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INTRODUCTION

Dermatology, Data, and Informatics

The ability to capture, store, and analyze vast amounts of data has revolutionized human endeavors, and medicine is no exception. Information technology has touched every aspect of medicine, and this influence will only grow over time. However, a clinical dermatologist in practice today only sees the surface of this influence, through interactions with electronic medical records or through patients bringing the results of Internet searches to their visits. He or she will often miss the vast underlying structures that gird our system, that spur its advances, and that will continue to change the way we care for our patients. In this issue, we hope to shed light on these underlying methods, detailing the various roles of information technology in dermatology and what may lie ahead.

We start with a discussion of informatics in basic science. The Human Genome Project was announced in 1990. Thanks to strides in technology, it was completed in 2003, ahead of time and under budget.[1] These strides have built upon each other, allowing for ever greater insights into the complex systems that underlie fields such as structural biology and immunology. In their review, Parad and Liao detail the applications of informatics in dermatology basic science, using psoriasis as a model disease to track these changes.[2] Starting with basic linkage studies, they proceed to a discussion of genome-wide association studies, exomic sequencing, microarrays, single-cell RNA sequencing, and microbiomics. In accessible terms, they discuss differential expression analysis, network analysis, and pathway analysis, highlighting important insights. The article by Miroslav Blumenberg goes further, discussing the applications of these techniques across a range of dermatologic illnesses, demonstrating discoveries in conditions ranging from atopic dermatitis to normal skin aging.[3]

Next, this issue turns from basic science to the actual daily practice of clinicians. Currently, information technologies hold the potential to transform our daily clinical practice. Medication interactions and personalized medication regimens are critical areas in which these approaches can yield significant gains. Given the vast numbers of medications, the dozens of potential side effects and interactions, the increasing complexity of modern medication regimens, and the growing amounts of pharmacogenomic data that should inform our care, optimal medication management encompasses a scope of data far beyond what any clinician can reasonably master and maintain. However, several groups are creating accessible resources that clinicians can access at the point of care. Daneshjou et al. have written a cogent review of informatics in the area of pharmacogenomics, discussing initiatives such as the Pharmacogenomics KnowledgeBase and the Clinical Pharmacogenetics Implementation Consortium that clinicians can use to improve the care of their patients.[4] While still under development, approaches such as the "green button consult" have allowed health systems to create giant retrospective case-control studies to ask targeted clinical questions while in clinic, generating evidence-based medicine with a granularity never before possible.[5] Like all retrospective case-control studies, these must be applied with care, as they are susceptible to issues with bias and confounding, but they hold great promise. Slightly less promising to date have been the government policies regarding health information. In their article, Park et al. provide an overview of the history behind our health information system, discussing the origins of medical documentation, its original purposes, and how it has changed over time.[6] Next, they discuss the emergence of electronic medical records, the Health Insurance Portability and Accountability Act, and the complex relationship between this law and how we care for patients. The authors point to the role of electronic health records in clinician burnout, with its various shortcomings and flaws. Finally, they turn to potential solutions, introducing the concept of "design thinking" and its potential uses in health policy.

Having reviewed the impact of informatics on basic science and on clinical practice, we turn to patients and to their changing interactions with both technology and with the medical system. The dissemination of smartphones has made patients capable of capturing and storing complex, high-level data. In their article, Petrie et al. discuss the use of patient-centered technology to drive research and perhaps someday improve the early detection of melanoma. [7] They address many of the challenging issues raised by such research, including data security, privacy, and federal regulation. With new technologies, patients can not only capture their own information but access large amounts of it as well. In their paper, Jia et al turn to patient-accessible sources of health information, from Google to social networks to consumer genetic testing.[8] Given that we turn to Internet search engines for so many questions, it is not surprising that patients use these tools to ask intimate questions about their own health. Although these tools may sometimes elicit unnecessary alarm or misinformation, they nevertheless hold the potential to educate patients, provide a sense of community for those suffering from rare diseases, and improve care.

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Finally, we turn to the future, and to the application of modern artificial intelligence to dermatology, teledermatology, and pathology. While the field of artificial intelligence dates to the mid-20th century, it has waxed and waned over time. However, it has experienced a recent surge because of breakthroughs achieved through a combination of new computational techniques, powerful computers, and giant datasets.[9,10] This combination, sometimes referred to as "deep learning," has been applied across numerous fields, leading one leading academic to describe artificial intelligence as "the new electricity".[11] One of the primary applications of artificial intelligence has been in the fields of image recognition and computer vision. Given the visual nature of dermatology, there is a long-standing history of computer-based image analysis within our field.[12,13] However, many of these prior systems required algorithms carefully designed by domain experts and often proved brittle to subtle changes. Deep learning, on the other hand, can learn the important features of an image on its own, through viewing millions of examples and correcting itself over time.[9] Schlessinger et al. discuss these advantages in their review of the potential applications and pitfalls of this technology.[14] From time-consuming tasks to detecting new, subtle patterns in data, there are numerous potential advantages. However, there are numerous challenges, ranging from bias to interpretability to regulatory barriers.

The advances in many of these fields have been contingent on large datasets. In this issue, Rotemberg et al. discuss the implementation of these datasets in dermatology.[15] The authors elaborate on the requisites to a well-functioning public dataset, including transparent labels, metadata, and patient data. The International Skin Imaging Collaboration is the best online example of such a dataset. The International Skin Imaging Collaboration dataset makes large public challenges possible, in which teams from all over the world can compete to produce the best algorithms on defined tasks. Such competitions accelerate the pace of algorithmic improvement while providing constant benchmarks that allow us to accurately compare different algorithmic architectures and approaches. Rounding out this section, Giuste et al. review the applications of this technology in various areas, ranging from teledermatology to pathology.[16] Traditional pathology is a discipline born of the industrial revolution, with glass, paraffin, and textile dyes at the heart of the pathologist's daily work. Given that the field still contains stains with name such as "Prussian blue," the application of cutting-edge technology next to 150-year-old techniques is striking. Nevertheless, the importance of pattern recognition suggests a potential role for artificial intelligence in this field as well. Pathology poses several challenges, including the enormous, gigabyte-size high magnification images, but these are gradually being overcome. The authors walk through several applications, from basic pixel counting to identification of nuclei, interpretation of relevant markers—such as lymphocyte infiltration and mitotic indices—and other potential tasks.

A century ago, aspiring physicians aimed to learn and memorize all medical knowledge over the course of their training. The primary textbooks sought to deliver all the pertinent information within their specialties, and the total scholarly output was rising at a rate of approximately 2% to 3% per year.[17] Since the Second World War, the total scholarly output has been increasing at approximately 8% to 9% per year, leading to a doubling approximately every 8 years. This growth makes the increasing subspecialization of medicine appear more adaptive, as it makes plain the difficulty inherent in mastering the literature of any field. Furthermore, it also speaks to the need for physicians to become information specialists in order to remain relevant and to add value in a system in which machines are growing ever more skilled at pattern recognition.[18] Dermatology has undergone innumerable changes over the past century, and the next century will see innumerable more. Nevertheless, while information technology will lead to a significant transformation in daily clinical practice, I am confident that the future of our specialty is a bright one.

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References

1. International Human Genome Sequencing Consortium. Finishing the euchromatic sequence of the human genome. *Nature*. 2004 Oct 21;431(7011):931-45.
2. Parad JE, Liao W. Bioinformatic Applications in Psoriasis: Genetics, Transcriptomics, and Microbiomics. *Sem Cutan Med Surg*. 2019. In press.
3. Blumenberg M. Skinomics, Transcriptional Profiling Approaches to Molecular and Structural Biology of Epidermis.*Sem Cutan Med Surg*. 2019. In press.
4. Daneshjou R, Huddart R, Klein T, Altman R. Pharmacogenomics in Dermatology: Tools for understanding gene-drug associations. *Sem Cutan Med Surg*. 2019. In Press.
5. Longhurst CA, Harrington RA, Shah NH. A 'green button' for using aggregate patient data at the point of care. *Health Aff (Millwood)*. 2014;33(7):1229-1235. doi:10.1377/hlthaff.2014.0099.
6. Park AJ, Maruthur MK, Swerlick RA. Information technologies in health care delivery and policy: giant steps and missteps. *Sem Cutan Med Surg*. 2019. In Press.
7. Petrie T, Samatham R, Goodyear SM, Webster DE, Leachman SA. MoleMapper: an application for crowdsourcing mole images to advance melanoma early-detection research. *Sem Cutan Med Surg*. 2019. In press.
8. Jia JL, Polin DJ, Sarin KY. Emerging technologies for health information in dermatology: opportunities and drawbacks of web-based searches, social media, mobile applications, and direct-to-consumer genetic testing in patient care. *Sem Cutan Med Surg*. 2019. In press.
9. LeCun Y, Bengio Y, Hinton G. Deep learning. *Nature*. 2015;521(7553):436-444. doi:10.1038/nature14539.10. Krizhevsky A, Sutskever I, Hinton GE. ImageNet classification with deep convolutional neural networks. In: Pereira F, Burges CJC, Bottou L, Weinberger KQ, eds. *Advances in Neural Information Processing Systems 25*. Red Hook, NY: Curran Associates, Inc.; 2012; 1097-1105.
10. Li, O. Artificial Intelligence is the New Electricity—Andrew Ng. https://medium.com/syncedreview/artificial-intelligence-is-the-new-electricity-andrew-ng-cc132ea6264. Accessed February 25, 2019.
11. Finlay AY, Hammond P. Expert systems in dermatology: the computer potential. The example of facial tumour diagnosis. *Dermatologica*. 1986;173(2):79-84.
12. Stoecker WV. Computer-aided diagnosis of dermatologic disorders. *Dermatol Clin*. 1986;4(4):607-625.
13. Schlessinger D, Chhor G; Gevaert O; Swetter SM; Ko JM; Novoa RA. Artificial intelligence and dermatology: opportunities, challenges, and future directions. *Sem Cutan Med Surg.* 2019. In press. *Sem Cutan Med Surg.* 2019. In press.
14. Rotemberg V, Halpern A; Dusza S; Codella NC. The role of public challenges and data sets towards algorithm development, trust, and use in clinical practice. *Sem Cutan Med Surg.* 2019. In press.
15. Giuste F, Vizcarra JC, Gutman DA. Digital Imaging Applications and Informatics in Dermatology. *Sem Cutan Med Surg.* 2019. In press.
16. Bornmann L, Mutz R. Growth rates of modern science: a bibliometric analysis based on the number of publications and cited references. *arXiv* [cs.DL]. http://arxiv.org/abs/1402.4578. Submitted February 19, 2014. Updated May 8, 2014. Accessed February 25, 2019 .
17. Jha S, Topol EJ. Adapting to Artificial Intelligence: Radiologists and Pathologists as Information Specialists. *JAMA*. 2016;316(22):2353-2354. doi:10.1001/jama.2016.17438.