International Journal of Medical Science and Clinical Research Studies

ISSN(print): 2767-8326, ISSN(online): 2767-8342

Volume 05 Issue 01 January 2025

Page No: 39-43

DOI: https://doi.org/10.47191/ijmscrs/v5-i01-07, Impact Factor: 7.949

The Role of Convolutional Neural Network (CNN) Based on Dermoscopy Imaging for Early Detection of Melanoma: A Systematic Review

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ABSTRACT

Background: AI systems for melanoma detection have shown considerable potential. Although, dermoscopy has become a widely utilized non-invasive method for diagnosing skin tumors. However, the variability in diagnosis caused by subjective interpretation of dermatological findings can affect both accuracy and consistency. Therefore, we conducted this study to review the accuracy, sensitivity, and specificity of Convolutional Neural Network (CNN) based on dermoscopy imaging in diagnosing melanoma.
Method: This systematic review was conducted in accordance with the Preferred Reporting Items of Systematic Reviews (PRISMA) guidelines. We limited the studies from 2019 until 2024. All studies that assessed diagnostic accuracy of CNN in diagnosing melanoma were analyzed. QUADAS (Quality Assessment of Diagnostic Accuracy Studies) is used to assess the quality of diagnostic accuracy studies.
Results: Eleven studies were eligible to be included in this study. The Area Under Curve (AUC) among the studies varied between 81.3% and 92.6%. Sensitivity varied between 69.1% and 94.2%. Specificity varied between 65% and 84.63%.
Conclusion: The AUC, sensitivity, and specificity showed good results compared to dermoscopy alone. However, the usage of artificial intelligence was as an adjunctive tool, not as a replacement for dermatologists.
KEYWORDS: Artificial Intelligence, Convolutional Neural Network, Dermoscopy, Early Detection, Melanoma

ARTICLE DETAILS

Published On:
06 January 2025

Available on:
https://ijmscr.org/

INTRODUCTION

Skin melanoma accounted for approximately 325,000 new cases in 2020, representing 1.7% of all global cancer diagnoses. In the United States, melanoma rates rose significantly from 7.9 per 100,000 people in 1975 to 25.3 per 100,000 in 2018. These data showed a marking increase of over 320%. The 5-year survival rate is 99.4% for those diagnosed at stages I–II and drops to 68.0% for stage III and 29.8% for stage. [1] Thus, an earlier diagnosis is associated with a more favorable prognosis.

Dermoscopy has become a widely utilized non-invasive method for diagnosing skin tumors. Over the past 20 years, its effectiveness in evaluating melanocytic tumors has been thoroughly validated.[2] The variability in diagnosis caused by subjectivity interpretation of dermatological findings can affect both accuracy and consistency. This challenge highlights the urgent need for innovative approaches, including, artificial intelligence-based diagnostic tools, to improve the efficiency, accuracy, and accessibility of dermatological assessments. In this regard, the advancement of artificial intelligence (AI) models offers significant potential to enhance precision and streamline processes in dermatopathology.[3]

Moreover, AI systems for melanoma detection have shown considerable potential with multiple retrospective studies. This demonstrates that AI algorithms can attain diagnostic accuracy similar to, or even greater, that of experienced dermatologists in controlled settings.[4] Nonetheless, these studies are limited by single-center design and a relatively small sample size of lesions. Therefore, we conducted this study to review the accuracy, sensitivity, and specificity of Convolutional Neural Network (CNN) Based on Dermoscopy Imaging in diagnosing melanoma.

METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items of Systematic Reviews (PRISMA) guidelines (Figure 1).[5] Studies were identified through an electronic systematic search of PubMed, EBSCO, ClinicalTrials.gov, and Cochrane Central (Wiley). The search keywords used were related to "artificial intelligence," "machine learning," "convolutional neural network," "dermoscopy," and "skin melanoma" using Boolean operators AND and OR. This study was limited from 2019 to 2024 to ensure that the source was relevant and updated to the current situation. The resulting studies were evaluated based on the relevancy of their titles and abstracts. All studies that assessed diagnostic accuracy were analyzed because this metric was commonly available in the reviewed papers. We excluded articles published in non-peer-reviewed journals, animal studies, lack of an abstract, and duplicates of already included papers.

QUADAS (Quality Assessment of Diagnostic Accuracy Studies) is a tool designed to evaluate the quality of diagnostic accuracy studies. It consists of 14 questions aimed at identifying potential bias. Responses to these questions are categorized as "yes," "no," or "unclear," and the interpretation of the assessment is as follows: a study is considered high quality if it receives 7 or more "yes" responses; low quality if fewer than 7 "yes" responses are given; unclear if at least one question is marked as "unclear"; and at high risk of bias if at least one question is answered with "no." The investigator (MM) systematically identified studies and assessed quality of the studies.

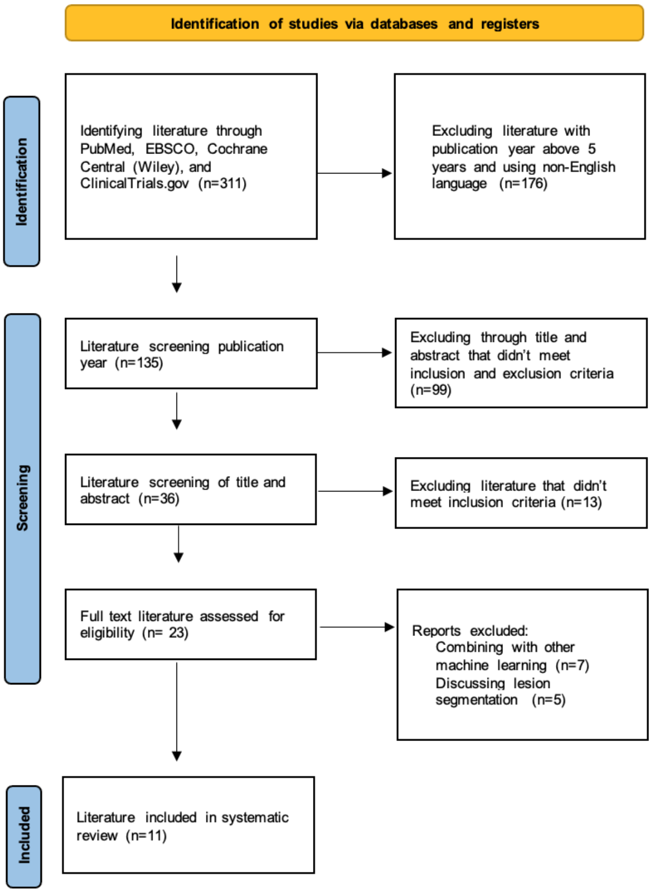

Figure 1. PRISMA Flowchart

RESULTS

In total, there were 11 studies that were eligible to be included in this study **(Table 1)**. Most studies used datasets from the International Skin Imaging Collaboration and only four studies used datasets from private archives. The Area Under Curve (AUC) among the studies varied between 81.3% and 92.6%. Sensitivity varied between 69.1% and 94.2%. Specificity varied between 65% and 84.63%.

Table 1. The literature included in this study

Authors	Dataset	Diagnostic Accuracy Rate	QUADAS Score
Foahom Gouabou et al.[6]	ISIC 2018	AUC: 93% BACC: 86%	8 = High Quality

Authors	Dataset	Diagnostic Accuracy Rate	QUADAS Score
Martin-Gonzalez et al.[7]	232 dermoscopic images	Sensitivity: 69.1% Specificity: 80.2% Accuracy: 77.6% AUC: 81.3%	8 = High Quality
Kaur et al.[8]	ISIC 2016, ISIC 2017, and ISIC 2020	Accuracy: ISIC 2016: 81.41%, ISIC 2017: 88.23%, and ISIC 2020: 90.42% AUC: ISIC 2016: 0.9033, ISIC 2017: 0.8658, and ISIC 2020: 0.9671	9 = High Quality
Xing et al.[9]	ISIC 2020	Sensitivity: 85.95% Specifity: 84.63% Accuracy: 84.59% AUC: 92.23%	9 = High Quality
Kim et al.[10]	ISIC 2017	Accuracy: 80.06%	8 = High Quality
Foahom Gouabou et al.[11]	ISIC 2018	BACC = 76.6% AUC: 87%	8 = High Quality
Guo et al.[11]	ISIC 2018	Sensitivity: 94.2% Specificity: 76.7% Accuracy: 78.4% AUC: 91.2%	9 = High Quality
Kaur et al.[12]	2150 dermosocpic images	Sensitivity: 82.99% Specificity: 83.89% Accuracy: 82.95%	8 = High Quality
Winkler et al.[13]	780 dermoscopic images	Sensitivity: > 93.3% Specificity: > 65% AUC: > 92.6%	7 = High Quality
Brinker et al.[14]	4204 biopsy-proven images of melanoma and nevi	Sensitivity: 82.3% (78.3–85.7%) Specificity: 77.9% (73.8–81.8%)	7 = High Quality
Maron et al.[15]	ISIC, HAM 10000	Sensitivity: 84.7% (81.9–87.6) Specificity: 79.1% (74.8–83.4) Accuracy: 81.9% (79.7–84.2)	9 = High Quality

DISCUSSION

Dermoscopy has developed over two decades and is extensively utilized for the assessment of pigmented skin lesions. Previous studies indicate that dermoscopy enhances the sensitivity and specificity for diagnosing early melanoma compared to unaided visual screening. Dermoscopy sensitivity varies between 60% to 100%, depending upon the examiners' experience and the diagnostic complexity of the evaluated lesions. Dermoscopy enhances diagnostic accuracy for melanoma; nonetheless, early melanoma might lack specific dermoscopic features, rendering diagnosis challenging even with dermoscopy.[16]

The result of dermoscopy was based on the dermatologist's skill in visualizing the lesion. Therefore, to minimize classification errors in skin lesion images resulting from the complexity and subjectivity of visual analysis, the development of an AI-based system can be useful.[17] The use of artificial intelligence in analyzing dermoscopic images, image segmentation and processing, and AI-based diagnostic systems had also been reviewed in the previous systematic review. Artificial intelligence has been utilized for predicting metastasis, assessing drug responses, and evaluating melanoma prognosis. Additionally, attention has been drawn to patients' perspectives on AI and the collaboration between human expertise and AI in melanoma care.[18]

Convolutional neural networks (CNNs) form the backbone of most computer vision algorithms which include image classification, object detection, speech recognition, sentiment analysis, and video recognition. Despite their widespread use, the field presents numerous challenges and opportunities.[19] CNNs eliminate the need for manually designed feature extraction. Moreover, CNN architectures do not image segmentation by human experts. However, they are highly data-intensive due to their millions of learnable parameters, making them computationally demanding and necessitating the use of graphical processing units (GPUs) for training.[20] Considering the benefits and limitations, we focused this study on CNN since this machine was focusing on vision algorithm which was more suitable for processing dermoscopy images.

Other studies comparing the performance of AI algorithms in analyzing dermoscopic images revealed that AI-based systems achieved a higher Receiver Operating Characteristic (ROC) (over 80%) for melanoma detection. In these comparisons, the average sensitivity and specificity of the algorithms were 83.01% and 85.58%, respectively.[21] Other studies also prospectively validated an open-source AI system for melanoma diagnosis using dermoscopy (PROVE-AI). ADAE demonstrated a sensitivity of 96.8% (95% CI: 91.1–98.9%) and a specificity of 37.4% (95% CI: 33.3–41.7%). Exposure to ADAE significantly enhanced dermatologists' ability to evaluate melanoma risk, with the AUC improving from 0.7798 to 0.8161 ($p = 0.042$).[22]

As we know, the baseline sensitivity of dermoscopy in detecting melanoma was 60.9% which was increased to 77.5% with the ABCD rule, 85.4% using the 7-point checklist, and 85.4% with the Menzies method.[23] If we compare this study, the sensitivity can be increased between 69.1% and 94.2%. This result showed that CNN can help to improve sensitivity and specificity in diagnosing melanoma. However, we did not analyze further in meta-analysis to see the significance of the differences.

Moreover, this study might open many other opportunities to research this field since the data set used was limited only to International Skin Imaging Collaboration (ISIC). Therefore, besides developing the machine, we also need a bigger dataset and more recent data. It was also important to highlight that artificial intelligence was an adjunctive tool, not a replacement for dermatologists. In the future, this AI can be helpful in primary care where there is no dermatology available to do reliable and low-cost screening.

CONCLUSION

This review emphasizes the potential of Convolutional Neural Networks (CNN) to improve diagnostic accuracy, thereby contributing to better patient outcomes. The AUC, sensitivity, and specificity showed good results compared to dermoscopy alone. However, the usage of artificial intelligence was as an adjunctive tool, not as a replacement for dermatologists.

DISCLOSURE

Funding: This study received no external funding
Conflict of interest: There are no conflict of interest

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