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A Systematic Review of the Use of Artificial Intelligence in Early and Accurate Diagnosis for Lung and Breast Cancer

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Background: This systematic review examines how the use of artificial intelligence compares to conventional methods in the early detection and accuracy of diagnosing lung and breast cancer.

Methods: A comprehensive systematic review was conducted using Google Scholar, ScienceDirect, MDPI Journals, PubMed, JAMA Network, The Lancet Digital Health, Frontiers, Journal of Patient Safety, Thorax, NPJ Breast Cancer, BMC, and Nature Medicine. The inclusion criteria were artificial intelligence models or components of artificial intelligence detecting or classifying breast or lung cancer and articles published within the last five years. The study excluded articles that did not include either breast or lung cancer. The results were compiled into a table based on the key data gathered, such as accuracy, specificity, sensitivity, or P-value.

Results: A total of 15 studies were reviewed, eight of the articles were on breast cancer, and seven of the articles were on lung cancer. Each study showed an improvement in their results of accuracy, specificity, and sensitivity. One article gave a confidence score of 63% and two other articles gave a significant P-value < 0.05.

Discussion: The limitations or bias include a small sample size of radiologists, and possible bias due to authors following their own model. Overall, the articles showed improvement, but many articles utilized subsets of artificial intelligence, which mainly consisted of machine learning or deep learning models. Therefore, more research needs to be done, but the current research available has shown a promising future of the use of artificial intelligence.

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Introduction

Artificial intelligence is a phenomenon created to simulate human cognitive capabilities through computer technology. It is composed of many different components or subsets, such as machine learning and deep learning technology, that combine to build up what we know as artificial intelligence. In recent years, the idea and usage of artificial intelligence have been more readily available for public usage and used more frequently in society everyday. With sources such as Chatgpt, PyTorch, Jasper, and more, these tools can be used by anyone. As the advancement of artificial intelligence continues to grow and improve, the idea of utilizing it in the healthcare setting also comes to light as an opportunity.

In healthcare, there are various conditions that patients must monitor for, with cancer being a major concern. According to the American Cancer Society, 1 in 3 people will be diagnosed with cancer in their lifetime. Fortunately, screening methods are available in clinics and hospitals to detect these malignancies. Everyone is screened for any number of cancers as they age, and two of the most common cancers diagnosed yearly are lung and breast cancer. Common screening modalities for these conditions are radiographic imaging, such as mammography, computed tomography (CT), chest radiography (chest x-ray), and magnetic resonance imaging (MRI). The key to increasing the life expectancy for patients with these conditions is to catch these malignant tumors sooner before they are able to metastasize, in addition to getting patients on treatment sooner. Therefore, this systematic review examines how the use of artificial intelligence compares to conventional methods in the early detection and accuracy of diagnosing lung and breast cancer.

Methods

A comprehensive systematic review following the PRISMA 2020 guidelines was conducted using Google Scholar, ScienceDirect, MDPI Journals, PubMed, JAMA Network, The Lancet Digital Health, Frontiers, Journal of Patient Safety, Thorax, NPJ Breast Cancer, BMC, and Nature Medicine using the search terms: artificial intelligence, artificial intelligence in early cancer diagnosis, accuracy of artificial intelligence in cancer diagnosis, artificial intelligence in breast cancer, artificial intelligence in lung cancer. The inclusion criteria were studies that utilized artificial intelligence models or components in detecting or classifying breast or lung cancer and articles published after 2017. By having articles published within the past five years, it ensured all the information gathered was relevant with the most updated material on the use of artificial intelligence in the early and accurate diagnosis of lung and breast cancer. The exclusion criteria were studies that did not include either breast or lung cancer and articles that were not peer-reviewed. The studies were grouped into two main categories of either lung or breast cancer and then divided into subcategories of background and conventional methods utilized and the incorporation of artificial intelligence.

When reviewing articles, if the study included components of artificial intelligence such as machine learning or deep learning, then it met the inclusion criteria for this systematic review. It also fit the inclusion criteria if the articles' purpose was to assist in searching for the components of lung or breast cancer and looked for malignancies in screening tools such as radiography. The participants in the study could be of any gender, race, or age. From the data, the main things that were collected were the accuracy, specificity, sensitivity, and P-value, when available, but additional results data were also collected and made into a table chart. Statistical significance was set at a P-value < 0.05 or if percentages or scores from results improved in the comparison of artificial intelligence and radiologist.

Background/Literature Review

Artificial intelligence models are composed of machine learning and deep learning components, which allow computers to mimic human intelligence. Machine learning is when the computers are given data with or without the outcomes in order to make a prediction based on the pattern to determine factors such as survival rates, risk groups, and the presence or absence of cancer. Deep learning is the artificial neural network where the information obtained is all cross-referenced with each other looking deeper at each layer of data to make a prediction.[1] As artificial intelligence develops, many researchers have sought to create models to determine how it can be used in cancer. The best way to create an effective treatment plan for patients with cancer is to diagnose the tumor when it is in its early stages of the disease. This is where the idea of utilizing artificial intelligence could assist in screening for cancer to establish an earlier diagnosis, especially in commonly diagnosed conditions such as lung and breast cancer.

Lung Cancer

Conventional methods

Lung cancer is one of the most prevalent cancers diagnosed worldwide, and it is also one with a high mortality rate. Imaging has been an important tool in screening for lung cancer and the most commonly used ones are chest x-ray and CT scans. When screening for lung cancer in high-risk populations, low-dose CT scans had shown to reduce mortality compared to other methods.[3] According to the Centers for Medicare & Medicaid Services, if a patient is age 55-57 with a ≥30 pack-year smoking history, the patient is eligible for a CT scan to screen for lung cancer.[1] In the CT scans of the thoracic region, the possibility of detecting a pulmonary nodule varies from 15-50%. It is important that when the nodules are found to determine the risk it poses to the patient and whether it needs further evaluation. The most recent guidelines suggest that a nodule at least 5 mm in diameter does not need further evaluation, but a nodule approximately 6 mm in diameter would suggest an optional follow-up appointment with a provider, and anything larger warrants a follow-up.[9]

Despite the benefits of low-dose CT scans, routine chest x-ray remains a commonly used and more accessible screening method. However, it comes with limitations due to lower resolution, potentially leading to inaccuracies in diagnosis. To address these challenges, researchers explore the potential of artificial intelligence in combination with chest x-ray to enhance the accuracy of detecting lung malignancies.[3] Then another challenge, but for CT scans, are the interpretation of the scans by different radiologists which can result in variability, leading to false positives or negatives.[14] Additionally, smaller lung nodules or lymph node metastasis may be missed during chest x-rays or CT scans.[2] Incorporating artificial intelligence into the current screening process can help minimize discrepancies that may lead to delayed treatment and diagnosis.

To leverage the benefits of artificial intelligence, researchers propose a model that integrates observations from chest x-rays and minimal electronic health records based on the Centers for Medicare & Medicaid Services criteria. The study shows promising results, with the addition of artificial intelligence increasing the area under the curve from 63.4% to 75.5% in predicting a 12-year incident cancer risk.[1] Another study utilizes prior and current patient scans alongside artificial intelligence to predict the risk of lung cancer. The artificial intelligence model, consisting of 6,716 cases from the National Lung Cancer Screening Trial, demonstrates reduced false positives and false negatives compared to readings by six radiologists.[14] By leveraging the power of artificial intelligence in lung cancer screening and diagnosis, medical professionals can enhance accuracy and improve patient outcomes, offering new opportunities in the fight against this deadly condition.

Use of Artificial Intelligence

The knowledge of tumor size and spread is crucial for effective treatment management in patients. Typically, radiologists measure tumors from CT scans, but variations can occur due to different observers and environmental factors. To address these challenges and achieve more consistent lesion measurements, researchers have turned to artificial intelligence. In one study, researchers reviewed eight public datasets comprising 1,617 cross-sectional lung CT images, which three board-certified radiologists independently evaluated. They employed an artificial intelligence model that utilized three consecutive convolutional neural networks to label lesions based on 32 pixels. The authors used the intraclass correlation coefficient to compare the results with radiologists' assessments, which yielded a value of 0.959. The artificial intelligence algorithm slightly overestimated the lesion size by 2.97% compared to the radiologists.[12]

Another publication focused on using artificial intelligence to assist in screening and detecting lung nodules to reduce missed or misdiagnosed cases. The program incorporated 6,400 images containing 974 nodules, which four radiologists labeled. The lung nodules were categorized as true nodules or false positives. The results indicated that the artificial intelligence system achieved high accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve for diagnosing benign and malignant lung nodules: 93.2%, 92.4%, 94.8%, and 97.6%, respectively. In contrast, CT scans alone, diagnosed by a physician, showed a much lower rate of detecting true positive nodules at 46.5%.[2]

Similarly, another study assessed 5,485 participants aged 55 to 74 with a 30-pack-year smoking history or former smokers who quit within the last 15 years in the National Lung Screening Trial. The participants underwent an annual chest radiography screening for three years, which was then analyzed by certified radiologists and artificial intelligence technology to detect abnormalities. The study determined the sensitivity and specificity of the artificial intelligence system and radiologists in detecting cancer or malignant nodules on chest x-rays. The artificial intelligence achieved a sensitivity of 75.0% with a specificity of 83.3%, while the radiologists' sensitivity and specificity were 85.4% and 91.5%, respectively, with P values of 0.13 and <0.001 for sensitivity and specificity, respectively.[3]

The Lung Cancer Prediction CNN was an artificial intelligence model designed to predict the risk of nodules. It was trained on data collected from the US National Lung Screening Trials. The model was compared to the Brock University model, which set the guideline for further evaluation with a PET-CT scan for nodules 8mm or greater. The study included 1,187 male and female patients above the age of 18 years, with a total of 1,397 nodules found. Among these, 234 nodules were determined to be cancerous in 229 patients. The Lung Cancer Prediction CNN achieved an area under the curve of 89.6%, outperforming the Brock model's 86.8%, with a P-value of <0.005. Furthermore, the Lung Cancer Prediction CNN had only one false negative, while the Brock model had six false negatives.[9]

Serial CT scans are often employed to monitor the growth of lung nodules over time. In a retrospective cohort study spanning ten years, a structured-query-language algorithm was used to identify lung nodules in CT reports. Artificial intelligence models were then utilized to categorize the nodules based on their features. The study included 14,586 patients and 110,339 scans with lung nodules over a 10-year period. Two clinicians sorted the scans and created 2,000 sentences for the artificial intelligence models to classify the lung nodules. The results showed an accuracy of 94%, sensitivity of 90%, and specificity of 96%.[7]

Breast Cancer

Conventional methods

Breast cancer is another cancer that is frequently diagnosed and is the leading cause of death among women with this condition. The primary screening modality to monitor and detect breast cancer early is mammography, which identifies tumors and prevents their spread to other parts of the body.[11] Mammography effectively detects microcalcifications, in which the calcium deposits appear as white specks in breast tissue on the mammogram and may indicate malignancy.[4] The use of screening tools has significantly reduced breast cancer mortality rate. While mammography remains the main screening tool, MRI has demonstrated its capability to assist with early detection by approximately 20%. However, MRI is time-consuming, exposes patients to radiation, and is costly, making it mainly a second-line screening method.[5]

Given that breast cancer is a leading cause of death for women, mammograms are routinely used and done to detect tumors at an early stage. To ensure precise and accurate readings of the frequent mammograms observed by radiologists, the integration of artificial intelligence models can prove to be beneficial. Currently, radiologists' sensitivity in interpreting these mammograms have been reported to range from approximately 77% to 87%, with a specificity of 89% to 97% and an average detection time of 30 to 60 seconds.[6] Studies suggest that incorporating artificial intelligence could increase sensitivity and specificity to 86.1% to 93.0% and 79.0% to 90.0%, respectively.[6]

One challenge in the detection process is the interference caused by the density of breast tissues.[6] These models can assist with these complications and aid radiologists in identifying malignancies in radiographs and improve overall clinical care.[11] Although computer technology was introduced in the 1990s to assist in interpreting radiographic images of breast cancer, it did not yield significant advancements back then. However, in recent years technology has advanced remarkably, approaching human intelligence and unlocking the potential that was previously unseen back in the 1990s.[4]

Use of Artificial Intelligence

Artificial intelligence models have been developed to aid in diagnosing breast cancer using mammography.[5] One study created an artificial intelligence model specifically for detecting and interpreting the microcalcifications in mammography. A collection of 4,810 digital mammograms from 2,448 consecutive female patients were used. The authors aligned the labeled radiographic images interpreted by doctors and the predicted microcalcifications suspected by the artificial intelligence model. It showed that there were similarities between both scans, but in some scans, the model included additional microcalcifications that the radiologist did not detect with a confidence degree of an average of 63% and sensitivity of 78%.[4]

Similarly, another study utilized the You Only Look Once Computer-Aided Diagnosis system to detect and classify masses found in mammograms simultaneously. The proposed model is divided into four stages: preprocessing, extracting, detecting, and organizing the 600 mammograms collected from the Digital Database for Screening Mammography. It also included augmented mammograms to train and test the model based on information on the masses. From the results, the model had an accuracy of 99.7% for determining mass location and 97% for distinguishing the lesion as benign or malignant.[10]

In another publication, the artificial intelligence models were utilized as a first-line basis to diagnose cancer without a radiologist or as a final reader to reevaluate radiographic images that were deemed negative. Comparing it to the previous studies, this was the first one to diagnose breast cancer without the assistance of a radiologist. The retrospective simulation study included 7,364 women with 547 women with breast cancer. The artificial intelligence algorithm was trained using 170,230 mammograms from 36,468 women with breast cancer gathered from five different institutions. Each image was given a score based on its probability of being cancerous. The lowest score is safe to rule out cancer, and the highest increases the possibility of cancer. The authors determined that the artificial intelligence score did not miss any cancer screening in the mammograms with the lowest 60% score but began to miss detection as it continued to the 70-90% lowest score.[5]

This article utilized the UNet model to improve the segmentation, classification, and detection of breast cancer. The UNet model consists of datasets from DDSM and INbreast, which gathers the data to utilize the pixels in the images to classify if any of the masses are normal or abnormal. The results showed that the UNet model could evaluate the masses with an intersection over union score of 90.5%, with an area under the curve of 99.9% for both datasets. This supports that the model does well compared to the currently existing methodologies.[13] As technology continues to advance, new models of artificial intelligence get developed to improve from the previous models before it. Another article observes a new model, the Vanilla UNet, based on the previous UNet model, to precisely segment mass lesions found on mammograms. It utilizes data from 4 different databases for 2,066 images to train their new model. Comparing the Vanilla UNet to previous models such as the original U-Net, VGG16-based SegNet model, and Dilated-Net showed an improved average Dice coefficient index, Intersection over Union metric, and Boundary F1 contour matching score.[15]

Besides mammography, extracting information from electronic medical records with artificial intelligence technology is another way that it could be utilized. Time is an important factor in determining cancer and catching it early. Still, the follow-up process after an abnormal mammography screening is rarely performed promptly. It could go unnoticed in a pile of free-text documentation in electronic medical records. This study contains a sample size of 421 mammography reports ranging from zero to six on the recommended follow-up, with zero being incomplete and needing further evaluation. Then one being normal, leading up to six being most probable for cancer and requiring a biopsy. The reports were reviewed by a general internist that determined the score and then compared to the scoring that the artificial intelligence model defined for each report. The precision and accuracy of the artificial intelligence model was 98% for both, with the main complication in the reports with a score of zero.[8]

Results

This systematic review evaluated 15 peer-reviewed articles published within the last five years. Eight of the articles reviewed breast cancer, and seven of the articles reviewed lung cancer. The eight articles on breast cancer mainly covered the use of mammography and the assistance of artificial intelligence. For lung cancer, one article used the assistance of artificial intelligence with chest x-ray, and six used the assistance of artificial intelligence with CT imaging. Nine articles compared the use of artificial intelligence to a radiologist or specialist, two articles compared the use of artificial intelligence to another artificial intelligence model, and four articles looked at the use of artificial intelligence alone.

From the articles gathered, the overall results in Table 1 showed an improved scoring with the use of artificial intelligence in percentages of accuracy, sensitivity, specificity, and P-value. A possible bias was that three articles utilized an artificial intelligence model they created and conducted the study. Another possible bias is the studies that compared radiologists to artificial intelligence had a small sample size of radiologists ranging from two to six individuals looking through the scans.

Discussion

From the results, it can be concluded that the use of artificial intelligence could be beneficial with assisting in the early detection and accuracy of diagnosing lung and breast cancer. From the literature, the articles showed improvement in accuracy, sensitivity, specificity, and P-value, but many articles utilized subsets of artificial intelligence, which mainly consisted of machine learning or deep learning models. Therefore, more research needs to be done, but the current research available has shown a promising future of the use of artificial intelligence. The limitations of this systematic review includes that it was specific to only lung or breast cancer, so the comparison for the use of artificial intelligence with radiography cannot be definitive to other cancers that use the same screening methods. Another limitation is the databases that were utilized contained many patients that were at high risk in breast or lung cancer, but each study had their own set of inclusions and exclusions, which limited the amount of data that could be presented. For future research, the incorporation of additional details such as race, gender, and demographics or smoking history and history of breast cancer could assist in providing additional factors that could contribute to a more accurate diagnosis or adapting and building more on the current models to continuously improve them for future use and possibly incorporate other cancers.

Conclusion

Breast and lung cancers are some of the most common cancers that are found worldwide. By catching and treating these conditions sooner is the key to decreasing mortality. With the popularity of artificial intelligence, it opens the opportunity for researchers to utilize these tools in the screening process for these conditions. Artificial intelligence is composed of the subset of deep learning and machine learning models, which allow computer technology to analyze data similar to a human to come up with a prediction of an outcome. This systematic review examined how the use of artificial intelligence compares to conventional methods in the early detection and accuracy of diagnosing lung and breast cancer.

The research findings reveal that the use of components of artificial intelligence did show an improvement in factors such as specificity and sensitivity, which assist in determining the accuracy of diagnosing a condition. Many articles were only subsets of artificial intelligence technology and contained potential bias and limitations. Therefore, more research is needed, but current research shows promising outcomes to improve and assist in future diagnosing. Future research can include more initial screening information such as smoking history or family history of breast cancer to the current models.

Registration and protocol

Review was not registered and protocol was not prepared.

Support

None.

Competing Interests

None.

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Appendix

Table 1

Results from Articles

Article Title	Results
The role of artificial intelligence in early cancer diagnosis	The study shows promising results, with the addition of artificial intelligence increasing the area under the curve from 63.4% to 75.5% in predicting a 12-year incident cancer risk.[1]
Artificial Intelligence in lung cancer diagnosis and prognosis: Current application and future perspective	The results indicated that the artificial intelligence system achieved high accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve for diagnosing benign and malignant lung nodules: 93.2%, 92.4%, 94.8%, and 97.6%, respectively. In contrast, CT scans alone, diagnosed by a physician, showed a much lower rate of detecting true positive nodules at 46.5%.[2]
Validation of a deep learning algorithm for the detection of malignant pulmonary nodules in chest radiographs	The artificial intelligence achieved a sensitivity of 75.0% with a specificity of 83.3%, while the radiologists' sensitivity and specificity were 85.4% and 91.5%, respectively, with P values of 0.13 and <0.001 for sensitivity and specificity, respectively.[3]
Artificial intelligence-based diagnosis of breast cancer by mammography microcalcification	It showed that there were similarities between both scans, but in some scans, the model included additional microcalcifications that the radiologist did not detect with a confidence degree of an average of 63% and sensitivity of 78%.[4]
Effect of artificial intelligence-based triaging of breast cancer screening mammograms on cancer detection and radiologist workload: A retrospective simulation study	The authors determined that the artificial intelligence score did not miss any cancer screening in the mammograms with the lowest 60% score but began to miss detection as it continued to the 70-90% lowest score.[5]
Automated Breast Cancer Detection in digital mammograms of various densities via deep learning	Currently, radiologists' sensitivity in interpreting these mammograms have been reported to range from approximately 77% to 87%, with a specificity of 89% to 97% and an average

	detection time of 30 to 60 seconds.[6] Studies suggest that incorporating artificial intelligence could increase sensitivity and specificity to 86.1% to 93.0% and 79.0% to 90.0%, respectively.[6]
Development of a structured query language and natural language processing algorithm to identify lung nodules in a cancer center	The results showed an accuracy of 94%, sensitivity of 90%, and specificity of 96%.[7]
Using natural language processing to extract abnormal results from cancer screening reports	The precision and accuracy of the artificial intelligence model was 98% for both, with the main complication in the reports with a score of zero.[8]
External validation of a convolutional neural network artificial intelligence tool to predict malignancy in pulmonary nodules	The Lung Cancer Prediction CNN achieved an area under the curve of 89.6%, outperforming the Brock model's 86.8%, with a P-value of <0.005. Furthermore, the Lung Cancer Prediction CNN had only one false negative, while the Brock model had six false negatives.[9]
Simultaneous detection and classification of breast masses in digital mammograms via a deep learning YOLO-based CAD System	From the results, the model had an accuracy of 99.7% for determining mass location and 97% for distinguishing the lesion as benign or malignant.[10]
Deep learning for semi-automated unidirectional measurement of lung tumor size in CT	The authors used the intraclass correlation coefficient to compare the results with radiologists' assessments, which yielded a value of 0.959. The artificial intelligence algorithm slightly overestimated the lesion size by 2.97% compared to the radiologists.[12]
Breast cancer: One-stage automated detection, segmentation, and classification of digital mammograms using unet model based-semantic segmentation	The results showed that the UNet model could evaluate the masses with an intersection over union score of 90.5%, with an area under the curve of 99.9% for both datasets.[13]
End-to-end lung cancer screening with three-dimensional deep learning on low-dose chest computed tomography	This study demonstrates reduced false positives by 11% and false negatives by 5% compared to readings by six radiologists.[14]
Convolutional Neural Network for automated mass segmentation in Mammography.	This study showed an improved average Dice coefficient index by 95.1%, Intersection over Union metric 90.9%, and Boundary F1 contour

	matching score 96.4%.[15]

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