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REVIEW

Neural networks applied to the detection and diagnosis of Breast Cancer, a systematic review of the scientific literature of the last 5 years

Redes neuronales aplicadas a la detección y diagnóstico del Cáncer de Mama, una revisión sistemática de la literatura científica de los últimos 5 años

Walter Aviles-Yataco[1] ✉, Brian Meneses-Claudio[1]

[1]Facultad de Ingeniería. Universidad Tecnológica del Perú. Lima, Perú.

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ABSTRACT

One of the fatal diseases that occurs in women is breast cancer and is associated with late diagnosis and poor access to medical care according to the patient's needs, therefore neural networks play a relevant role in detection of breast cancer and aims to be a support to guarantee its accuracy and reliability in cancer results. Therefore, the aim of the present systematic review is to learn how neural networks help to improve accuracy in breast cancer diagnosis through image recognition. For this, the formula generated with the PICO methodology was used; Likewise, the first result was 203 investigations related to the topic and based on the established inclusion and exclusion criteria, 20 final free access scientific articles were selected from the Scopus database. In relation to the results, it was found that the use of neural networks in the diagnosis of breast cancer, especially convolutional neural networks (CNN), has proven to be a promising tool to improve the accuracy and early detection of the disease, reaching achieve an accuracy of 98 % in the recognition of clinical images, which means a big difference compared to traditional methods. On the other hand, although there are challenges such as the limited availability of high-quality data sets and bias in training data, it is suggested to investigate the development of methods that integrate multiple sources of information and the use of deep learning techniques.

Keyword: Breast Cancer; Diagnosis; Neural Networks; Deep Learning.

RESUMEN

Una de las enfermedades mortales que se presenta en la mujer es el cáncer de mama y está asociada a un diagnóstico tardío y a un escaso acceso a una atención médica acorde a las necesidades de la paciente, por ello las redes neuronales juegan un papel relevante en la detección del cáncer de mama y pretende ser un apoyo para garantizar su precisión y fiabilidad en los resultados oncológicos. Por lo tanto, el objetivo de la presente revisión sistemática es conocer cómo las redes neuronales ayudan a mejorar la precisión en el diagnóstico del cáncer de mama a través del reconocimiento de imágenes. Para ello, se utilizó la fórmula generada con la metodología PICO; así mismo, el primer resultado fueron 203 investigaciones relacionadas con el tema y con base en los criterios de inclusión y exclusión establecidos, se seleccionaron 20 artículos científicos finales de libre acceso de la base de datos Scopus. En relación a los resultados, se encontró que el uso de redes neuronales en el diagnóstico del cáncer de mama, especialmente las redes neuronales convolucionales (CNN), ha demostrado ser una herramienta prometedora para mejorar la precisión y detección temprana de la enfermedad, llegando a alcanzar una precisión del 98 % en el reconocimiento de imágenes clínicas, lo que significa una gran diferencia en comparación con los métodos tradicionales. Por otro lado, aunque existen retos como la limitada

disponibilidad de conjuntos de datos de alta calidad y el sesgo en los datos de entrenamiento, se sugiere investigar el desarrollo de métodos que integren múltiples fuentes de información y el uso de técnicas de aprendizaje profundo.

Palabra clave: Cáncer de Mama; Diagnóstico; Redes Neuronales; Aprendizaje Profundo.

INTRODUCTION

According to studies conducted by Organización Mundial de la Salud (2023), breast cancer is found in 86 % of all countries; it is also located among the first two leading causes of death in women from cancer in 95 % of all countries.[1,2] This is evidence of a worldwide problem in the area of medical care, especially harming women in each country. Also, the highest rates of death from breast cancer, in low-resource countries and helpless people, are associated with delayed diagnosis and poor access to medical care according to the patient's needs.

In addition, health systems must be strengthened to implement sustainable, cost-effective and equitable services for early clinical diagnosis and early treatment of breast cancer, exclusively in middle- and low-income localities.[3] In other words, early clinical identification of breast tumors with timely pathological diagnosis and execution of a high-level clinical procedure helps the patient. In addition, health systems have to quickly differentiate between malignant and benign results and for this purpose the application of neural networks will be performed, since as indicated by Mridha (2021) neural networks play a relevant role in the detection of breast cancer and is not intended to replace the radiology specialist, on the contrary it seeks to be a support to ensure its accuracy and reliability in the results of cancer.[4]

Also, the neural networks achieved an accuracy of 96,4 %, a sensitivity of 97,5 % and a specificity of 97,8 % in the analysis of breast regions from thermal images. In addition, convolutional neural networks (CNN) prove to be the most accurate and common breast cancer tracking models, and the accuracy metric is the most popular performance evaluation method.[5]

Deep learning and neural network algorithms provide significant performance improvements compared to other traditional forms of machine learning and artificial intelligence.[6] Deep learning applications are in various fields such as image classification, natural language processing, games, etc and it is very popular in medical imaging for the identification of malignant tumors in the skin, the diagnosis and segmentation of brain tumors and other diseases.[7]

Likewise, according to Nasser and Yusof (2023), the main advantage of a neural network-based approach is their ability to learn automatically from unlabeled raw data, offering various alternatives for effective breast cancer detection. Moreover, most deep learning-based systems outperformed systems based on traditional methods since, how to effectively detect masses that are surrounded by dense tissues must be addressed by smarter deep learning algorithms.[8]

Based on information acquired from various sources on the subject of neural networks applied to breast cancer detection and diagnosis, the purpose of the present systematic review is to answer the following initial question: How much can the accuracy of breast cancer diagnosis be improved by using neural networks in image recognition?

Our systematic review will investigate questions such as: What types of neural networks applied to breast cancer diagnosis were discussed?, What database did the researchers use as samples?, What types of clinical images have the greatest future projection for breast cancer detection using neural networks?, What are the evaluation metrics used in the methods proposed in the articles to determine the accuracy of breast cancer diagnosis using neural networks?, What are the evaluation metrics used in the methods proposed in the articles to determine the accuracy of breast cancer diagnosis using neural networks?, What are the evaluation metrics used in the methods proposed in the articles to determine the accuracy of breast cancer diagnosis using neural networks?, What are the evaluation metrics used in the methods proposed in the articles to determine the accuracy of breast cancer diagnosis using neural networks?. If various neural network methods/techniques were used/analyzed/discussed in the study, which one was more accurate/effective/etc?, What country conducted the most research on the use of neural networks in breast cancer detection?, Which year had the highest annual publication volume of articles on cancer diagnosis using neural networks?.

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To answer the research questions, our objective is to understand how neural networks help improve the accuracy in the diagnosis of breast cancer through image recognition. This process will be carried out through a systematic review that consists of the collection of information, documents or academic articles published in the last 5 years.

METHODS

Description of the systematic search strategy

In the current research work, the PICO method was used to compile scientific articles, as indicated by Martínez Díaz, Ortega Chacón and Muñoz Ronda (2016), the PICO format is frequently applied in the elaboration of research unknowns. Also, it is a multidisciplinary method and is composed of the following structure: (P) population, (I) intervention, (C): comparison (O) result expected. Also, a research is born out of a need to formulate a question.[9,10,11]

To carry out the search, 5 keywords were proposed, the terms used were: “Breast Cancer”, “Neural Networks”, “Diagnostic Accuracy”, “Artificial Intelligence”, “Image Recognition”.

Moreover, the research question was posed: How much can the accuracy of breast cancer diagnosis be improved by using neural networks in image recognition?. On the other hand, the methodology provided a formula that was successfully used in the SCOPUS bibliographic source and the scientific studies were filtered with the execution of the inclusion and exclusion methods.

Question PICO and its components

Table 1. PICO

How can the accuracy of breast cancer diagnosis be improved using neural networks in image recognition?		
P	breast cancer diagnosis	"breast cancer" OR "breast cancer screening" OR "digital breast screening" OR "routine screening for breast cancer" OR "misdiagnosis" OR "diagnosis of breast cancer" OR "mammography"
I	neural networks	"artificial neural network" OR "ANN" OR "CNN" OR "neural network" OR "unsupervised neural network" OR "recurrent neural network" OR "convolutional neural network" OR "multilayer neural network" OR "generic neural network" OR "cellular neural network"
C	traditional methods	“traditional methods” OR “traditional building methods” OR “machine learning”
O	precision in diagnosis	“early diagnosis” OR “effective diagnosis”
P	adult women	“women”

Search equation used

The PICO method provided the following formula and was used in the Scopus academic library to search for scientific documents that contribute to the research.

("breast cancer" OR "breast cancer screening" OR "digital breast screening" OR "routine screening for breast cancer" OR "misdiagnosis" OR "diagnosis of breast cancer" OR "mammography" AND "ANN" OR "artificial neural network" OR "CNN" OR "convolutional neural network" OR "multilayer neural network" OR "generic neural network" OR "neural network" OR "cellular neural network" OR "recurrent neural network" OR "unsupervised neural network" AND "early diagnosis" OR "effective diagnosis" AND “Women”)

Definition of inclusion and exclusion criteria for scientific articles

Exclusion and inclusion requirements are essential during the selection process as they reduce errors when collecting research on the topic of study (Quispe et al., 2021).[12] Therefore, after collecting research information, a precise analysis was carried out considering the following points:

Inclusion criteria

- CI1. Included articles should address the application of conventional and unconventional neural networks in clinical image detection.
- CI2. Documents published in Spanish and English.
- CI3. The articles focused exclusively on the diagnosis of breast cancer using neural networks.
- CI4. Articles published between 2019 and today.

Exclusion criteria

- CE1. Articles in languages other than English and Spanish.

- CE2. Documents published before 2019 were excluded.
- CE3. Documents other than original articles, other sources such as books, theses and magazines were excluded.
- CE4. Documents focused on other techniques for cancer detection other than the use of Neural Networks were excluded.

Results obtained from the scientific literature search process

To carry out the search process for scientific articles related to the present research, the formula generated with the PICO methodology mentioned above was used and the first result was 203 research studies related to the topic.[13]

Description of the considered selection logic (PRISMA)

The prism method provides various benefits in the selection of research used in the systematic literature review. Likewise, it consists of a process of 27 requirements and 4 periods that increases the possibility of finding articles that contribute to the research. Therefore, in the first filter of selection of articles, a depuration was made according to the denomination and synopsis of the 203 documents. In addition, the articles are directly related to the use of Neural Networks in the diagnosis of breast cancer through image detection.[14,15]

Detailed description of the steps of the selection process and its results (PRISMA)

In the first instance 203 articles were obtained, the investigation was carried out exclusively in the SCOPUS bibliographic source and no duplicate files were found, therefore no investigation was discarded in the first filter. Subsequently, 92 articles were leaked because they were not directly related to the research topic after analyzing the names of research articles and synopses of the results in the first search, resulting in 111 investigations. Next, the research was then downloaded, but 19 articles were not downloaded because they were not freely accessible to users or were not available, leaving 90 articles. In this way, these last studies were filtered by some exclusion criteria, such as being different from the Spanish or English language, documents that are not original articles (books, theses and journals), studies focused on other techniques for cancer detection other than the use of Neural Networks and the year of publication before 2019. Finally, 20 final scientific articles were collected for the present systematic literature review.[16,17,18] PRISMA flowchart that graphically reflects the selection process

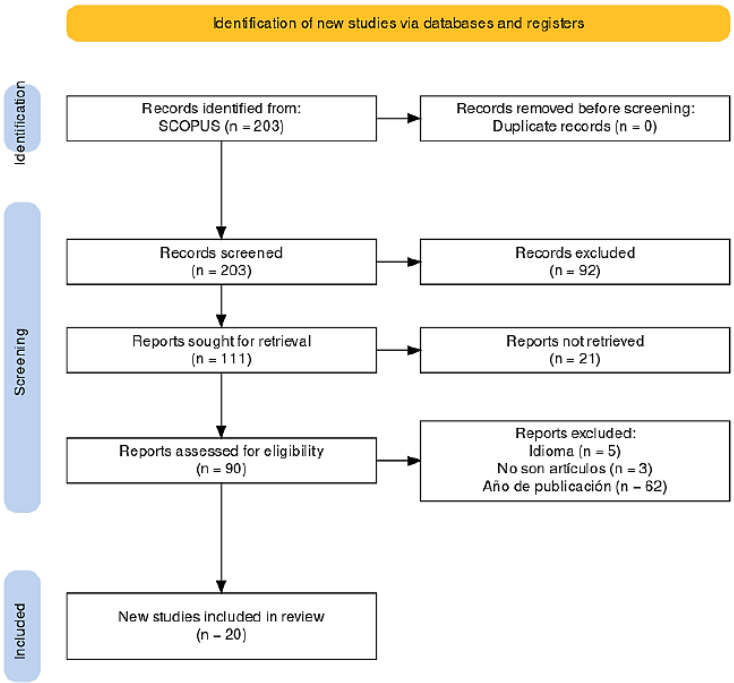

Figure 1. PRISMA

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Table 2. Final list of selected studies

Author	Title	Year	Document	Base
Agnes et al.	Classification of Mammogram lmages Using Multiscale all Convulation Neural Network (MA-CNN)	2020	Article	Scopus
Bharati et al.	Artificial neural network based breast cancer screening: A comprehensive review	2020	Article	Scopus
Murtaza et al.	Breast Cancer Multi-classification through Deep Neural Network and Hierarchical Classification Approach	2020	Article	Scopus
Hosseinzadeh Kassani et al.	Classification of histopathological biopsy images using ensemble of deep learning networks	2020	Article	Scopus
Murtaza, et al.	Ensembled deep convolution neural network-based breast cancer classification with misclassification reduction algorithms	2020	Article	Scopus
Hakim, et al.	Microcalcification detection in mammography image using computer-aided detection based on convolutional neural network	2021	Article	Scopus
Sánchez Cauce, et al.	Multi-input convolutional neural network for breast cancer detection using: thermal images and clinical data	2021	Article	Scopus
Hakkoum, et al.	Assessing and Comparing Interpretability Techniques for Artificial Neural Networks Breast Cancer Classification	2021	Article	Scopus
Algarni, et al.	Convolutional neural networks for breast tumor classification using structured features.	2021	Article	Scopus
Davoudi et al.	Evolving convolutional neural network parameters through the generic algorithm for the breast cancer classification problem	2021	Article	Scopus
Ramya N. et al.	Breast Cancer lnvasive Carcinoma Detection Using Deep Convolution Neural Networks	2022	Article	Scopus
Ramesh K. et al.	Biomedical Application of Identified Biomarkers Gene Expression Based Early Diagnosis and Detection in Cervical Cancer with Modified Probabilistic Neural Network	2022	Article	Scopus
Ahila A. et al.	Meta-Heuristic Algorithm-Tuned Neural Network for Breast Cancer Diagnosis Using Ultrasound lmages	2022	Article	Scopus
Fagbuagun O.A. et al.	Breast Cancer Diagnosis in Women Using Neural Networks and Deep Learning	2022	Article	Scopus
Hameed Z. et al.	Multiclass classification of breast Cancer histopathology images using multilevel features of deep convolutional neural network	2022	Article	Scopus
Kumar P.P. et al.	Breast Cancer Detection on Mammographic lmages using Hyper Parameter Tuning & Optimization: A Convolution Neural Network & Transfer Learning Approach	2022	Article	Scopus
Nasser M., et al.	Deep Learning Based Methods for Breast Cancer Diagnosis: A Systematic Review and Future Direction	2023	Article	Scopus
Alshehri A. et al.	Breast Cancer Detection in Thermography Using Convolutional Neural Networks (CNNs) with Deep Attention Mechanisms	2022	Article	Scopus
Aidossov N. et al.	An lntegrated lntelligent System for Breast Cancer Detection at Early Stages Using IR.	2023	Article	Scopus
Mirasbekov Y. et al.	Images and Machine Learning Methods with Explainability	2023	Article	Scopus
Lin C.-J. et al.	Vector Deep Fuzzy Neural Network for Breast 202 Cancer Classification	2023	Article	Scopus
Jabeen K. et al.	BC2NetRF: Breast Cancer Classification from Mammogram Images Using Enhanced Deep Learning Features and Equilibrium-Jaya Controlled Regula Falsi-Based Features Selection	2023	Article	Scopus
Ma X. et al.	Label-free breast cancer detection and classification by	2023	Article	Scopus

	convolutional neural network-based on exosomes surface- enhanced raman scattering

RESULTS

Different factors influence a correct diagnosis of breast cancer that lead to a false positive or false negative and to reduce the error rate, the implementation of methods using neural networks is suggested. As indicated by Aidossov et al. (2023),[19] neural network is widely recommended as a prominent tool in the field of machine learning, especially in image recognition since neural networks are a well-established method of artificial intelligence (AI) and have demonstrated outstanding results in various medical diagnostic problems.[20] In recent times, different types of neural networks have been known to support breast cancer detection such as convolutional neural networks (CNN), deep bayesian networks (DBN), deep neural networks (DNN), recurrent neural networks (RNN) and artificial neural networks (ANN). In the reviewed articles, the researchers prefer to use convolutional neural networks as shown in Table 3, and as mentioned by Sánchez Cauce, Pérez Martín and Luque (2021) are a class of deep neural networks used for pattern recognition in images.[21,22] These networks can extract complex features in an automated manner from the input data. Its effectiveness in image processing is due to its ability to learn global patterns across different neural layers. Also, software libraries that implement CNNs have contributed to their widespread use in the field of image processing in recent years.[23,24]

Table 3. Types of neural networks

Type of Neural Networks Discussed	Frequency	Author
Traditional Neural Network	1	Agnes et al. 2020
Artificial Neural Network	2	Bharati et al. 2020 / Hakkoum et al. 2021
Convolutional Neural Network	5	Murtaza et al. 2020 / Kassani et al. 2020 / Hakim et al. 2021/ Murtaza et al. 2020/ Sánchez-Cauce et al. 2021
Deep Neural Network	0	
Recurrent Neural Network	0	

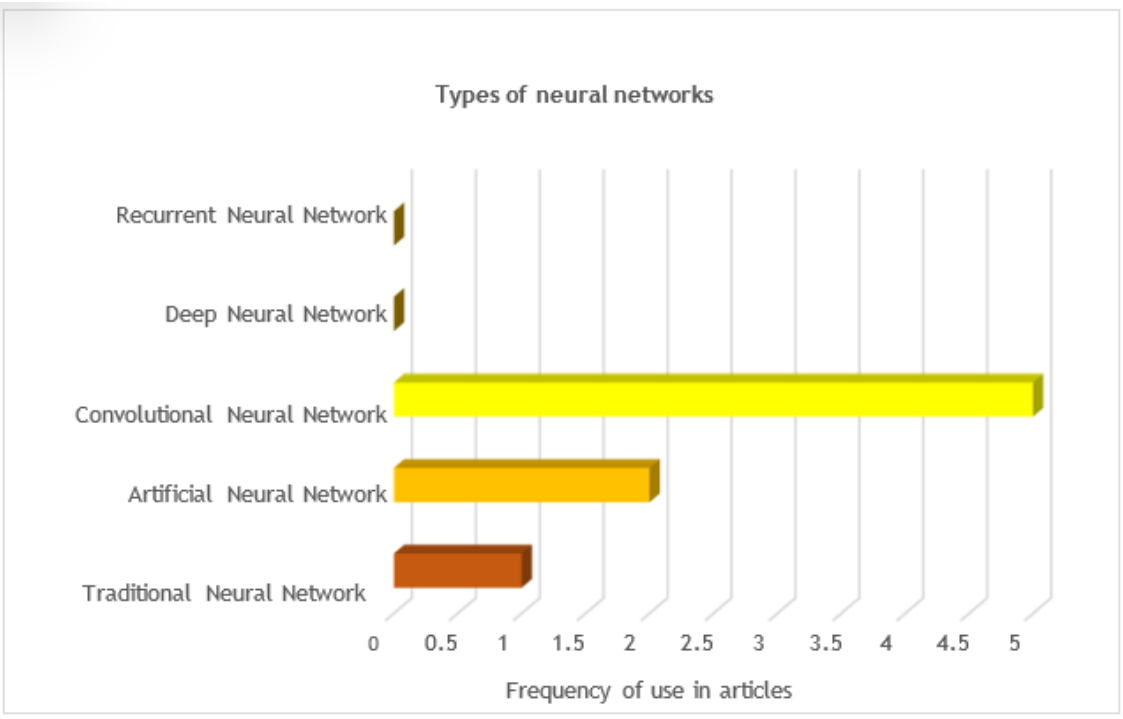

Figure 2. Types of neural networks

For the evaluation of the proposed models, databases containing mammograms are of vital importance. They play a fundamental role in the research and study of breast cancer and provide a set of superior quality medical images and associated clinical data that allow researchers and clinicians to

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perform detailed analyses and comparative studies.[25,26,27,28,29,30] There are different databases on the internet and free of charge, as well as other databases with more images and more updated that have a monetary cost to access it. Depending on the type of image that researchers need, they will opt for a certain database.[31] According to table 4, the most used base is Breakhis, which was used in 6 researches works according to Murtaza, Shuib, Wahab, et al. (2020)[32] and this database was created in collaboration between the P&D and Pathological Anatomy and Cytopathology Laboratory in Paraná, Brazil. This data set was collected using excisional biopsies of breast tumor tissue from 81 subjects, excluding the duplicate patient. Each patient has multiple high-resolution biopsy images.[33,34,35] In total, the data set consists of 7909 images taken with a microscope at four different magnifications: 40×, 100×, 200× and 400×.

The BreakHis samples are divided into 8 types of results, as shown in figure 3.

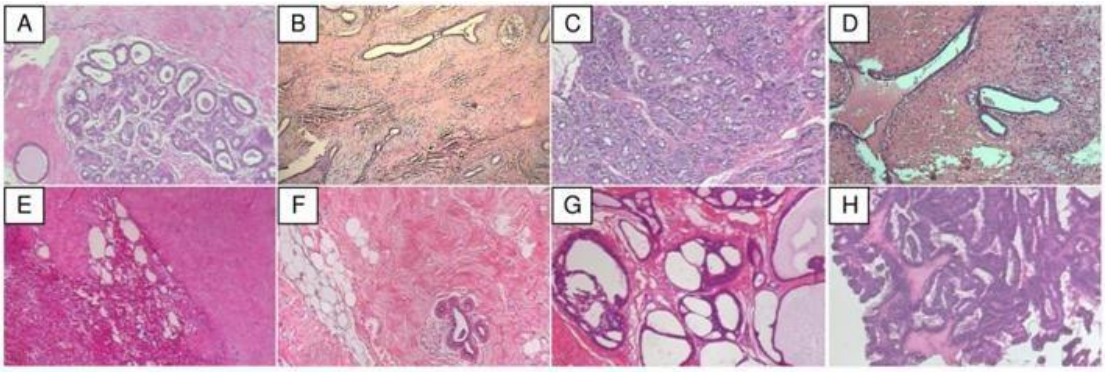

Figure 3. Breakhis results (A)Adenosis, (B)Fibroadenoma, (C)Tubular adenoma, (D) Phyllodes tumor, (E) Ductal carcinoma, (F) Lobulary carcinoma, (G)Mucinous carcinoma, (H)Papillary carcinoma

Table 4. Types of databases

Database	Accessibility	Type	Frequency	Reference
WBCD	Public	Images	2	(Algarni, Aldahri and Alghamdi, 2021; Hakkoum, Idri and Abnane, 2021)
BreakHis	Public	Images	7	(Hosseinzadeh Kassani *et al.*, 2019; Murtaza, Shuib, Mujtaba, *et al.*, 2020; Murtaza, Shuib, Wahab, *et al.*, 2020; Davoudi and Thulasiraman, 2021; Alshehri and Alsaeed, 2022; Hameed *et al.*, 2022; Cheng Jian *et al.*, 2023)
INbreast	Public	Images	2	(Bharati, Podder and Hossain Mondal, 2020; Hakim, Prajitno and Soejoko, 2021)
MIAS	Public	Images	4	(Agnes *et al.*, 2020; Kumar and Bai, 2022; Jabeen *et al.*, 2023; Nasser and Yusof, 2023)
DMR	Public	Thermal Images	3	(Sánchez Cauce, Pérez Martín and Luque, 2021; Fagbuagun *et al.*, 2022; Aidossov *et al.*, 2023)

Mammography has limitations in detecting breast tumors in situations of high breast density or in young women. Frequent use of mammography is restricted due to exposure to ionizing radiation, and compression of breast tissue may cause discomfort in some women.[36,37,38,39]

One option to overcome these limitations is thermography, which is a technique that uses infrared (IR) photography to accurately measure temperatures on the surface of the breast. As breast tumors are metabolically active, they generate more heat than the surrounding healthy tissues, thus the thermography is a valuable tool for the detection of breast tumors because identify thermal abnormalities that could indicate the presence of cancer.[40,41]

According to Aidossov et al. (2023),[42] thermography is considered a safe and non-invasive approach to detect breast cancer, this it is based on the measurement of heat wavelength.[43] These characteristics make thermography suitable for regular and repeated use in the detection and monitoring of this disease.[44,45,46]

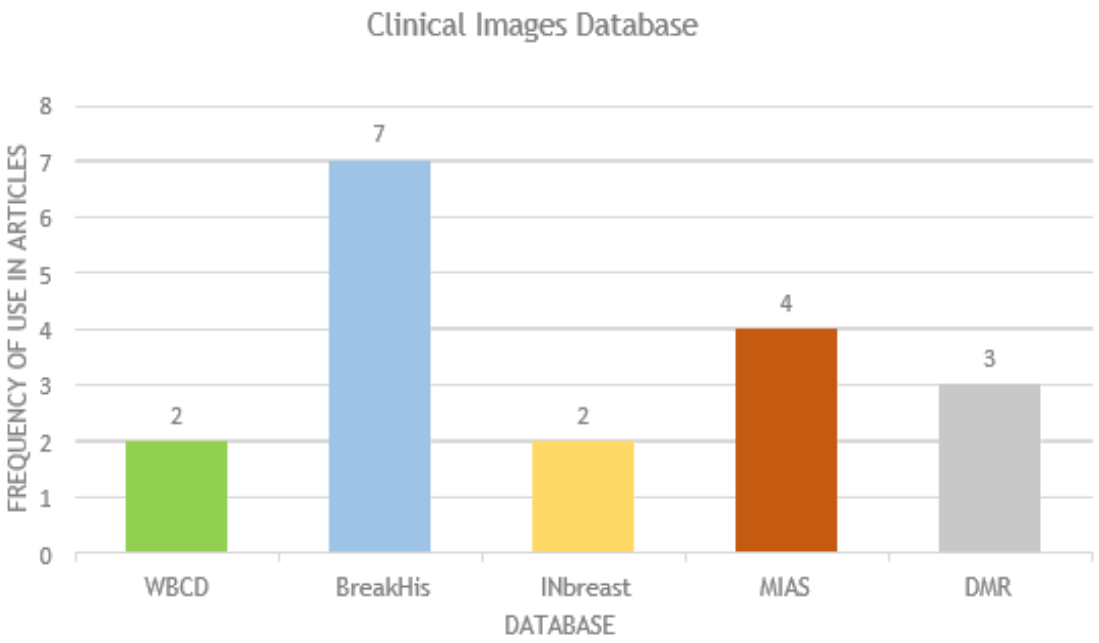

Figure 4. Database used

It is expected to improve the results, which in themselves are very promising since there is not much data to train a neural network that evaluates thermal images, the only database used is DMR. In the Table 5 shows that the highest accuracy achieved is 98,25 % in the early diagnosis of breast cancer.

Table 5. Thermal image results

Author	BBDD used	Neural network method used	Precision	Sensitivity	Specificity
Fagbuagun O.A. et al.	Research database (DMR)	Convolutional neural network (CNN)	98,25 %	99,5 %	46,15 %
Aidossov N. et al.	Research database (DMR)	Convolutional neural network (CNN)	95 %	92 %	97 %
Sanchez-Cauce R. et al.	Research database (DMR)	Convolutional neural network (CNN)	97 %	83 %	100 %

To evaluate quantitatively, 8 different evaluation metrics were used throughout the different research articles. Some were used more than others, providing sufficient results to compare the different methods presented, as shown in Table 6. Among the metrics most used by the authors are precision, specificity and sensitivity, each metric has its respective formula that provide the result to determine the most precise neural network method when diagnosing breast cancer through the recognition of clinical images.[47,48,49,50]

Precision: An intuitive performance measure that represents the proportion of correctly predicted observations relative to total observations.[51]

Specificity: Indicates the proportion of negative instances correctly identified in relation to the total number of negative instances in the data set.[52]

Recall (Sensitivity): The proportion of positive observations correctly predicted relative to the total observations in the class 'yes' in reality.[53]

F1 Score: A weighted average of precision and recall. This metric considers both cases in which false positives occur and those in which false negatives occur.[54]

Area under the ROC curve (AUC-ROC): It is a metric that evaluates the discrimination ability of a model and is commonly used in binary classification problems.[55]

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Accuracy: Calculates the proportion of correct predictions in relation to the total predictions made.

Metric	Calculation Formula
accuracy	$accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}$
precision	$precision = \frac{TP}{(TP + FP)}$
sensitivity	$sensitivity = \frac{TP}{(TP + FN)}$
specificity	$specificity = \frac{TN}{(TN + FP)}$
$F1 - score$	$F1 - score = 2 \times \frac{(precision \times recall)}{(precision + recall)}$
TPR	$TPR = \frac{TP}{(TP + FN)}$
FPR	$FPR = \frac{FP}{(TN + FP)}$
$dice - coefficient$	$dice - coefficient = \frac{2 \times \lvert P \cap GT \rvert}{\lvert P \rvert + \lvert GT \rvert}$

Figure 5. Evaluation metrics formulas

Table 6. Evaluation metrics

Author/Metrics	Accuracy	Precision	Specificity	Sensitivity	AUC	F1-Score	Confusion matrix	ROC Curve
Sánchez-Cauce R. et al.	✓	✓	✓	✓				
Aidossov N. et al.		✓	✓	✓	✓	✓	✓	✓
Fagbuagun O.A. et al.	✓		✓	✓	✓			
Algarni A. et al.	✓	✓		✓		✓		
Hakkoum H. et al.	✓	✓		✓				
Alshehri A. et al.		✓		✓	✓			
Davoudi K. et al.		✓	✓	✓				
Murtaza G. et al.		✓	✓	✓				
Lin C.-J. et al.		✓	✓	✓				

The following presentation highlights the results obtained when using neural networks in the diagnosis of breast cancer. These networks have proven to be a promising tool, achieving high precision and sensitivity. The data presented showed a significant improvement in early detection and higher accuracy compared to the methods.[56,57,58,59]

Specific results on the accuracy and sensitivity achieved by neural networks in breast cancer indicated impressive accuracy rates, implying that they can identify complex patterns and detect the presence of breast cancer with high reliability. The sensitivity was also high, meaning they can correctly detect positive cases of this disease.[60]

These results are promising, as early diagnosis of breast cancer is essential for effective treatment and better survival rates. Neural networks offer a new perspective by improving the accuracy and sensitivity in detection, allowing early intervention and proper follow-up of patients.

Although challenges remain and more research is needed, the results presented support the value of

neural networks in breast cancer diagnosis. These technological advances promise a hopeful future in the fight against this disease and offer hope for improving the care and treatment of patients affected by breast cancer.[61]

In table 7 shows that the highest precision obtained was by Algarni, Aldahri and Alghamdi (2021) and Jabeen et al. (2023), who achieved an average of 98 %, and a sensitivity of 97 % and 98,1 % respectively. Both methods used convolutional neural networks but Algarni, Aldahri and Alghamdi (2021) evaluated their proposal with the WBCD database and Jabeen et al. (2023) used the MIAS mammography database. No study was found where both authors evaluated their proposed method with the same source of mammographic images.[45,49,56,57]

Table 7. Results

Author	BBDD used	Year	Neural Network method used	Precision	Sensitivity	Specifity
Algarni A. et al. 2021	Wisconsin Breast Cancer Database (WBCD)	2021	CNN	98,0 %	97,0 %	98,0 %
Alshehri A. et al. 2022	BreakHis	2022	CNN	96,0 %	97,0 %	98,0 %
Davoudi K. et al. 2021	BreakHis	2021	CNN	94,4 %	69,4 %	85,5 %
Hameed Z. et al. 2023	BreakHis	2022	CNN	97,3 %	96,0 %	
Lin C.-J. et al. 2023	BreakHis	2023	CNN	94,4 %	96,5 %	89,7 %
Ahila A. et al. 2022	https://scholar.cu.edu.g/q=afahmy/pages/dataset	2022	wavelet neural network and gray wolf optimization algorithm.	98,0 %	98,8 %	
Kumar P.P. et al. 2022	MIAS	2022	CNN	96,0 %	97,0 %	98,0 %
Jabeen K. et al. 2023	MIAS	2023	CNN	98,0 %	98,1 %	

Research on the use of neural networks in the early detection of breast cancer was conducted in various countries around the world. Multiple nations have made significant contributions in this field, promoting studies and research to improve the accuracy in the detection of this disease. Thanks to international collaboration, it has been possible to share knowledge and resources between different countries to generate advances in the detection and treatment of breast cancer through neural networks.[35,44]

In the 20 articles reviewed, it is evident that the countries with the greatest contribution to the research are Asian countries India and Malaysia, who in 3 articles each have contributed from their point of view and proposed a method to diagnose breast cancer using the different types of neural networks.

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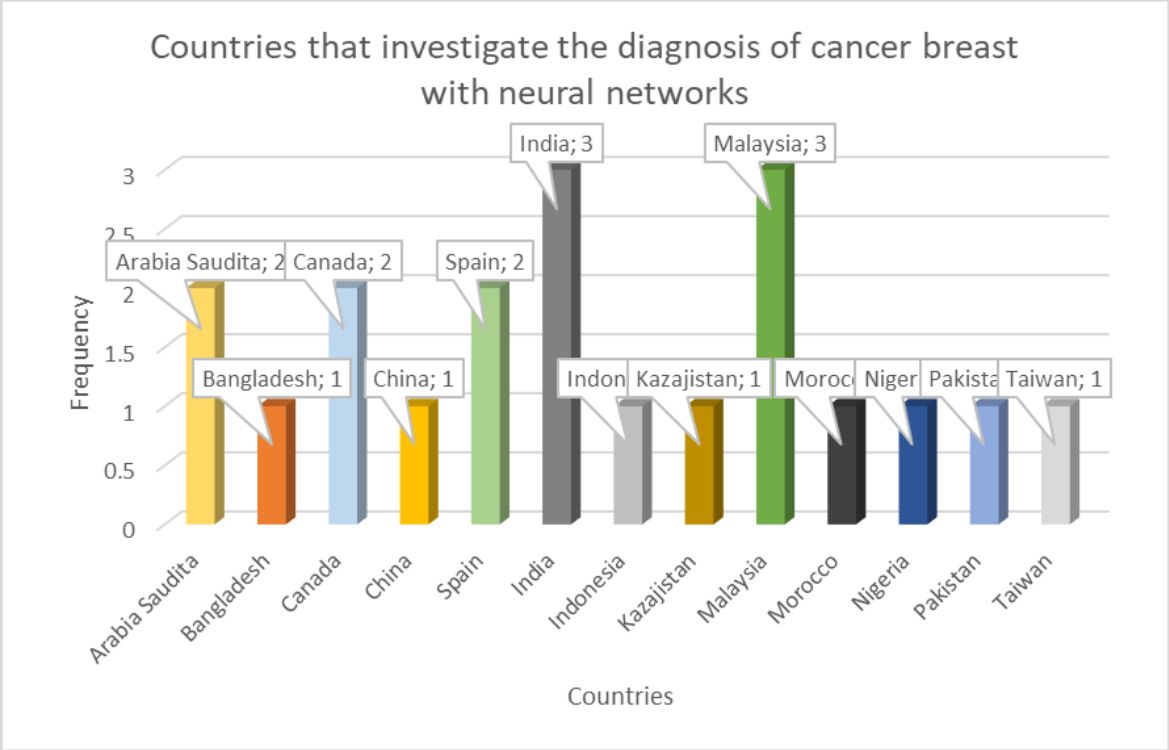

Figure 6. Countries that research neural networks and breast cancer

Through figure 7, we will analyze the research trend in the field of neural networks applied to the diagnosis of breast cancer using image recognition. It is important to keep in mind that research into the use of neural networks in cancer diagnosis is a dynamic and constantly evolving field. As technologies and methodological approaches advance, new knowledge is generated and studies are published that contribute to the progress of the discipline.[62]

It is evident that the difference is +-1 in research per year from 2020 to 2023 as it varies between 4 to 6 articles per year and it is concluded that the research of breast cancer diagnosis through neural networks is a promising topic from which many benefits are expected in the near future.

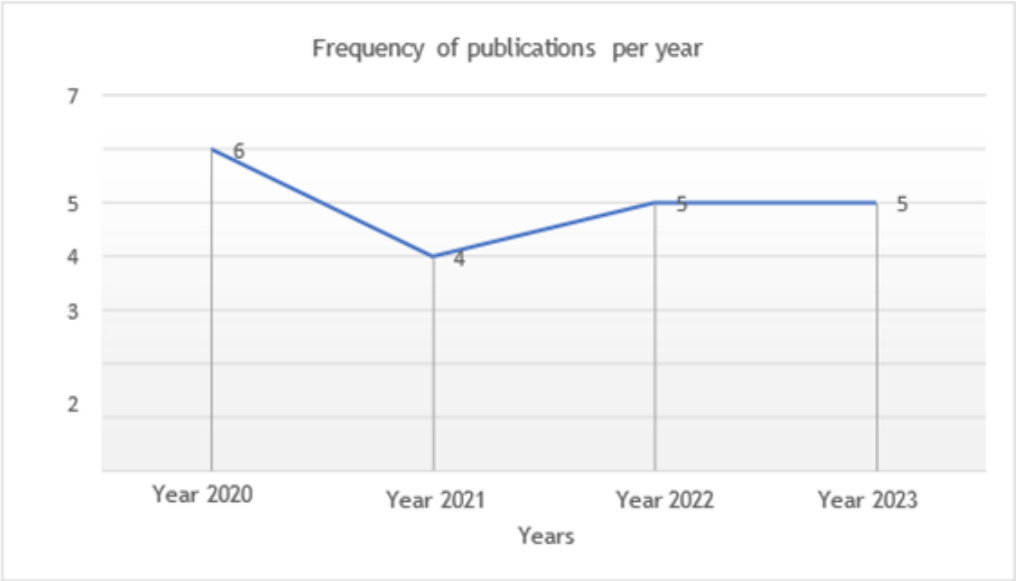

Figure 7. Frequency of publications per year

https://doi.org/10.56294/sctconf202235

In this study, the results demonstrated that neural networks have high potential to improve the accuracy of diagnosis and early detection of this disease that affects a large part of the population.

The study discusses different types of neural networks used in the diagnosis of breast cancer. According to Aidossov et al. (2023),[63] convolutional neural networks (CNN) are widely recommended due to their ability to recognize patterns in images. CNNs extract complex features from input data and have demonstrated outstanding results in medical diagnosis. Several reviewed articles also support the use of CNNs in breast cancer detection like Davoudi and Thulasiraman (2021),[64] Hakkoum, Idri and Abnane (2021),[65] Sánchez Cauce, Pérez Martín and Luque (2021),[12] Alshehri and Alsaeed (2020),[22] and Hameed et al. (2022),[66] unlike what was reported in a previous systematic literature review by Husaini et al. (2020),[41] who emphasizes ANN artificial neural networks and their contribution to the recognition of clinical images aided by machine learning.

The reviewed studies used various evaluation metrics to determine the accuracy of the proposed methods. Among the most commonly used metrics are precision, sensitivity, specificity, area under the ROC curve, and F1 score. These metrics provide a comprehensive view of the performance of neural network models in breast cancer diagnosis (Algarni, Aldahri and Alghamdi, 2021;[67] Hakkoum, Idri and Abnane, 2021;[68] Hameed et al., 2022;[69] Aidossov et al., 2023).[25] In comparison to the study carried out by Clift et al. (2023),[70] who used a random effects meta-analysis that combined estimates of discrimination and calibration metrics, calibration plots, and decision curve analysis to evaluate the performance, transportability, and clinical utility of the model.

Regarding the validation of the results of this research, the highest precision obtained was by Algarni, Aldahri and Alghamdi (2021),[36] and Jabeen et al. (2023),[47] who achieved an average of 98 %, and a sensitivity of 97 % and 98,1 % respectively, which indicates good performance. of models in the accurate detection of breast cancer. When comparing these results to traditional methods used in breast cancer diagnosis, such as human accuracy in interpreting mammograms, we see significant improvement, as the average accuracy of breast cancer diagnosis by doctors generally ranges between 75 % and 85 % as indicated (Elmore et al., 2015).[2] This suggests that neural networks may be a valuable tool to complement existing methods and improve early detection of breast cancer.

CONCLUSION

In conclusion, it is evident that the use of neural networks in the diagnosis of breast cancer has proven to be a promising tool with the potential to improve the precision and early detection of this disease.

The studies reviewed have discussed various types of neural networks, with emphasis on convolutional neural networks (CNN) due to their ability to recognize patterns in mammographic images as these networks have shown outstanding results and have outperformed traditional methods used in the diagnosis of breast cancer. The evaluation metrics used in the studies, such as accuracy, sensitivity, and specificity, have demonstrated high levels of accuracy in diagnosing breast cancer using neural networks.

Also, there is continued interest in the research and development of methods using neural networks in the diagnosis of breast cancer, as evidenced by the constant frequency of publications over the years.

On the other hand, there are limitations of this RSL and the included studies. Some of the limitations identified are the lack of high-quality data sets and bias in the training data of neural networks. Furthermore, the limited availability of thermal images and the need for additional research in this field represent challenges to overcome. In addition, it is recommended to address these limitations by collecting larger, high-quality data sets, as well as developing methods that integrate multiple sources of information, such as magnetic resonance imaging and genetic data for future research. Finally, it is suggested to explore the use of deep learning techniques and the implementation of neural networks in clinical environments for their integration into medical decision-making support systems.

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Nulla aliquet facilisis dignissim. Integer quis justo at mauris blandit viverra id at neque. Nunc sed consectetur nisi. Praesent dictum feugiat cursus.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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AUTHORSHIP CONTRIBUTION

Conceptualization: Walter Aviles-Yataco, Brian Meneses-Claudio.
Research: Walter Aviles-Yataco, Brian Meneses-Claudio.
Writing - original draft: Walter Aviles-Yataco, Brian Meneses-Claudio.
Writing - revision and editing: Walter Aviles-Yataco, Brian Meneses-Claudio.