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ARTIFICIAL INTELLIGENCE AS A DECISION TOOL FOR SKIN LESIONS TRIAGE IN PRIMARY CARE: A NARRATIVE REVIEW

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ABSTRACT

Background: Skin lesions are one of the common reasons for consultations in primary care (PC). Among them, skin cancers are a key clinical challenge, where early detection is crucial for the patient's prognosis. Primary care physicians (PCPs) are responsible for the initial classification of skin conditions, determining which cases require referral to a specialist. In recent years, solutions using artificial intelligence (AI) have been gaining growing interest in medicine, offering new possibilities for diagnostic support, including in the field of dermatology.
Objectives: The aim of this narrative review is to analyze the literature on whether and how artificial intelligence (AI) can support primary care physicians in the initial classification of skin lesions.
Methods: A comprehensive review of the literature regarding the application of artificial intelligence in skin cancer diagnosis was conducted. The analysis covered results from clinical trials and reviews identifying implementation barriers.
Key findings: Results from recent multicenter clinical trials demonstrate that Artificial Intelligence algorithms achieve high diagnostic sensitivity for melanoma, as well as robust accuracy for non-melanoma skin cancers. Comparative studies indicate that while AI performance is comparable to that of board-certified dermatologists, it statistically outperforms less experienced physicians.
Conclusion: The conclusions from the study indicate that artificial intelligence can support primary care physicians by increasing their diagnostic effectiveness in the triage of skin lesions. As a support tool, it has the potential to reduce the risk of missing cancers while reducing the number of unreasonable referrals to specialists. However, a key condition for introducing these technologies into everyday clinical practice is to resolve identified ethical and technological barriers.

KEYWORDS

Artificial Intelligence, Primary Care, Skin Lesions, Skin Cancer, Dermoscopy, Melanoma

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Introduction

Cutaneous melanoma represents a critical global public health challenge worldwide. It currently ranks as the 17th most frequently diagnosed malignancy globally (Bray et al., 2024). Furthermore, the disease burden is projected to escalate significantly; epidemiological models forecast that the annual incidence will increase by more than 50% by 2040 (Arnold et al., 2022).

Nonetheless, the clinical challenge extends beyond melanoma. The incidence of keratinocyte carcinomas (KCs), primarily basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), has increased substantially in recent decades (Urban et al., 2021). Consequently, dermatological concerns have become a frequent reason for consultation in primary care, positioning general practitioners at the forefront of triaging this growing volume of lesions.

In most healthcare systems, Primary Care Physicians (PCPs) serve as the first point of contact for patients presenting with concerning skin lesions. Consequently, they act as critical "gatekeepers," tasked with distinguishing rare malignancies from common benign conditions. However, this diagnostic triage remains inherently challenging. PCPs relying solely on visual inspection or basic dermoscopy often exhibit variable diagnostic accuracy compared to dermatologists. This performance gap creates a significant clinical dilemma: it carries the risk of under-diagnosing early-stage melanomas while simultaneously leading to a high volume of unnecessary referrals for benign lesions, which ultimately strains specialist resources. While earlier systematic reviews noted that technological advances, such as computer-aided diagnostic tools, show the potential to exceed the performance of dermatologists, at that time they had not yet been sufficiently tested in the primary care setting (Jones et al., 2019).

Therefore, this narrative review aims to provide an updated assessment of the current role of Artificial Intelligence (AI) as a decision-support tool for skin lesion triage in primary care. Specifically, it evaluates the diagnostic accuracy and practical implementation challenges of these technologies in the general practice environment.

Methodology

This paper presents a narrative review focusing on the efficacy of machine learning algorithms, particularly Convolutional Neural Networks (CNNs) in dermatoscopy. A literature search was conducted using the PubMed database, prioritising articles published in English.

The Clinical Need: Challenges in Primary Care Dermatology

The rising demand for dermatological services in primary care is fundamentally driven by a rapid increase in the incidence of skin malignancies. Global epidemiological data from 1990 to 2017 reveal a dramatic surge in the occurrence of both melanoma and keratinocyte carcinomas (KCs). During this period, the incidence of squamous cell carcinoma (SCC) rose by 310%—the highest growth rate among all neoplasms tracked by the Global Burden of Disease study—while melanoma cases increased by 161%. Consequently, basal cell carcinoma (BCC) incidence rose by 77%, ranking as the leading cause of invasive neoplasms worldwide in 2017, when excluding other benign and in situ conditions (Urban et al., 2021).

The rapidly increasing incidence of skin malignancies stands in stark contrast to the available medical resources (Goyal et al., 2020). This disparity is further exacerbated by the limited access to specialized dermatological care in many regions (Urban et al., 2021). As a result, primary care physicians (PCPs) serve as the first point of contact for the evaluation of concerning skin lesions, placing them at the forefront of skin cancer triage (Jones et al., 2019).

Unlike dermatologists, who benefit from specialized training and daily experience in pattern recognition, primary care physicians (PCPs) are tasked with distinguishing rare malignancies from a vast majority of common benign lesions while simultaneously managing a broad range of other medical complaints. Such conditions contribute to a "structural diagnostic gap" where the inability to reliably triage lesions results in increased risk of both diagnostic delays and a high volume of unnecessary specialist referrals (Jones et al., 2019).

While dermoscopy is an established standard in current dermatological practice (Goyal et al., 2020), its effectiveness remains highly operator-dependent (Jones et al., 2019). Although dermoscopy improves accuracy compared to visual inspection alone, this benefit is significantly reduced when the tool is used by untrained clinicians (Jones et al., 2019). The learning curve for dermoscopy is steep and requires continuous practice, which is often unfeasible given the general lack of adequate clinical expertise and the time-constrained environment of primary care (Goyal et al., 2020; Jones et al., 2019). Consequently, diagnostic sensitivity varies widely, leading to inconsistency in patient management and further straining specialist resources (Jones et al., 2019).

The inefficiencies in the current triage process carry profound consequences for both healthcare systems and patient outcomes. Early detection of skin cancer remains pivotal for successful treatment, as it is correlated with a 99% overall survival rate, whereas prognosis declines significantly once the disease progresses beyond the primary site (Goyal et al., 2020). To minimize the risk of missing a life-threatening cancer, primary care physicians often prioritize diagnostic safety, which can lead to a lower threshold for specialist referral (Jones et al., 2019). This clinical uncertainty often results in a high volume of benign lesions being referred or surgically removed, effectively increasing the ratio of benign-to-malignant excisions (Jones et al., 2019). Such unnecessary interventions generate substantial costs for the healthcare system, contribute to longer waitlists for patients in need of urgent care, and result in avoidable scarring and anxiety for healthy individuals (Jones et al., 2019). This systemic strain underscores the immediate need for scalable, AI-driven solutions that can provide accurate decision support at the first point of contact (Goyal et al., 2020).

Artificial Intelligence in Dermatology

To understand the potential of artificial intelligence (AI) in primary healthcare, it is first necessary to explain the technological basis of its operation. Modern diagnostic tools are based on deep learning, an advanced branch of machine learning, with a specific focus on Convolutional Neural Networks (CNNs) (Esteva et al., 2017). Rather than following clinical guidelines such as the ABCDE rule (Goyal et al., 2020), these models learn to identify complex patterns from images by processing raw pixels and diagnostic labels directly (Esteva et al., 2017). These networks are designed to process images through a sequential cascade of layers, which progressively convert the visual data into a probability distribution (Esteva et al., 2017). This multi-layered architecture allows for the capture of fine-grained details and variability in skin lesions (Esteva et al., 2017). Such precision is vital because malignant and benign lesions frequently exhibit overlapping characteristics, making them extremely challenging to distinguish (Esteva et al., 2017).

The clinical efficacy of such models was demonstrated in the landmark study by Esteva et al., 2017. In this research, a Convolutional Neural Network (CNN) was trained on a dataset of 129,450 clinical images representing 2,032 different diseases. The model's performance was evaluated against 21 board-certified dermatologists using biopsy-proven images across two critical diagnostic tasks: distinguishing keratinocyte carcinomas (KCs) from benign seborrheic keratoses and identifying malignant melanomas versus benign nevi. The results indicated that the CNN achieved diagnostic sensitivity and specificity comparable to all tested experts. Furthermore, the algorithm reached an area under the curve (AUC) of over 91% for each case, demonstrating its potential to match the competence of specialized clinicians in skin cancer classification (Esteva et al., 2017).

In the context of implementing artificial intelligence (AI) in primary care, it is crucial to distinguish between two fundamental approaches to diagnostics, which differ primarily in their image acquisition methods. The first category includes direct-to-consumer applications, where analysis is typically performed on standard macroscopic photographs taken independently by the patient (Freeman et al., 2020). The second category comprises professional systems designed for clinical settings, which combine a smartphone with a dermoscopic attachment (Marsden et al., 2023; Menzies et al., 2023; Papachristou et al., 2024). However, for integration into the healthcare system, the purely macroscopic approach may be insufficient due to variable image quality and a lack of rigorous clinical validation (Freeman et al., 2020). Consequently, professional mobile dermoscopy offers a superior alternative that integrates seamlessly into the clinical workflow. By delivering the standardised images that are fundamental for the accurate performance of AI algorithms, it provides an immediate risk assessment.

Results

Given the potentially fatal consequences of undiagnosed skin malignancies, early diagnosis is key to patient survival (Goyal et al., 2020). The stage of advancement at the time of diagnosis is the most critical factor in determining prognosis. Survival rates are highest for localised melanoma (99.4%), significantly lower for regional stage melanoma (73.3%), and drop dramatically in cases of distant metastasis (35.6%) (Okobi et al., 2024). In this context, a fundamental requirement for AI tools implemented in primary care is maximising diagnostic sensitivity. The primary goal of these tools is not to make a definitive histopathological diagnosis but rather to reliably identify all suspicious lesions. This allows for the rapid referral of patients to specialists and minimizes the risk of missed diagnoses.

Recent studies have demonstrated that AI algorithms can significantly enhance the diagnostic capabilities of non-specialist physicians. Strong evidence of the usefulness of AI for less experienced clinicians was provided by a multicentre clinical trial conducted in Australia and Austria (Menzies et al., 2023). This study compared the effectiveness of AI algorithms with diagnoses made by both certified dermatologists and novice physicians. The analysis revealed a convincing difference: while the diagnostic accuracy of AI was statistically equivalent to that of experts, it was significantly higher than that of novices. As a result, for general practitioners and less experienced clinicians, AI serves as a key support tool, effectively narrowing the gap in results and raising their diagnostic standards to a level comparable to that of specialised dermatologists (Menzies et al., 2023). It is worth noting that in this study, images were acquired using smartphones integrated with a dermatoscope attachment. This technique (mobile dermoscopy) allows for the acquisition of high-quality images of intradermal structures, which is a prerequisite for the diagnostic accuracy of classification algorithms (Menzies et al., 2023).

To validate these capabilities in a real-world setting, a large, prospective study was conducted across 36 primary care centers in Sweden (Papachristou et al., 2024). In this multicenter trial, participating physicians used a setup consisting of a smartphone with a dermoscopic attachment to capture and analyze images of pigmented lesions. The results confirmed the high reliability of AI as a diagnostic filter. The system correctly identified 95.2% of all melanoma cases including 100% of invasive melanomas (Papachristou et al., 2024). The parameter confirming the safety of the tool was a Negative Predictive Value (NPV) exceeding 99%. In clinical practice, this means that if the algorithm assessed a lesion as benign, the probability that it was actually cancer was close to zero (Papachristou et al., 2024). However, these results also highlight the necessary compromise associated with screening tools. With the predefined cut-off point designed to maximise detection, specificity was 60.3%. In the context of primary care, detecting any potential malignant changes is an absolute priority. It should be remembered that this comes at the cost of lower specificity, which leads to a certain number of false alarms and an increased number of preventive referrals to dermatologists (Papachristou et al., 2024).

While melanoma is prioritized due to its high mortality risk, non-melanoma skin cancers (NMSCs) account for the vast majority of skin cancer diagnoses worldwide. Non-melanoma skin cancers (NMSCs), the most prevalent category of malignant neoplasms worldwide—with basal cell carcinoma (BCC) being the most common form—impose a substantial strain on healthcare systems (Urban et al., 2021). Consequently, the clinical utility of any diagnostic tool in primary care must be assessed not only in terms of its ability to detect melanoma, but also its effectiveness in identifying these highly prevalent malignancies.

To address this urgent need, a study was conducted to evaluate the effectiveness of AI-based decision support system for identifying non-melanoma skin cancer (NMSC). In this validation study, images were captured using a smartphone integrated with a dermatoscope attachment, which ensured high-quality optical data. The results demonstrated that the AI algorithm is highly effective across the full spectrum of skin cancer. It achieved a sensitivity of 100% for melanoma, >98% for Squamous Cell Carcinoma (SCC) and 94% for Basal Cell Carcinoma (BCC) (Marsden et al., 2023). Crucially, the system demonstrated a high Negative Predictive Value (NPV) ranging from 93% to 100%, indicating that it can reliably rule out malignancy with a high degree of certainty (Marsden et al., 2023). Furthermore, achieving AUROC of up to 80,9% for benign lesions, the tool shows potential to aid in the management of non-malignant cases (Marsden et al., 2023).

In conclusion, the analysed studies consistently demonstrate the exceptional sensitivity of AI algorithms in detecting malignant lesions. Taken together, the evidence suggests that the primary purpose of this technology is not to replace clinicians, but rather to enhance the diagnostic proficiency of primary care physicians to a level comparable to specialists'. By acting as a "second opinion”, AI can provide diagnostic confidence, support decisions to refer high-risk lesions, and potentially reduce unnecessary referrals for clearly benign cases. However, realising this potential in real-world settings requires addressing several technical and operational challenges, which will be discussed in the subsequent chapter.

Implementation Barriers

While the diagnostic effectiveness of AI algorithms described in the previous chapter is highly promising, the transition from controlled studies to the primary care setting presents significant challenges. Bridging the gap between theoretical accuracy and real-world clinical utility requires overcoming a wide range of implementation barriers. These challenges are multifaceted, ranging from technical limitations related to image acquisition, to complex ethical and legal issues concerning algorithmic accountability and explainability, to human factors such as automation bias. This chapter provides a critical analysis of the limitations that currently hinder the widespread adoption of AI tools in general practice.

The fundamental technical barrier stems from the fact that AI's diagnostic effectiveness is strictly limited by the quality of the input data (Menzies et al., 2023). In contrast to dermatologists, who can cognitively compensate for minor image imperfections, for an algorithm, any visual artefact is significant informational noise (Narla et al., 2018). This discrepancy is due to the fact that AI models are trained primarily on high-quality, standardised data sets. As a result, they often have difficulty interpreting real-world images (Menzies et al., 2023). Specifically, image acquisition is prone to technical pitfalls such as blurred images resulting from focus instability, obstruction by hair, and artefacts such as air bubbles caused by improper dermatoscopic technique (Menzies et al., 2023).

Reliance on unstandardised input data reveals another critical vulnerability: susceptibility to confounding factors in the form of non-biological artefacts. This issue is exemplified by a study in which it was observed that a deep learning model showed a tendency to classify lesions as malignant if a ruler was present in the image. These anomalies stemmed from the specific nature of the training datasets, where malignant melanomas were frequently documented with measurement tools. As a result, the system inadvertently "learned" to identify the ruler itself, rather than the tumour features, as a predictor of malignancy

(Narla et al., 2018). This case demonstrates that without rigorous standardisation, AI may generate false positive results driven by background noise.

Beyond technical limitations, the integration of artificial intelligence into clinical practice creates profound ethical and legal dilemmas. The issues most frequently raised in the literature concern the opacity of algorithms (the "black box" phenomenon) and the resulting uncertainty regarding professional responsibility. Consequently, establishing a clear regulatory framework and ethical standards is considered a prerequisite for the clinical adoption of these technologies (Liopyris et al., 2022; Marques et al., 2024).

A fundamental challenge is the lack of interpretability of advanced algorithms, stemming directly from their architecture. Unlike traditional statistical models, deep neural networks generate intricate, non-linear dependencies that are mathematically abstract and often unintelligible to humans (Esteva et al., 2017). This leads to the 'black box' phenomenon. Consequently, clinicians receive a diagnosis but lack insight into the logical decision-making pathway that led to it (Marques et al., 2024). Such opacity poses a significant ethical barrier, as physicians require an understanding of the causal mechanism before undertaking therapeutic interventions.

The absence of this causal understanding directly contributes to legal ambiguities regarding liability. AI systems operate autonomously, generating diagnostic results and placing the burden of final verification on the healthcare practitioner. However, clinicians frequently lack the expertise to comprehend the rationale behind a particular result or to effectively assess potential errors. This raises the complex legal question of whether full responsibility should be attributed to the clinician acting solely as a verifier in the event of a diagnostic error resulting in harm to the patient. As artificial intelligence does not currently possess legal personality, the question of whether liability should extend to software developers remains a critical and unresolved issue (Marques et al., 2024).

Conclusions

The integration of artificial intelligence into primary care offers valuable support in skin cancer diagnostics. The evidence presented in this thesis confirms that AI algorithms, when paired with smartphone-based dermoscopy, have achieved a level of diagnostic sensitivity comparable to board-certified dermatologists and statistically superior to novice physicians. The capacity of these systems to detect both life-threatening melanomas and high-incidence non-melanoma skin cancers (BCC, SCC) positions them as a vital tool in addressing the rising global burden of skin malignancies.

The primary value of this technology lies not in replacing the clinician, but in elevating the competency of non-specialist personnel. Artificial Intelligence (AI) empowers primary care physicians to make more accurate triage decisions, thereby minimising the risk of missed diagnoses while potentially optimising referral pathways.

However, widespread clinical implementation faces significant hurdles. The 'Black Box' phenomenon regarding algorithmic opacity and the complex legal questions surrounding liability attribution remain critical barriers that necessitate clear regulatory frameworks. Ultimately, while the technology provides the data, the final ethical and clinical responsibility remains with the physician.

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