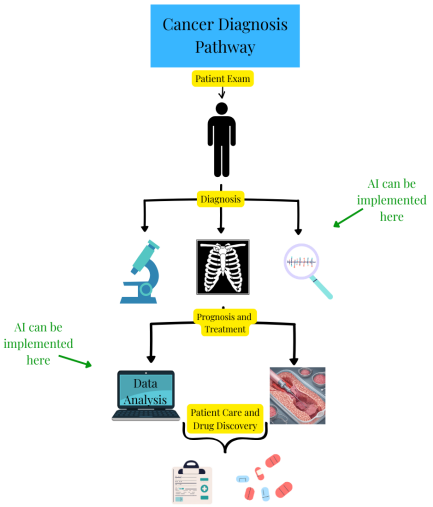

Figure 1. Original medical (cancer) diagnosis pathway. Shows the steps a patient's information follows from initial exam to treatment. Green arrows indicate where AI could be implemented. Created and copyrighted by Veeksha Patlolla.

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4. Pathway with AI

While the current system is working in terms of providing patients with sufficient care, the integration of AI into the data pipeline will streamline the process, provide quicker results, and save both doctors and patients time. Figure 1 illustrates the traditional cancer diagnosis pathway. Green arrows highlight stages where AI can be implemented, including scan analysis, pathology review, and treatment planning. As the process of cancer diagnosis is lengthy and requires a plethora of steps to ensure accuracy, integrating AI into the system will cut down the time spent analyzing scans. Not only is AI going to analyze scans and use information to make a diagnosis, but it also seeks cancer cells that would be overlooked by the human eye. Inferring Super-Resolution Tissue Architecture (iSTAR), a newly introduced AI tool in hospitals, has aided clinicians in diagnosing and treating undetected cancers. The tool essentially introduces a way to provide clarity to medical imaging scans to monitor margins after cancer surgeries. Using this tool, patients' survival and response to immunotherapy can be deduced from what iSTAR detects. An AI tool like iSTAR is implemented into the data pipeline when analyzing scans and lab tests. The iSTAR can mimic a pathologist's method in studying tissue samples, starting broad and then zooming into the cellular structure, ultimately noticing more small details than before (*AI Tool Brings Precision Pathology for Cancer Into Focus,* 2024)

The AI algorithms can be used in treatment as well, using patient records and known databases to help oncologists create an informed treatment plan. The use of AI can follow the pipeline into drug discovery and predict patient outcomes based on the stage of cancer and recent advancements in treatment. CPR handles patient records, and implementing AI into the CPR system would produce a timely, hospital environment (Institute of Medicine (US) Committee on Improving the Patient Record, 1997). AI can take on the complex tasks of accurately detecting cancer and making diagnoses by analyzing patient histories. A specific branch of AI is machine learning (ML), where data can be mass integrated and uses statistical research to narrow possibilities, providing the most accurate predictions. Though AI is still a tool in continuous development, leaving space for its efficiency and accuracy in the data pipeline will benefit oncology research for patient outcomes (Bhinder, B., et al., 2021).

5. Types of Cancer and Following Treatments Enhanced by AI

There are multiple types of known cancers in the medical world, and each has a varied treatment approach. Each cancer requires a specialized treatment plan that falls within the parameters of the patient's medical history and stage of cancer. With the implementation of AI, this process is expedited and more detailed when different cancer types are presented. For breast cancer, the usual treatment plan follows determining the stage of cancer using tumor markers and initial diagnosis. Treatment options include surgery, chemotherapy, and radiation. Within the different surgeries, the surgeon removes the cancerous tumor that is visible and viable to retrieve (Breast Cancer during Pregnancy, 2022). However, with AI technology, patients can be spared from high dosage or longer chemotherapy treatments by studying cancerous and non-cancerous cells together and evaluating the effectiveness of the immune system. In a Northwestern Medicine study, a new AI tool has been used to categorize breast cancer patients as high-risk or lower risk and determine who can use a lower amount of chemotherapy (Paul M., 2023). The same can be applied to radiation therapy as AI will provide doctors with the ability to monitor in real-time and a predicted analysis. Radiation exposure is harmful, but AI can increase radiation protection and minimize risks. AI applications can reduce treatment side effects and leave the patient with an improved treatment plan (Refahi, S., et al., 2024).

Breast cancer is not the only common cancer that AI can be integrated into; pancreatic cancer treatment is receiving similar advancements. The pancreatic cancer diagnosis process is akin to the general procedure, starting with scans and moving toward treatment (Pancreatic Cancer Treatment, 2024; Tripathi, S., et al., 2024). The AI tools increase the quality of radiology scans and incorporate patient data, scientific research, and medical measures to acquire a treatment plan. The plan is improved by implementing the details that are caught in AI algorithms, including tumor mass and cancerous cells in scans, to achieve more satisfactory results. Targeted therapy is a treatment plan that is explicitly used to attack certain cancerous cells, and AI can efficiently locate the necessary areas. Another form of treatment is cancer drugs, which are used to prevent cancer cells from growing by killing them (How Cancer Drugs Work, 2023).

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At the National Institutes of Health, researchers have developed an AI tool that can be used to predict a patient's response to a cancer drug using data from tumor cells. Usually, bulk sequencing requires averaging the total cells in a tumor, but tumors do not consist of a single cell. Instead of the usual "bulk sequencing" of DNA and RNA in tumor cells, the new approach of single-cell RNA sequencing provides more accurate and long-lasting results on a "single-cell level" but is quite expensive. However, with AI technology, researchers are modifying to use the new approach instead of bulk RNA, to predict patient drug responses (AI Tool Helps Predicts Patient Responses to Cancer Drugs, 2024).

The technology is improving to predict both drug combinations and single drugs. AI has positively impacted many types of cancer treatments, updating older treatments and enhancing them along with modern medicine.

6. Types of AI and Its Accuracy

Medical advancements with AI have been present for over a decade and have only increased in usefulness. AI can be split into two different types: virtual and physical. The physical AI depicts surgical robots that aid in surgeries, and virtual AI ranges from CPR to "network-based guidance in treatment decisions". Using the database of information that already exists to establish insights about pattern associations. Within the virtual AI category lie two further approaches to implementing AI into medicine: flowcharts and databases. The flowchart method creates a feeding system where information is fed into the system, including patient history, symptoms, and procedures. This approach can be limiting in its efficiency as all the information would still need to be inputted and updated, as well as the information learned during a patient visit cannot be observed. The database approach differs from the flowchart as it is trained to pattern recognize and find repetitive algorithms within medical images (Amisha et al., 2019).

The results of AI accuracy in breast cancer detection from Mohammad Talal Elhakim showcase that the AI detection system had a higher accuracy rate in most of the outcomes, as seen in their summary of findings. Mammography screening was the main subject of this study and replaced the first reader in a double reading system in a Danish screening study (Figure 2).

The two methods in which this study was conducted include AI individually and AI replacing the first reader. Both cases led to favorable results as they concluded that accuracy could be improved with the introduction of AI replacing the first reader in double reading, especially in interval cancers. The study presents AI as a feasible alternative to having solely radiologists working on analyzing scans. The accuracy rates shine a positive light on AI working with human intellect in the cancer diagnosis field (Elhakim et al., 2023). The detection and treatments are being tailored towards the breast cancer patient. Figure 2 shows the comparison between standard double reading by radiologists, AI alone, and combined AI with radiologists. The study by Elhakim et al. demonstrates that replacing or supplementing the first reader with AI improves detection rates, particularly for interval cancers, highlighting AI's potential as a reliable diagnostic aid. This supports the broader argument that AI can complement human expertise in clinical settings. The technology for AI is building a future where fighting against cancer and succeeding is plausible, especially with early detection and accurate diagnosis (Bcrf, 2024; Yan et al., 2023).

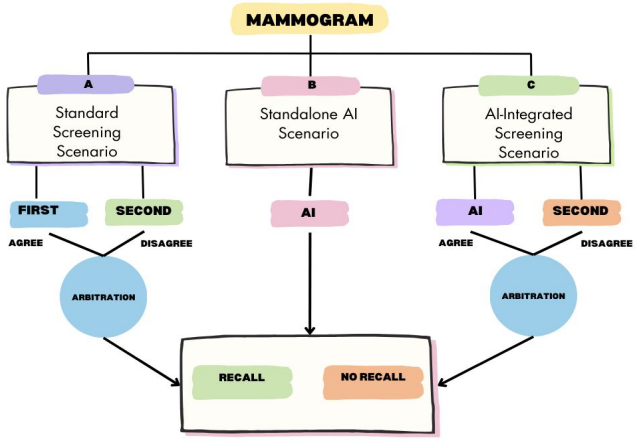

Figure 2. AI integration in breast cancer screening. Compares standard double reading by radiologists (left), AI alone (middle), and combined AI with radiologists (right). Created and copyrighted by Veeksha Patlolla.

7. Negatives of AI

While AI is our future, challenges still arise with its use. For example, the AI system requires a certain amount of data to detect discrepancies in scans properly. To provide AI

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with the tools it needs to execute its job, the system needs to be extensively trained, from recognizing patterns to locating specific parts of images. Sava (2023) reports that tens of thousands of images must be utilized to train the AI in locating multiple types of cancer and other diseases. While giving the system enough data for it to be able to recognize the pattern and detect data in the scan seems intensive, the result will become an immeasurable change in the healthcare field (Figure 3). The issue can be resolved by simply expanding the data set into more eclectic types of images and training the machine learning models further than before. Figure 3 illustrates how AI models are trained using large datasets of imaging and patient records. This training allows AI to recognize patterns and make predictions for diagnosis and treatment planning. The figure also underscores practical limitations, such as the need for extensive, high-quality data, which may be costly or difficult to obtain, creating barriers for smaller or underfunded healthcare facilities.

In a letter written by Dalmacito Cordero Jr., The Downsides of Artificial Intelligence in Healthcare, it is explicitly stated that AI will fail to establish the doctor-patient bond that the patient can rely on and trust. Due to AI's nature to diminish any emotion to carry out the procedure with no human reaction, the lack of humanity will minimize the patient's ability to remain calm. The doctors are irreplaceable in that aspect; however, in the case of cancer diagnoses, the doctors and AI work together to supply the patient with the highest level of care. Through empathy but also machine accuracy, the diagnoses and later steps will be held to the utmost standard, utilizing the current and future approaches in harmony (Cordero, D., 2024).

Like any new technique and technology, AI integration into not only healthcare but society requires a significant amount of attention, ensuring that the method benefits humans while maintaining accuracy and privacy. Other practical barriers include potential bias in AI models, which could affect diagnostic accuracy across different patient populations. AI bias can result from skewed data in the collection process, forming an underlying flaw in how the program interprets new information. Understanding that the future of medicine lies within AI is to comprehend how to navigate the issues and create a system that works seamlessly in the industry.

8. Data Privacy

Furthermore, in terms of data privacy, transferring all patient data through the data pipeline and AI system would demand a considerable amount of security, as the data is extremely sensitive. Security companies such as the HITRUST AI Assurance Program are aiming to mitigate the risk of any security breaches by evolving along with AI, making for a modern approach to managing AI. Privacy violations can take place, but the same problem is viable in the textbook method of manual data pipeline. Patient needs are prioritized, meaning that their data is to be protected to establish a trustworthy reputation for the hospital. The risk can run high with AI implementation, but using companies like HITRUST, there are better chances of highlighting the ethical components of the AI system. Minimizing all data breaches is possible by using techniques from HITRUST, such as applying transparent AI models and strengthening all cybersecurity aspects (Navigating the Security Risks of AI in Healthcare, 2023).

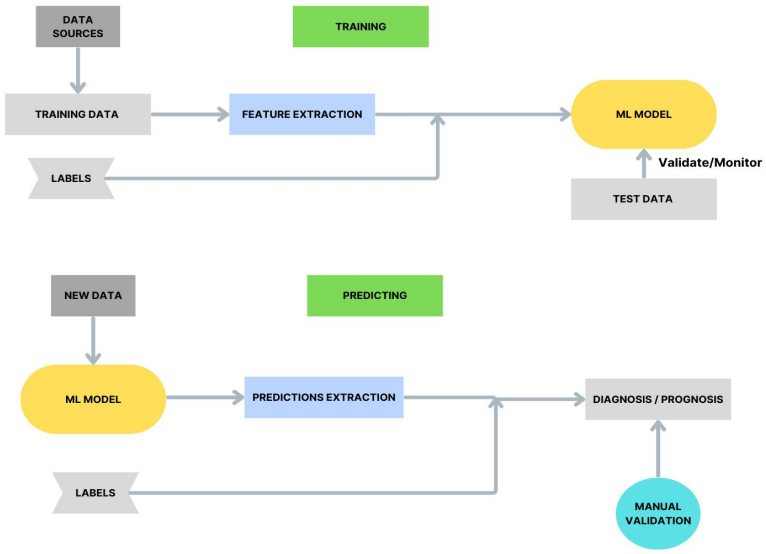

Figure 3. AI training data pipeline. Illustrates the flow of data used to train AI models for cancer diagnosis and prognosis. Created and copyrighted by Veeksha Patlolla.

The liability from using the large-scale nature of AI results in major privacy risks due to possible cyberattacks. Human error is a liable issue when uploading patient data as well; a simple mismanagement could expose patient

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information publicly online. Accidentally including patient information in data for online research could cause legal problems for both the hospital and the patient. The risks could materialize at any point in the AI data pipeline, and the security protection should be taken to the strongest standard. According to the article, How Might Artificial Intelligence Applications Impact Risk Management? by John Banja, PhD, health information has become increasingly available online, which puts hundreds of thousands of patients at risk for 'medical insurance fraud'.

Though AI also presents data risk, companies are stepping up to solve any security issues that simultaneously arise with AI. Patient confidentiality must remain protected, minimizing information breaches and increasing ease in the diagnosing process. Minimizing breaches, addressing bias, and ensuring equitable access are key considerations when implementing AI in clinical settings.

9. Conclusion

In conclusion, cancer is among the leading causes of death worldwide (Cancer statistics, 2024), and the use of AI systems being integrated into cancer diagnosis will improve patient outcomes by increasing the accuracy of diagnosis. Locating cancerous cells and making an informed decision with the foundation of patient history and scientific input is the minimum of how AI can change cancer care procedures. AI and machine learning can impact both diagnosis and prognosis through immense accuracy, including detailed imaging followed by a thorough examination of results to provide the patient with up-to-date information and treatment plans. This innovative technique will completely change the way that AI is used in the medical world and supply cancer patients with a modern system of care. Future research should focus on addressing these limitations, integrating AI into diverse clinical settings, evaluating effectiveness across additional cancer types, and developing strategies to mitigate barriers such as cost, accessibility, and bias. By addressing these challenges, AI can be effectively adopted to enhance modern cancer care.

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