

## ABOUT THE AUTHOR

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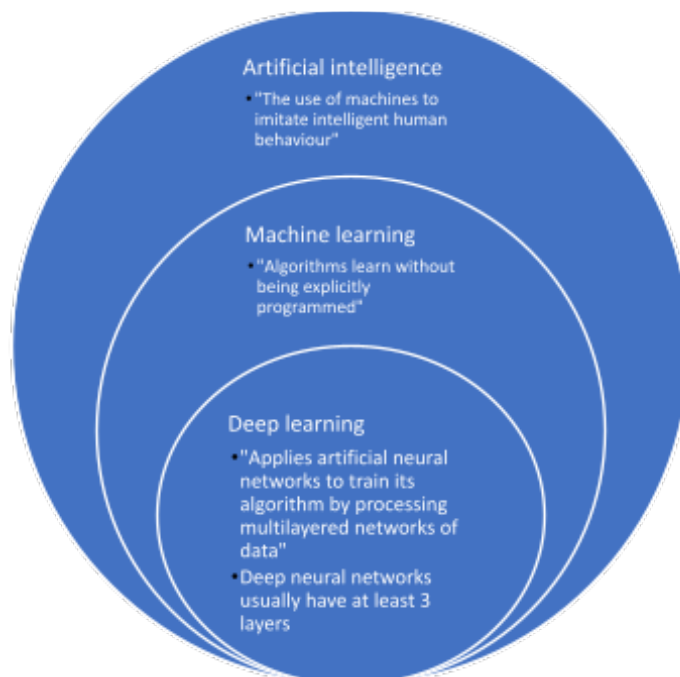
## THE CURRENT LANDSCAPE OF ARTIFICIAL INTELLIGENCE IN DERMATOLOGY

The role of artificial intelligence (AI) in medicine is evolving rapidly. The pace at which technology is progressing necessitates that we understand AI, and specifically, its role in the management of dermatological disease. The objective of this article is to provide resources for further learning about the role of AI in dermatology, and to describe its current landscape and future directions.

### Background

For many clinicians, "AI" might as well stand for "altogether impossible". As technology advances, it will be increasingly important for us to understand how to interpret scientific articles about AI, not just for our own learning, but also for the purpose of teaching trainees or engaging with peers at journal club. To this end, *JAMA* published a users' guide entitled, "How to Read Articles that Use Machine Learning".<sup>1</sup> This can be found on their "Machine Learning" hub,<sup>2</sup> which has other relevant articles and multimedia content, including "On Deep Learning for Medical Image Analysis,"<sup>3</sup> and its accompanying video, "Understanding How Machine Learning Works."<sup>4</sup> Recently, *CMAJ* published a series of three articles on machine learning in health care, exploring its implementation<sup>5</sup>, problems in deployment<sup>6</sup>, and evaluation<sup>7</sup>.

AI is conventionally defined as "the use of machines to imitate intelligent human behaviour."<sup>8</sup> Machine learning (ML) and deep learning (DL) are subsets of AI (**Figure 1**).



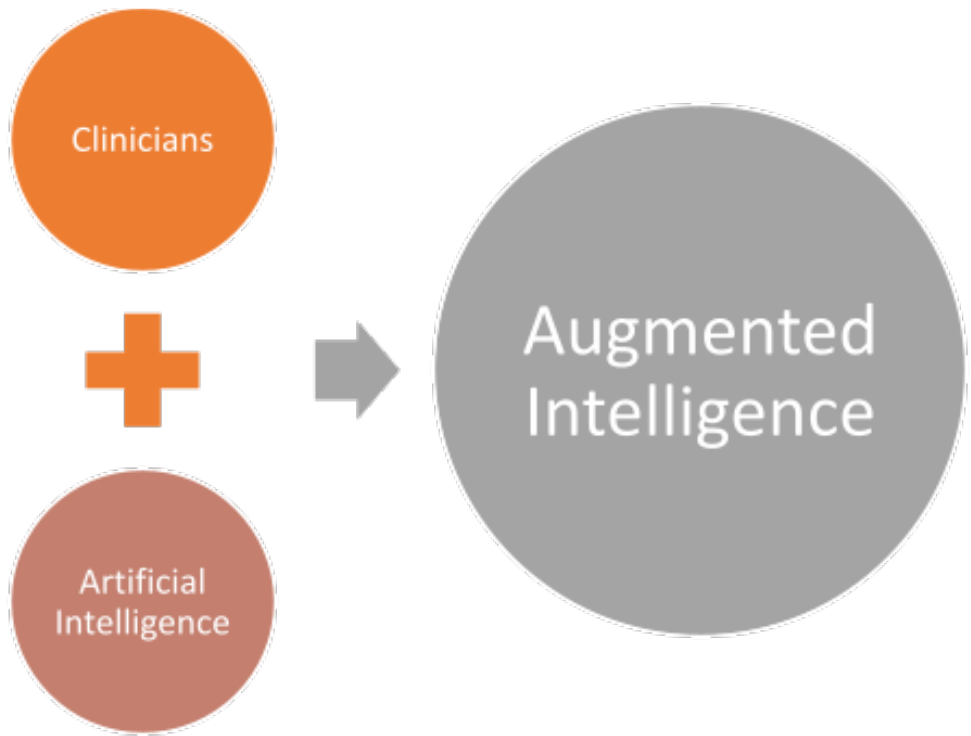
**Figure 1.** Definitions of artificial intelligence, machine learning, and deep learning. Adapted from *JAAD*.<sup>8,9</sup>

Augmented intelligence (Aul) describes the interaction between clinicians and artificial intelligence (**Figure 2**). With the expansion of AI research in dermatology, in 2019, the American Academy of Dermatology (AAD) issued a position statement on Aul which emphasized the assistive role of AI for clinicians and presented four aims of Aul: (1) enhancing patient experience, (2) improving population health, (3) reducing costs, and (4) improving the professional fulfillment of care teams. The position statement puts forth recommendations for the development of Aul, with the goal of providing high quality care to patients. Key issues include model development, clinical deployment, post-marketing surveillance, engagement, education, privacy and medico-legal issues, and advocacy.<sup>10</sup>

### AI applications in dermatology

Several comprehensive reviews on the use and application of AI in dermatology have been published,<sup>8,9,11,12</sup> including a review by Canadian colleagues Gomolin et al.,<sup>12</sup> and selected studies of interest will be highlighted below.

The most common application of AI in dermatology is in the diagnosis of malignant lesions, including keratinocyte carcinomas and melanoma. In 2017, researchers at Stanford published a paper in *Nature* describing a deep convolutional neural network which achieved performance on par with 21 dermatologists at classifying keratinocyte carcinomas versus benign seborrheic keratoses, and malignant melanomas versus benign nevi, based on clinical and dermoscopic images.<sup>13</sup> Since then, there have been other similar papers published.<sup>14,15</sup>



**Figure 2.** Augmented Intelligence; courtesy of Rebeca Pinca, MD.

One of the first prospective diagnostic accuracy studies comparing a dermatologist's clinical examination at the bedside, teledermatology, and non-invasive imaging techniques (FotoFinder®, MelaFind®, and Verisante Aura) in the diagnosis of melanoma was done by Canadian colleagues MacLellan et al. They recruited 184 patients and 209 lesions were imaged, assessed, and excised. Skin specimens were assessed by 2 blinded pathologists for the gold standard comparison. Histopathologic examination resulted in diagnoses of 59 melanomas and 150 benign lesions. Sensitivities and specificities were, respectively, MelaFind (82.5%, 52.4%), Verisante Aura (21.4%, 86.2%), FotoFinder Molealyzer Pro (88.1%, 78.8%), the teledermoscopist (84.5%, 82.6%) and the local dermatologist (96.6%, 32.2%). The authors note that the high sensitivity of some non-invasive devices in the diagnosis of melanoma is consistent with prior studies. However, they

comment that low specificity and low diagnostic accuracy preclude some of these machines from replacing a dermatologist's clinical experience in selectively choosing which lesions to excise. When the FotoFinder Tuebinger was used as an aid to the clinical diagnosis, both of the melanomas missed by the local dermatologist were identified, and when it was used as an aid by the teledermatologist, missed melanomas were reduced from 4 to 3. This symbiosis between clinician and AI illustrates the potential benefits of augmented intelligence. The practical limitations to using these devices in a clinical setting include size, location, and Fitzpatrick skin phototype (skin types higher than III were excluded due to limitations of the machines for melanoma diagnosis in patients with higher phototypes).<sup>16</sup>

Canadian colleagues Breslavets et al. compared the ability of a dermatologist, two laypersons (science students) and an artificial neural network (ANN) to estimate

the percentage body surface area of psoriasis involvement. The ANN had a mean percentage error (MPE) of 8.71% (SD, 6.70%; 95% CI, 7.64%-10.02%) compared with the physician's MPE of 28.16% (SD, 22.69%; 95% CI, 24.76%-32.61%). This study showed that AI applications may potentially play an important role in aiding in the triage of patients and that the technology employed via ANN may provide a more consistent assessment of skin areas affected by psoriasis through calculating the percentage of the affected skin, compared with routine measurement by the palm method.<sup>17</sup>

Other potential applications of AI in dermatology include onychomycosis,<sup>18</sup> alopecia areata,<sup>19</sup> lupus,<sup>20</sup> ulcers,<sup>21</sup> and acne.<sup>22</sup>

Precision medicine is another area with potential AI applications in dermatology. A review of ML in dermatology found that it is being applied to electronic medical records, patient laboratory data, and genomic data from next-generation sequencing to study the genetic basis of diseases; to identify associations between comorbidities, risk factors, and disease prognosis; and to design and predict responses to pharmacologic therapies. The authors describe potential applications including prediction of adverse drug reactions and responses to therapy in oncologic dermatology, autoimmune and rheumatologic skin disease.<sup>23</sup>

Numerous direct-to-consumer mobile applications are being developed with the aim of improving access to health care, especially in limited resource settings. A recent systematic review of diagnostic accuracy studies for algorithm-based

smartphone apps to assess risk of skin cancer found that they were unreliable for detecting melanoma and other skin cancers.<sup>24</sup> There are benefits of a full cutaneous examination that would be limited with a direct-to-consumer app. It is common for patients to report a concern about a seborrheic keratosis, and after ruling out anything serious, clinicians may find another lesion of concern during their examination that the patient was either unconcerned about, or unaware of, due to difficulty in visualizing their back or other body areas. This may potentially cause delay in diagnosis of subtle lesions.

### AI and health care disparities

It is important to ensure that health care disparities are addressed early in the implementation of AI in dermatology. One of the largest open-source public-access archives of pigmented lesions, the International Skin Imaging Collaboration: Melanoma Project, relies mostly on images of fair-skinned individuals and neural networks based on such training data sets may not be accurate in skin of colour.<sup>25</sup> While the incidence of melanoma is higher in this population, it is important to ensure that the accuracy of AI is high for all skin types. Han et al. performed a study to validate algorithms for the diagnosis of skin cancers by testing them on different data sets than those they were originally trained on.<sup>26</sup> They found that algorithms trained on Caucasian skin performed suboptimally when tested on data sets of Asian skin, as subtypes of melanoma differ in prevalence amongst skin types. Similarly, algorithms trained on Asian skin performed suboptimally when tested on data sets of Caucasian skin, as the appearance of BCC tends to differ amongst skin types.

### Patient perspectives

As progress is made in evaluating the role of AI for clinical implementation, it is important to consider the perceptions and preferences of patients prior to its widespread use<sup>27</sup>. Nelson et al<sup>28</sup> published one of the first studies exploring this domain, specifically on the use of AI for skin cancer screening. They used a semi-structured interview technique for their qualitative study of 48 patients at the Brigham and Women's Hospital and the Dana-Farber Cancer Institute, 33% with a history of melanoma, 33% with a history of nonmelanoma skin cancer only, and 33% with no history of skin cancer. Half the patients were interviewed about a direct-to-patient AI tool and half were interviewed about a clinician decision-support AI tool. The most commonly perceived benefits of AI for skin cancer screening were increased diagnostic speed and health care access; the most commonly perceived risk was increased patient anxiety. Patients commented on the importance of physician compassion, empathy, eye contact, and human touch, as well as the AI's inability to answer follow-up questions, discuss treatment options, and educate and reassure patients. Ironically, the greatest strength of AI was perceived by patients to be more accurate diagnosis – and its greatest weakness, less accurate diagnosis. Three quarters of those interviewed would recommend AI to friends and family members. The vast majority (94%) emphasized the importance of symbiosis between humans and AI, highlighting the role of augmented intelligence.



## Conclusion

AI will likely revolutionize the practice of medicine in the coming years, and it is therefore important that dermatologists are at the forefront of AI advances in dermatology. Zakhem et al. reviewed studies on AI and skin cancer, and only 41% had dermatologists as co-authors. Articles that included dermatologists described algorithms built with more images versus articles that did not include dermatologists (mean, 12,111 vs 660 images, respectively).<sup>29</sup> Currently, there are numerous limitations to the current landscape of AI in dermatology, including lack of extensive validation and prospective studies in clinical settings, lack of guidelines regarding ethics, concerns about lack of inclusivity and equal access, and potential funding biases in publications. However, AI advances on the horizon have the potential to be helpful tools in our clinical practices as we care for our patients.

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