# Journal Pre-proof


Machine learning for precision dermatology: Advances, opportunities, and outlook

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PII: S0190-9622(20)32161-7

DOI: https://doi.org/10.1016/j.jaad.2020.06.1019

Reference: YMJD 14918

To appear in: *Journal of the American Academy of Dermatology*

Received Date: 12 September 2019

Revised Date: 8 June 2020

Accepted Date: 26 June 2020

**Article Type:** Research Letter

**Title**: Machine learning for precision dermatology: Advances, opportunities, and outlook

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**Funding Sources**: E.Y.L. acknowledges support from the UCLA-Caltech Medical Scientist Training Program (T32GM008042) and the Dermatology Scientist Training Program (T32AR071307) at UCLA, and an Early Career Research Grant from the National Psoriasis Foundation.

**Conflicts of Interest**: None

**Reprint requests:** Ernest Y. Lee, MD, PhD

**Manuscript word count**: 505 words
**References**: 15 (25 supplemental references)
**Figures:** 1
Supplementary figures: 0
**Tables:** 0
Supplementary tables: 1 (available at http://dx.doi.org/10.17632/8w4dkfbdpk.1)

**Keywords:** Machine learning, artificial intelligence, precision medicine, precision dermatology, biomarkers, diagnosis, treatment

To the editor:

With the explosion of “big data” in medicine driven by the advent of electronic medical records, next-generation sequencing and “multi-omics”, and non-invasive imaging techniques, dermatology is a field at the precipice of an artificial intelligence (AI) revolution. Yet to the majority of clinicians, machine learning (ML) is a magical “black box” that is powerful but inaccessible. Here, we review the latest advances in machine learning applied to dermatological diagnosis and treatment and highlight key discoveries with translational potential. ML is an AI technique that focuses on designing machines (or computers) that mimic human pattern recognition and problem solving[1]. With the rise of “big data” and “data science”, machine learning and artificial intelligence already impact our daily lives in innumerable ways. Comparatively, clinical medicine has been slower to integrate machine learning into daily practice[2]. Machine learning has typically been considered a tool well outside of a typical clinician's purview. At the same time, there is now an enormous demand for high quality research that is advancing health care using ML and AI[3]. ML is a natural fit for translation into dermatology because dermatology is a specialty that is heavily reliant on visual evaluation and pattern recognition.

We searched the literature for high quality studies published within the last 5 years describing the latest advances in machine learning applied to precision dermatology (Supplementary Table 1). Since digital photography is so prevalent, many ML studies in dermatology focus on lesion image analysis[4-7] and classification[8,9]. However, we also find that ML is now also being applied to electronic medical records (EMR), 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 (Supplementary Table 1). Applications span prediction of adverse drug reactions[10] to responses to therapy in oncologic dermatology[11] and autoimmune and rheumatologic skin disease[12]. Together, these landmark studies outline a promising generalized framework that leverages gene expression data and "multi-omics" for biomarker discovery in autoimmune skin diseases, and for biologics and immunotherapies in general (Figure 1A, B). The convergence of ML and next-generation sequencing represents a golden opportunity to advance precision dermatology, and multidisciplinary collaborations between machine learning experts, biologists, and dermatologists will be required to expand the scope of this research.

The promise of an AI revolution in dermatology also comes with an accompanying fear of "black boxes" and a concern for how this may impact patient care and patient perceptions of care. Similarly, there is a prevailing fear among physicians that machines will largely replace clinicians in dermatology, as well as in radiology and pathology[13]. It is our view that machine learning will not replace dermatologists[14]. Rather, these tools will enable dermatologists to provide a higher quality of care to their patients[15]. In fact, we believe that machine learning tools, such as downloadable local programs on personal computers, open-source online webservers, or mobile applications on smartphones, will be tightly integrated into the daily clinical practice of the dermatologist in the near future.

**Figure 1: Machine learning for precision medicine**. (A) Schematic demonstrating training and validation of a machine learning model from multimodal input patient data, such as clinical images, patient demographics, and "multi-omics". (B) Application of the machine learning model to choose individually-tailored therapies for specific disease states.

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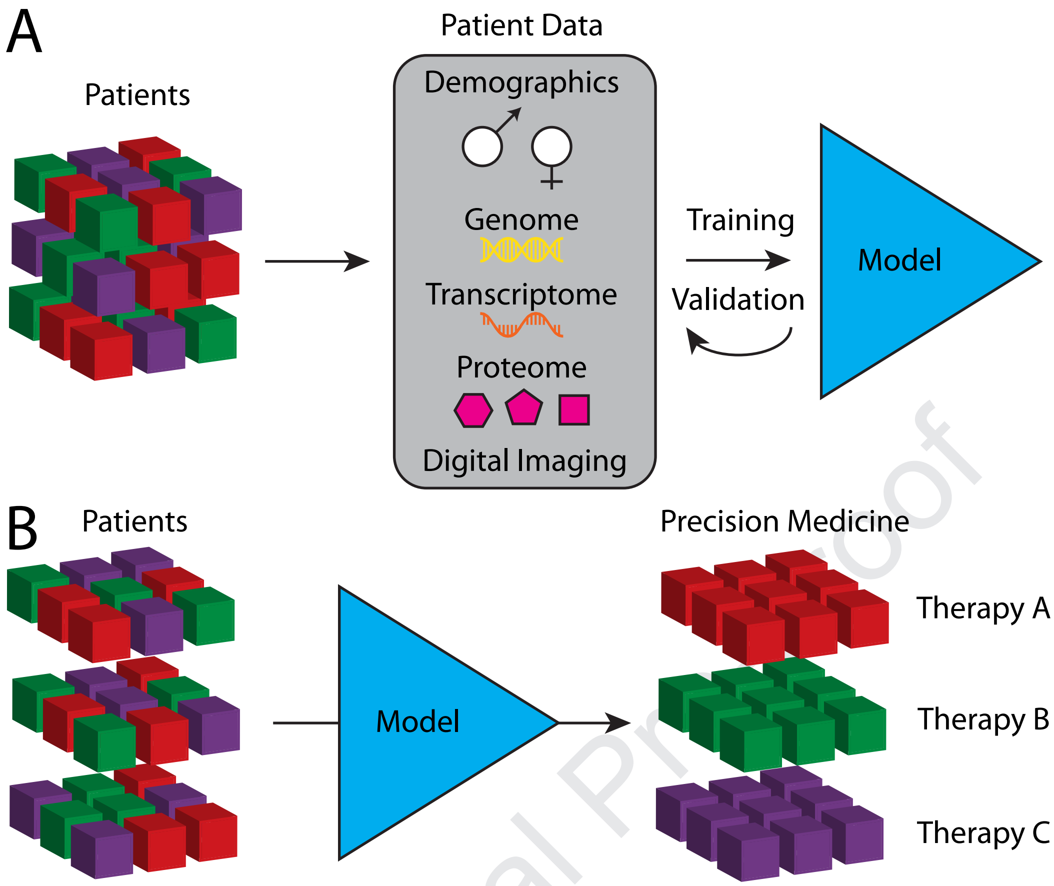
A
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