

ARTIFICIAL INTELLIGENCE IN DERMATOLOGY: A COMPREHENSIVE REVIEW OF DIAGNOSTIC AND THERAPEUTIC APPLICATIONS, CHALLENGES AND FUTURE PERSPECTIVES

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ABSTRACT

Skin diseases are among the most common diseases affecting 1.9 billion people worldwide. They remain a major cause of non-fatal disease burden, in part because diagnosis of skin diseases is often challenging due to high visual similarity of skin conditions, subjectivity of clinical diagnosis, and lack of dermatologists worldwide. Deep learning-based artificial intelligence (AI) applied to dermatological images has emerged as a promising tool for dermatological diagnosis and treatment in the last decade. This review provides a comprehensive overview of skin diseases, conventional diagnosis and treatment in dermatology, and core AI technologies, including convolutional neural networks (CNN), computer vision, natural language processing (NLP), and explainable AI, that are currently applied in dermatology for a range of applications including skin cancer, inflammatory and pigmentary skin diseases, disease severity scoring, individualized treatment planning, teledermatology, and even dermatological drug discover. We also discuss current regulatory developments including the first AI-enabled primary-care skin cancer device authorized by US Food and Drug Administration in 2024.

KEYWORDS: Artificial Intelligence, Dermatology, Machine Learning, Deep Learning, Convolutional Neural Networks, Skin Cancer, Skin Disease Diagnosis, Teledermatology, Explainable AI, Personalized Treatment.

1. Executive Summary

The report explores how artificial intelligence (AI) is currently being applied in dermatology, specifically in the domains of diagnostics, treatment and disease management, data sources, clinical workflows, benefits and limitations,

current applications, prospects and ethics and regulation issues. The report starts with the fact that skin diseases are a significant burden worldwide and that skin diagnosis is particularly challenging because many diseases have a similar appearance. It also pinpoints the lack of dermatologists and inequitable distribution as a significant access barrier. These factors provide a realistic environment where computers can aid the clinician.

According to the report, AI is a “computational paradigm” that can “be used for tasks that are related to data analysis, learning, decision making, and problem solving.” The field of dermatology is well-positioned for AI-driven solutions as much of the diagnosis relies on visual data. Patterns can be learned from large sets of clinical and dermoscopic images, for example, by modern systems such as deep learning and convolutional neural networks (CNNs). The report also discusses machine learning, artificial neural networks, computer vision, natural language processing (NLP), and explainable AI (XAI).

The report considers AI to be supplemental to the role of the dermatologist and existing diagnostic criteria, not a substitute for them.^[1] The cited evidence has very good performance in retrospective studies of image-classification for skin cancer, with the report citing pooled AI sensitivity of ~87% and specificity of ~74%, in contrast to dermatologists in the cited meta-analysis, who achieved ~80% sensitivity and ~74% specificity. But, the report notes, “Retrospective images from a collection may not reflect actual clinical conditions.

The applications are not limited to cancer detection. It covers the application of AI in the fields of acne, psoriasis, eczema, rosacea, fungal infections, vitiligo, hair and nail disorders, severity assessment, prediction of treatment response, longitudinal monitoring, tele dermatology, and drug discovery/redesign. It underscores the value of clinical, laboratory, molecular and genomic data and patient-reported data to inform more tailored management strategies.^[2]

Simultaneously, the report is quite detailed in its discussion of restrictions. These include skin-tone and dataset bias, variable image quality, limited external and prospective validation, privacy and consent requirements, limited generalizability across populations, transparency requirements, and difficulties integrating AI into clinical workflows and regulatory systems.^[3] It thus outlines future areas of dermatological AI research in the context of various data sources, clinically proven systems, explainability, multimodal models, wearable monitoring, and responsible human oversight.

2. Introduction and Rationale

The introduction sets the context for the relevance of AI in dermatology. Skin diseases vary from those that are acute and transient to chronic inflammatory, autoimmune, pigmentary, infectious, and malignant. Early diagnosis is crucial as many conditions are more amenable to treatment when diagnosed early and early diagnosis of melanoma and other skin cancers is especially important.^[4]

The report points to a few limitations in the current diagnostic processes. Firstly, the distribution of dermatologists across countries and regions is uneven, and particularly critical in low and middle-income countries. Secondly, there may be differences in the accuracy of diagnosis between GP, non-dermatologist clinician and dermatologist.

Third, even amongst those who have more experience in dermatology, there can be disagreement in the diagnosis of lesions with similar appearances. So, it is not just a question of knowledge, it is a visual problem, as well as a human variability problem, a workload problem, and an access problem.^[5,6]

A potential way to aid in this process is by analyzing visual patterns quickly and consistently, which AI can do. It mentions that deep CNNs trained from huge image collections are emerging and cites a remarkable instance with more than 129,000 images of over 2,000 categories of skin disorders.^[7] Works that followed extended the use of AI from mere classification to severity grading, predicting how a treatment will affect the condition, and teledermatology, or even multimodal applications.

The scope of the review is thus very wide. Topics include core concepts of skin disease, traditional diagnosis and treatment, AI technologies, applications in diagnosis, applications in therapy & management, data sources, workflow, benefits, challenges, real-world examples, prospects and ethical and regulatory considerations. The overall argument of the report is that AI has tremendous potential but needs to be implemented carefully in the clinical setting.^[8,9,10]

3. Understands basic aspects of skin diseases

Skin, the largest organ of the human body, is described in the report and three main layers are identified: the epidermis, dermis and subcutaneous tissue. The skin is protection against pathogens, physical damage, U.V. rays and loss of water. It also plays a role in regulating temperature, sensation, vitamin D production, endocrine activity and immunity.^[11]

3.1 Internal and external parasites

Skin diseases are classified into five categories in the report: infectious, inflammatory, pigmentary, autoimmune, benign and malignant. Examples of infectious diseases are bacterial diseases (impetigo, folliculitis and cellulitis), viral diseases (herpes simplex, herpes zoster, chicken pox and warts), fungal diseases (tinea, ringworm and candidiasis) and parasitic disease (scabies).

Some inflammatory disorders are eczema or atopic dermatitis, psoriasis, contact dermatitis, seborrhoeic dermatitis, rosacea and acne vulgaris.^[12] Pigmentary disorders consist of vitiligo, melasma and post-inflammatory hyper pigmentation. Autoimmune diseases include bullous pemphigoid, pemphigus vulgaris, cutaneous lupus erythematosus and alopecia areata. Benign lesions include seborrhoeic keratoses, dermatofibromas and benign melanocytic naevi. Basal cell carcinoma, squamous cell carcinoma and melanoma are all forms of malignant disease.^[13]

The presentation discusses the various risk factors and the clinical features of celiac disease.

Several risk factors were mentioned in the report including ultraviolet exposure, fair skin, immune suppression, genetic predisposition, and environmental exposure and occupational exposure. Genetic factors and immune dysfunction may play a role in inflammatory disease. Skin disease may manifest as alterations in colour, lesion size, lesion symmetry, skin texture, lesions distribution and progression over time. The reason for the natural relationship between image-based AI and dermatological evaluation lies in these visible features.^[14,15]

3.2 Conventional diagnostic challenges

Inter and intra observer variability can be seen in visual inspection. Dermoscopy helps to see subsurface structures, but this requires special interpretation. Specialist dermatology is also not available in many places. It is recommended that the current structural hurdles can be mitigated with the implementation of tools which will benefit from the use of AI, but without replacing clinical expertise.^[16]

4. Conventional Diagnosis and Treatment

4.1 Diagnostic approaches

The typical approach to diagnosis is a history and physical exam. The initial diagnostic assessment includes the nature or morphology, distribution, duration and symptoms of the lesion. Dermoscopy is employed especially for pigmented lesions and shows the structures in magnified form not easy accessible to the naked eye.

In the absence of a confident diagnosis from clinical examination or dermoscopy, biopsy with histopathological examination is the gold standard for diagnosing a malignancy. In the case of infectious diseases, the report points to the culture, potassium hydroxide preparation, and PCR as potential approaches.^[17,18] Blood counts, inflammatory markers and autoantibodies may assist with the evaluation of systemic or autoimmune skin disease and patch testing can identify allergens involved in allergic contact dermatitis.

4.2 Treatment modalities

Topical therapy, systemic therapy, phototherapy, cryotherapy, laser therapy and surgical excision are important treatment modalities described. The prevention of skin damage, the photoprotection, avoiding triggers and maintaining the skin barrier are also long-term management.^[19,20]

Some skin diseases can be treated with topical treatments, while others are more systemically involved or severe may need systemic treatment. In particular, the report mentions that moderate to severe psoriasis and atopic dermatitis might need systemic immunosuppressive or biologic therapy. This treatment complexity can provide opportunities for AI to help with treatment selection, prediction and monitoring of response.

AI is currently being used to supplement rather than replace conventional care. Current conventional care-AI relationship is complementary.

The report does not suggest that AI will replace the existing clinical practices. Rather, AI can aid with image interpretation, triage, risk estimation, treatment selection and follow up. AI is still considered a decision-support technology, with histopathology being the gold standard for diagnosis of malignancy.^[21,22]

5. Future and challenges in the field of AI in dermatology.

5.1 Machine learning

Machine learning is the application of algorithms that are used to learn the statistical patterns from data. The report links conventional machine learning techniques to a type of clinical data that is structured or tabular, and to applications like prediction of treatment response and risk stratification.

5.2 Deep learning and Artificial neural networks

Deep learning involves learning hierarchical representation by using multilayered neural networks. The overall computing model for classification and regression with clinical and laboratory information is artificial neural networks. Deep learning becomes relevant in situations where large and complex datasets are available.^[23]

5.3 Convolutional neural networks

CNNs are highlighted since they are appropriate for spatial and image data. In dermatology, they can categorize lesions, segment skin lesions from healthy skin, and extract visual attributes and quantify morphological attributes. They are key

to numerous applications in the skin-cancer and skin-disease fields described in the report.

5.4 Computer vision

Computer vision is the ability of computers to analyze visual data. It can help in dermatology with disease pattern detection, disease boundary detection, lesion segmentation and measurement.^[24,25]

5.5 Natural language processing

NLP can gain useful information from unstructured text like clinical notes and EHR. It's potential for clinical decision support, risk stratification and patient information processing and identification of signals relevant to drug repurposing is described.

5.6 Explainable AI

XAI tackles the black-box problem by offering interpretable insights into the reasoning behind a model's decision-making process. Examples listed in the report include Grad-CAM, SHAP and LIME. Heat maps may be used to display regions that may affect image classification, and feature-based explanations may be used to gain insight into model outputs and foster trust.^[26]

6. AI in Medical Writing

6.1 Skin cancer detection

The most advanced field of dermatological AI that is discussed in the report is skin cancer. The ability to differentiate between benign and malignant lesions and the detection of melanoma, basal cell and squamous cell carcinoma have been studied using AI systems. The quoted systematic review and meta-analysis provides an 87% pooled sensitivity and 77% pooled specificity for AI, versus an 80% sensitivity and 74% specificity for dermatologists in the included evidence.

These figures should be considered relative to the other figures. A lot of the studies mentioned in the report were retrospective, and the images used were of high quality curations, the report says. Images within clinical environments are not uniform and are complex in many ways. Therefore, good performance in a data set does not imply good performance in routine practice.^[27,28]

6.2 Inflammatory and other conditions

In addition, deep-learning systems have been studied for the detection and classification of acne, psoriasis, eczema and rosacea, including the severity of the disease. Further investigations have included fungal infections, extent mapping of vitiligo, as well as hair and nail disorders. The report indicates that evidence in these areas is less as compared to skin cancer.

6.3 Dermoscopic feature analysis

AI can extract features that dermatologists look for visually, such as pigment networks, blue-white veil patterns and atypical vascular features. Such features can be used for classification and clinical decision support systems and displayed along with risk scores.^[29]

6.4 Severity assessment

The report refers to one systematic review and meta-analysis in which an average accuracy of about 81% was found in

which the deep-learning models and image- based approach to inflammatory skin disease achieved a 95% or higher accuracy in some cases. But the performance varied regarding the disease and the severity index. The report does not, therefore, view these systems primarily as substitutes for clinical assessment, but rather as tools for standardized assessment, monitoring from a distance, and other established tools like the Psoriasis Area and Severity Index (PASI).^[30]

7. How to leverage AI for treatment and management. How to use AI for Treatment and Management

7.1 Personalized treatment planning

Clinical, laboratory, and molecular data can be used to estimate treatment response with the help of AI. Psoriasis and atopic dermatitis are examples discussed. Machine-learning models have been developed to predict longer term responses to psoriasis biologic therapy with clinical variables collected in patient registers and, in some instances, dermal biomarker variables.

In the cited papers, random forest and gradient boosting models are claimed to yield good results. Machine learning has also been investigated to identify those who are at risk for developing psoriatic arthritis and to predict progression of therapy.

Combination of serum biomarkers and multivariate machine learning models has been studied to predict the disease severity over time in atopic dermatitis.

7.2 Disease monitoring

Monitoring skin cancer and chronic inflammatory conditions like psoriasis and atopic dermatitis can be aided by analyzing serial images using AI. This can be useful in determining progression or relapse between current images and previous images and could minimize the need for face-to-face reviews. However, the report notes that there is a lack of prospective evidence for relapse monitoring and much of the literature "has concentrated on initial diagnosis."^[31]

7.3 Teledermatology

AI could be used in store and forward teledermatology and even in mobile phone- based screening. The report mentions a prospective study to detect skin cancer using a CNN-based Smartphone with sensitivity of 82% and specificity of 77%. The same performance boosted to 83% sensitivity and 87% specificity when using AI with a human teledermatologist.

Practical is a key issue of image quality. It says image capture failures are observed even under controlled image capture conditions, and the failure rate is significantly higher when patients are involved in the image capture. AI tool-enabled teledermatology can enhance workflow and access, however, image quality and human oversight are crucial.

The use of repurposed drugs in drug discovery.

The report outlines opportunities for AI in drug discovery and repurposing for dermatology. NLP and machine learning can scour vast pharmacological and clinical data resources for trends and characteristics linked to positive drug utilization and negative events, as well as off-label uses. It's been tested on a variety of diseases, such as psoriasis, atopic dermatitis, and alopecia areata.^[32]

8. Data Sources and AI Workflow

8.1 Major data sources

Important data sources mentioned in the report include clinical photographs, dermoscopic images, histopathology images, electronic health records, laboratory results, genomic and biomarker information, and patient-reported outcomes.

Clinical photographs are macroscopic information captured using cameras or smart phones. Lesion images are provided by the Dermoscopic datasets, HAM10000 and the International Skin Imaging Collaboration archive. Histopathology provides a tissue level contribution. Risk factors, comorbidities and treatments are found in both structured and unstructured data in the EHR. Laboratory information can contain biomarkers, autoantibodies and microbiological information. Precision-dermatology models may be aided by genomic or biomarker data, and patient-reported outcomes may be used to provide patient-centred measures.

8.2 stages of AI workflow

Collection of data: Clinical data, patients' images and other patient-related data are collected.

- Pre-processing images: Normalization of image size, artefact removal (hair) and standardization of images.
- Feature extraction: colour, texture and border properties can be either manually coded or learnt from deep networks.
- Model training: Supervised learning with annotated dermatological images; transfer learning is frequently employed as the number of specialized dermatology datasets is relatively low.
- Diagnosis: the model could give a diagnosis, ranked differential diagnosis and/or the probability of malignancy.

Recommendation for treatment: Advanced systems may link diagnostic outputs to treatment-selection support or management pathways.

Monitoring and follow-up: current images or information are compared to previous information to see if things are improving, if cancer has come back or if cancer developed.

This workflow example highlights how AI performance relies on than just the algorithm. The utility of a system is influenced by different data collection, data preprocessing, annotations, training, clinical interpretation and follow-up.^[33]

9. Panacea's AI Solutions for the healthcare industry

The report provides a few suggested benefits. Being able to detect the disease early can make it easier to achieve better results, particularly for melanoma and other skin cancers. Some interobserver variation may be minimized by automated analysis, which can yield a more consistent score. High throughput screening is possible with rapid image analysis, which could be useful when specialist resources are limited.

Patients who need a specialist evaluation can be identified using AI-assisted screening by primary-care clinicians or community health workers. AI in this capacity can act as a triage tool instead of a last-resort diagnostic tool. It can also help tailor treatment by predicting which treatments might work for a specific patient using the data available.

Another significant benefit is telemedicine. AI can aid in remote image processing and provide access to specialist expertise in remote areas. Systems can automatically triage lower-risk cases, freeing up clinical time for routine and/or lower-risk cases.

These benefits are associated with better patient outcomes being achieved if interventions take place earlier and more consistently, according to the report. Importantly, these are stated as possible clinical advantages that would need to be validated, the image quality verified, diversity in datasets, clinical integration and human supervision.^[34]

Summary of advantages

- Early detection of potentially serious lesions.

More standardized, image-based assessment. Quickly processing lots of images.

Scalable screening and triage in primary-care or remote settings. Support for individual treatment planning.

Enhanced teledermatology process and access.

- Decreased clinical workload.
- Support for long-term follow-up of chronic disease.

10. Challenges and Limitations

10.1 Optical sensors and satellite images.

One of the report's most significant limitations is the presence of skin-tone bias. Many public dermatology datasets have an imbalanced number of images from lighter skin types, and darker Fitzpatrick V-VI skin types could be present in fewer than 5% of images in some of the popular ones. Lower sensitivity for some algorithms is seen on darker skin tones in testing on the Diverse Dermatology Images benchmark.

This report highlights the issue of diversity of datasets as the root cause of the problem. Algorithms alone are not sufficient to remedy insufficient training and testing data.

10.2 Quality of images and actual conditions

Numerous research studies employ standard pictures. There are many ways that real-world images can differ from the ideal, particularly with lighting, focus, framing, background, device type, and whether it's a clinician's or patient's image. This variability can affect performance and is especially significant in smartphone-based systems^[35].

10.3 Generalizability

Models developed in different health systems and/or geographic populations may not apply to others. Performance may vary due to disease prevalence, patient characteristics, image acquisition and clinical presentation.

10.4 Reproducibility of the results

Much of the evidence which exists today is derived from retrospective studies based on curated data sets, the report says. Given this, clinical validation is needed to ascertain the performance of systems in actual use.

10.5 Privacy, consent and transparency

Dermatological images may include identifiable data and hence protection of data is an issue. Patient consent is crucial

when images are captured or utilized. Transparency as highlighted in the report to enable clinicians to understand the decisions made by AI.

The clinical deployment of regulatory strategies and clinical integration.

The practical implications of integrating AI into EHRs, clinical workflows, and liability frameworks are not without their challenges. The challenges of integrating AI into EHRs, clinical workflows, and liability frameworks are not without their practical implications. Post-deployment learning systems adds to the regulation. The report touches on mechanisms like Predetermined Change Control Plans but says that the application of the continually learning systems is not yet widely known.^[36]

11. REAL-WORLD APPLICATIONS AND CASE STUDIES

11.1 Skin-cancer AI

The report starts with a proof-of-concept done at Stanford CNN in 2017 and follows the process through to subsequent validation experiments on a variety of hardware and clinical environments. Some datasets resulted in very high performance, whereas uncured real world data resulted in more variable performance.

11.2 Derma Sensor

In the report, a big example of a regulatory device is the Derma Sensor which is an AI-powered handheld spectroscopy device with an AI classification algorithm. It was authorized by the United States Food and Drug Administration (US FDA) in January 2024 to be used as a medical device for assisting primary care healthcare providers in the detection of skin cancer, and had also been approved for clinical use in several other countries.

11.3 Acne assessment

Acne severity has been studied using deep-learning systems from images captured with a smart phone, including prediction of Investigator's Global Assessment scores. The report is concerned about the lack of ethnic diversity in the image databases, which limits their general applicability.

11.4 AI-assisted teledermatology

NHS and European teledermatology applications were described in which the use of AI-enabled triage has led to a reduction of the number of unnecessary face-to-face consultations without compromising on the sensitivity for malignant disease. The examples mentioned above are just a few of the ways that AI can enhance workflow, but they also demonstrate the value of image quality and clinical supervision.^[37]

11.5 Psoriasis and eczema

In addition to diagnosis, AI has been investigated in disease activity monitoring, biologic-response prediction and adverse event prediction. The report also refers to smart patches that can track skin biomarkers including pH and biomechanics, which could be a path towards continuous monitoring.

12. Comparative Understanding: Conventional and AI-assisted diagnosis.

The comparison performed in the report indicates that while conventional diagnosis is largely based on visual examination, dermoscopy and biopsy, AI assisted diagnosis incorporates image based deep-learning classification and computational decision support. Traditional assessment is subject to variability among clinicians and constraints on

clinician availability. While AI can generate fast and consistent responses to the same input, it might have systematic biases when the training data are biased.

Histopathology is the gold standard for the diagnosis of malignancy in conventional practice. Therefore, using AI should not be interpreted as a replacement for biopsy when indicated clinically, but as an additional decision support tool.^[38]

Explainability also differs. Clinician can often explain what has been considered in a clinical setting, while AI models might need specific XAI techniques like Grad-CAM and SHAP, which make relevant features more apparent. This distinction is crucial, because besides being accurate, the model needs to be able to be used clinically and acted upon by health care professionals.

Technology-to-application relationships

- CNN → skin-lesion classification.

CNN + Grad-CAM can be used to improve the interpretability of melanoma classification.

Random forest / gradient boosting → prediction of biologic treatment response in psoriasis.

NLP → extracting information from EHRs and identification of drug-repurposing signals.

- Multimodal or vision-language models: combined model of reasoning from both images and texts.

Reported performance examples

Pooled sensitivity of around 87% and specificity of around 77% have been cited in the literature for the detection of melanoma/BCC/SCC.

Acne: model-specific studies have shown up to 90-99% accuracy.

Psoriasis: average severity-assessment accuracy ~81%, some studies higher. Early evidence for biomarker-based outcome prediction in atopic dermatitis. Vitiligo: initial lesion-area mapping, low level of large-scale validation.

13. Future Perspectives

The report forecasts that smartphone-detected dermatology apps will become more precise and be more likely to be part of a broader teledermatology system, and not just a diagnostic device. This direction is consistent with the need to use automated analysis in conjunction with professional review in practice.

Another emerging technology field identified is wearable technologies. The use of wearables could allow for continual assessment of skin and physiological parameters, and also give information regarding inflammatory flare ups in diseases like psoriasis and atopic dermatitis. This may move dermatology from a “snapshot” evaluation to a more continuous monitoring process.

Another key future area for precision dermatology. Use of AI in conjunction with genomic information, biomarkers, and longitudinal clinical data could enable personalized prognosis of treatment response and disease progression. The report ties this in with the larger trend towards personalized medicine.

Explainable AI will definitely gain prominence. The report makes a case for the necessary explainability of AI decisions, particularly with the emergence of explainability requirements. Explainability can also aid in more safe interaction between humans and AI, and the detection of cases when the algorithm has made use of inappropriate visual features.

Another promising line of research is multimodal models and vision-language models. These systems are capable of processing information with both image and text and can provide description reasoning of clinical images. These systems still need to be rigorously clinically validated before they can be widely adopted, the report says.

Lastly, the report highlights a more distant future of AI-powered robotic dermatologic surgery and digital twins. It separates these ideas from more recent applications, since these are much less developed.

14. Ethical and Regulatory Considerations

Ethics also plays a crucial role in the report due to the use of sensitive patient images and potentially life-impacting medical decisions in dermatological AI applications.

Safety is therefore crucial when taking, saving, sharing or publishing images, therefore privacy and informed consent are vital issues. In particular, the report stresses the need for informed consent when taking and using patient skin images in appropriate situations.

A second major concern is fairness. AI models should behave appropriately on all skin types, and the data sets should be representative of populations that will be using the technology. The report focuses on the importance of avoiding dark skin type discrimination.

There needs to be transparency as well. Clinicians should be mindful of the limitations and role of the outputs of AI and should not consider predictions made by algorithms as a rule infallible. Explanatory AI techniques can offer visual or feature level explanations that support the information, but an explanation is not a guarantee of clinical correctness.

Regulation is complicated by the nature of machine-learning systems that are changing. The report mentions hundreds of devices that are authorized for use in a variety of medical specialties using AI/ML, and the difficulties with systems that learn after they have been deployed. For one regulatory mechanism, Predetermined Change Control Plans are discussed, but it is not widely established that deployment of continuously changing decision-support systems is widely used.

The clinical duties and liability must also be taken care. AI needs to fit into the current workflow, and into EHRs and professional decision-making systems. Based on this, the report is that it is possible to have a responsible implementation with different sets of data, open models, clinical validation, clinicians, technologists and regulators.^[39]

15. Overall synthesis and conclusion

The report describes AI as a rapidly growing supporting technology in dermatology. It has the best current use in image-based diagnosis, particularly skin cancer classification and triage. CNNs and other deep-learning methods can process visual features at scale and may be able to offer fast and reliable assistance. AI is also advancing in the field of assessing inflammatory diseases, inflammatory disease severity, teledermatology, prediction of response to therapy,

monitoring disease, and drug discovery.

The usefulness of AI is dependent on the quality and representativeness of the data from which models are built and tested. This topic is repeatedly addressed in the report. A model may be well optimized on a curated data set but behave differently in real-life clinical use, such as images may not be as good, or the patient population may not match the distribution of training data.

The report also states that dermatological AI should work in conjunction with human oversight. AI is said to be a decision support tool and is not a replacement for histopathology, which remains the gold standard for the diagnosis of malignancy.

Human review is especially relevant in the context of poor images, uncertain findings, and insufficient training cases of a patient population.

There is a high probability that multimodal information will be involved in the future development, instead of images. Integrating photos or dermoscopy with clinical histories, EHR information, lab data, biomarkers, and genomic data and patient-reported outcomes may be useful for more personalized decision making. Wearables and longitudinal monitoring could offer more information in between clinic visits.

The report suggests, without naming them, that the technological advances are not enough to ensure successful integration. Plus, diversity of datasets, prospective external validation, explainability, privacy protection, informed consent, and regulatory oversight and workflow integration. Responsible development should, therefore, be based on computational skills and dermatological knowledge, clinical research and regulatory assessment.^[40]

Key takeaways

AI has a significant potential role in dermatological diagnosis and treatment. The current applications involve image-based deep learning, notably CNNs.

There is the most well-developed evidence base for applications of skin cancer.

AI can be used for severity assessment, prediction of treatment response, monitoring and teledermatology.

Data diversity is necessary because the effect of skin-tone bias on performance on underrepresented groups.

There are important limitations in terms of real-world image quality and external prospective validation.

The principles of privacy, informed consent, transparency and regulation are vital to responsible implementation.

Future systems will be increasingly multimodal, personalized and teledermatology and wearable technologies integrated systems.

AI should be used for clinical decision-making support and not to replace well established clinical standards.^[41]

16. CONCLUSION

Artificial Intelligence (AI) is a promising and rapidly evolving technology that has been applied in dermatology for the diagnosis, treatment, monitoring and management of skin diseases. The review illustrates how AI, particularly machine learning, deep learning, convolutional neural networks (CNNs), computer vision, natural language processing (NLP),

and explainable AI (XAI), can assist dermatologists in efficiently and consistently processing vast clinical and imaging datasets. The best evidence so far exists in image-based applications, especially in the identification and categorization of skin cancer, but it is also growing in the detection and categorization of inflammatory, pigmentary, infectious and other skin diseases.

AI can offer valuable features like early detection of possibly serious lesions, uniform disease severity evaluation, quick image analysis, teledermatology assistance, treatment response prediction, and long-term disease monitoring. This may also help to make dermatological care more accessible in regions where such specialists are not readily available. The value of AI, however, will greatly rely on the quality, variety, and representativeness of the data used to build and test the model. Model performance with a more representative dataset of the clinical setting may or may not be identical to that of a limited, well-curated dataset.

One of the significant issues highlighted in the report is that some dermatology datasets may be less representative of darker skin tones, potentially leading to disparities in AI performance across different ethnic and racial populations. However, other challenges exist such as image quality variation, external validation and prospective validation, informed consent and privacy concerns, transparency issues, regulatory issues, and incorporation into existing clinical workflows. These restrictions are indicative of the fact that an AI system's capabilities in lab or retrospective experiments do not guarantee its performance in real-world clinical settings.

As a result, for the time being, AI can be seen as a clinical decision support tool, not a substitute for dermatologists or tried and tested diagnostic techniques. In uncertain cases, poor quality images, and when more investigation is needed, the clinical judgement of the human still plays a vital part. Histopathology is also still considered to be the gold standard for the diagnosis of malignancy, when clinically indicated.

Prospective developments will be beyond image-only analysis to multi-modal systems comprised of clinical photographs and dermoscopic images, patient history, EHR, laboratory results, biomarkers, genomic data, and patient-reported outcomes.

Continuous assessment of chronic skin diseases can also be achieved by wearing technologies and longitudinal monitoring. Explainable AI could enhance transparency and clinician trust, and ongoing research could expand the use of AI in personalized care, drug development, teledermatology and more.

Overall, AI holds immense promise for revolutionizing dermatological healthcare by assisting with quicker, more uniform, and more accurate clinical decision-making, ultimately enhancing the quality and efficiency of care delivery. Despite this, these successful implementations will depend on the availability of diverse datasets, clinical validation (both external and prospective), models that are easily explainable, robust privacy protection, informed consent and appropriate regulation, and ongoing human oversight. The future of AI in dermatology will likely rely on responsible collaboration between dermatologists, researchers, technologists, patients, and regulatory authorities, alongside technological advances. In the end, AI should be used in tandem with existing clinical knowledge and protocols and contribute to the enhancement of dermatological health services, making them more accessible, efficient, and effective.^[42]

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