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

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Emerging technology is fundamentally changing how individuals interact with the health care system. Web-based searches, mobile applications, social media, and direct-to-consumer genetic testing companies are facilitating information exchange at a higher rate than ever before, creating a macroscopic shift in the mechanisms by which individuals seek health information. The visual nature of skin disease enables individuals to browse, share, and search based on images, adding another dimension to how dermatological information is transferred. These trends carry important implications on user health care behavior, and so it is vital for health care professionals to stay attuned to the morphing characteristics of their patients’ health management in order to continue to provide high-quality, patient-centered care.

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The last 2 decades have witnessed a significant shift in the mechanisms of health care delivery. Information in urban areas is flowing at record speeds and volumes, and rural areas that were previously deprived of readily available high-quality specialist care are rapidly gaining access to vast amounts of health information and resources. Emerging technology may act as a middleman between patients and providers; individuals can now use the Internet to learn more about their dermatological health status and educe themselves on health care conditions, causes, and treatments. Tools such as direct-to-consumer (DTC) genetic testing and web-based search engines enable new opportunities for self-diagnosis, while social media and mobile technology perpetuate the continuously morphing quantity and content of the knowledge shared between patients and their health care providers by allowing convenient and efficient information exchange among consumers (Figure 1). The shifting landscape brings with it increasing opportunity for individualization and customization of care, in which patients are playing a vital role in the management of their own health.

The increased modalities by which patients are accessing health information present unique health care opportunities as well as potentially dangerous pitfalls. Technology can play a supportive role by allowing patients to monitor their health care regimens and gain educational information about their health conditions, but it can also be used improperly to decide how to treat conditions without professional input. Furthermore, the quality of information received is not standardized, and patients are susceptible to receiving misleading information. Users may not have the training necessary to differentiate fact from rumor, putting proper health behavior and professional care utilization at risk while opening an opportunity for industry interests. The multitude of disparate information sources leads to fragmentation in patient care and can interfere with the team approach between patients and providers.

In addition to its impact on users, the data produced by these emerging technologies are opening many new avenues to researchers by offering a wealth of public information regarding user interaction with health-related information and functionality on technology-based interfaces. Data gleaned from these sources can inform research regarding health trends, outcomes, and associations. In particular, DTC genetic test results serve as contributors to massive biological datasets that can be harnessed to identify genetic associations with disease. Regardless of future direction, however, the present calls for a more granular investigation of the numerous emerging forms of technology-based health information sources and how they impact user interaction with dermatology services and the health care system at large (Figure 1).

Web-based searches

The Internet has emerged as a primary vehicle through which patients seek health information outside of the patient-physician clinical encounter. Recent studies have shown that approximately 72% of Internet users routinely look up health-related information online. Patients also often utilize the Internet to find health care providers; a recent analysis showed that dermatologists were among the most researched physicians among common medical specialties. The education to be gained about health conditions through online resources may also empower patients to take a more active role in their own health care, which is likely to lead to better health outcomes and perceived quality of care. However, there may be disadvantages to the near infinite amount of health information that is available online. Information acquired online is unlikely to all be peer-reviewed or similarly vetted and may include anecdotes, opinions, and other unreliable sources. Many patients lack the training to adequately assess the quality of information and run the risk of misusing or misconstruing information online to self-treat or self-diagnose their own conditions; this behavior con-

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Tributes to avoidance of physician consultation. A national survey recently identified that approximately 35% of patients who diagnosed their condition using online resources did not visit a clinician and seek expert diagnosis. Information available online may also come into conflict with health provider interpretations or treatment plans, which may lead to decreased patient-provider trust and poorer patient treatment adherence.

The visibility of skin conditions and lesions makes the Internet an even more important tool for patients. Patients are able to not only search for information using text terms and descriptors but also compare visuals and photos of conditions to their own. Patients may use Internet-based tools such as Google Reverse Image Search to self-generate differential diagnoses of medical conditions using photos of their own skin lesions, even though the accuracy of such searches has been inconsistent or poor. Incorrect self-generated diagnosis may cause patients to mistake malignant skin conditions for benign ones, leading to further delays in health provider diagnosis and care.

Dermatologists must be aware that a majority of patients seek health information online and, in many cases, use online information to corroborate and understand physician recommendations. With the overwhelming amount of health information available on the Internet, dermatologists must work with their patients to identify and assess the quality of information that patients find. Improved communication of health information between patients and their dermatologists may build better patient-provider trust and facilitate greater shared decision-making in the clinical encounter.

**Mobile**

A 2018 Pew Research Center survey shows that 77% of Americans own smartphones, and research finds that the average American with a smartphone checks it between 40 and 100 times per day. Smartphones are extremely convenient, bringing communication, Internet access, and third-party applications—the functionality of which ranges from leisure to providing knowledge and valuable health information—directly to users’ fingertips. Smartphones have the potential to, and do, play a significant role in health tracking and management. For example, Samsung phones are initialized with the Samsung Health application, which can track heart rate, weight and stress levels, walking and running mileage, and even the number of cups of water drank in a given day, all with the option of sharing progress with social media friends. Similarly, Apple phones now have the technology to track heart arrhythmias among other health conditions.

By their very nature, dermatologic conditions and the discussions thereof typically require visual input, more so than many other fields of medicine. In the past, mobile devices were limited
by low-quality cameras. As the quality of cameras improves, an increasing number of mobile applications are utilizing these portable cameras as part of their operation. Improved mobile camera technology now enables dermatology patients or would-be patients to send photos of their symptoms to others, compare them to photos found online, or apply photo-warping technology to, for example, find out what their face may look like in a decade if they were to habitually forego sunscreen—a function that is likely to promote healthy habits. The literature indicates that this mobile technology increases patient activation and autonomy by allowing users to explore their own health conditions and provide the initiative needed to seek out professional care. Mobile phone technology is especially impactful in rural areas, where health care may not be easily accessible. Photos of symptoms can be sent via encrypted and secure multimedia messaging service (MMS) to providers who are geographically separated from patients and who can make accurate and timely diagnoses to patients who may otherwise experience difficulty receiving professional medical input. For a number of years, volunteer dermatologists from the American Academy of Dermatology have used mobile apps to provide dermatologic care free of charge for underserved communities.

Third-party applications utilize the aforementioned camera technology and more in a variety of health-relevant ways. There are over currently over 200 dermatology-related apps in use, with functionality that includes disease diagnosis and management, education, and offering sunscreen/ultraviolet recommendations (Table 1). Particularly relevant to dermatology are the self-surveillance applications, which allow users to track what their skin looks like over a period of time, monitoring for changes that may need medical attention; for example, there are several mole monitoring apps that encourage early detection of melanoma. Mobile technology used for health care purposes can be either a benefit or a detriment. While mobile application–reliant self-surveillance may mobilize patients to seek out professional health care, it can also be dangerous—a misdiagnosis of serious conditions as benign may delay patient utilization of necessary health care. On the other hand, a recent study found that mobile apps have the power to not only motivate health-positive behaviors but also change user perceptions regarding tan skin being considered attractive, indicating the potential for public health campaigns with substantive, widespread impact.

MMS and text messaging are valuable mobile-based tools in the changing health care landscape. As previously discussed, MMS can utilize the mobile camera function to enable teledermatology—an extremely powerful health care resource for rural populations. Similarly, text messaging functions of mobile devices can be used as a delivery system of regular reminders to partake in healthy habits such as sunscreen use. A 2009 study showed that text message–based reminders to use sunscreen can increase sunscreen use by over 20%.

### Social Media

As opposed to the passive layout of many websites, social media platforms such as Facebook, Twitter, and YouTube seek to engage users interactively. Social media is revolutionizing the relationship between health care seekers and the United States health care landscape. Recent national estimates find that about 70% of US adults use at least one social media site—a number that has nearly doubled since 2009 and is predicted to rise over time (Figure 2). In addition to being an effective way to stay connected in an increasingly globalized world, social media is emerging as a popular source of health-related information. Social media allows patients and physicians alike to engage and connect with each other outside of the traditional clinic space, with many platforms supporting photo, video, and sound capabilities. As more and more users turn to their online social networks for health advice, the efficiency with which social media propagates information brings both positive and negative consequences to users’ health education and health-seeking behavior.

It is estimated that approximately 42% of health care consumers have used social media websites such as Facebook, Twitter, and LinkedIn to access health-related information. These social media platforms are easily accessible sources of a variety of opinions from those considered friends and acquaintances; thus, it is unsur-

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**TABLE 1. Common mobile applications in dermatology**

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The road goes both ways, as 65% of physicians use social media for professional purposes, perpetuating a robust online referral and marketing network that is increasingly patient driven. This extensive yet personal referral system is especially utilized by those coping with chronic conditions. In addition to service recommendations, social media users offer each other support and education. For example, Boston Children’s Hospital utilizes a number of disease-specific Facebook groups in which patients and caregivers can seek camaraderie and information about treatment options and programs available to them. Outside of these multipurpose social medial platforms, there also exist a number of specific forums (such as PatientsLikeMe), which allow patients to connect virtually with the shared interest in their own condition-specific care. Through these platforms, patients often provide emotional and social support for one another. Sometimes, a health care professional will be on the other end of the screen, answering online health questions and engaging patients. Unfortunately, despite perceived social support being continually linked with better health outcomes, social media–based discussions of health can just as easily lead consumers astray; the very same trust that is placed in online community members makes misinformation particularly impactful. Those offering health advice rarely have the training and qualification to do so, and reporting bias is not insignificant—it has been found that negative consequences of certain actions, such as the risk of melanoma in indoor tanning, are proportionally undermentioned in social forums. Similarly, many peer-reviewed academic journals are less likely to be found on social media, implying a lack of scientific rigor in the health information that users may be receiving. Nevertheless, social media remains a powerful conduit through which patients may engage and become an active participant in their health care.

Social media has become an important platform for public health information dissemination as it is able to quickly reach huge numbers of people, including individuals who may reside in geographically restricted or medically underserved areas. For example, as social media is heavily utilized in the youth demographic, platforms such as Twitter can be used to raise awareness of skin cancer risk. Dermatologic campaigns such as the recent “Don’t Fry Day” campaign on sun safety awareness and protection behaviors have shown promising results.

Direct-to-consumer genetics

In addition to the beginnings of social media, the early 2000s saw the emergence of direct-to-consumer (DTC) genetic testing—companies such as 23andMe and Color Genomics began to allow consumers to quickly and inexpensively assess their genetic markers and risks without the intervention of a health care professional. These new tools have a particular relevance to dermatology, with over 200 single nucleotide polymorphisms in the genetic code linked with a wide range of conditions, ranging from eczema to melanoma. Despite the well-documented skepticism amongst users and health care providers alike, DTC genetic testing may have positive impacts on users’ lifestyles and health habits, such as improved self-protection against preventable health risks and increased health care autonomy.

There is currently a dearth of conclusive evidence regarding how DTC testing shapes or influences health outcomes and a lack of consensus regarding even the psychological effects of engaging with these tests. There are a number of contradictory claims as to how DTC testing shapes or influences health outcomes and the psychological effects of engaging with these tests. There are a number of contradictory claims as to how DTC testing shapes or influences health outcomes and the psychological effects of engaging with these tests. There are a number of contradictory claims as to how DTC testing shapes or influences health outcomes and the psychological effects of engaging with these tests. There are a number of contradictory claims as to how DTC testing shapes or influences health outcomes and the psychological effects of engaging with these tests.
how DTC tests affect users’ anxiety: some literature claims that the act of taking a DTC genetic test lowers user anxiety, and other literature indicates that those psychological changes are ephemeral and insignificant.\textsuperscript{36,39,41} Behaviorally, these tests may serve as a catalyst for healthier habits. If a user interprets their results as indicating significant genetic risk for a disease, they may be incentivized to take preventative measures against it. For example, melanoma is one such disease with both genetic and environmental components; learning of genetic risk may motivate users to more actively avoid environmental risk exposure and self-screen more regularly.\textsuperscript{34} Given that around 90\% of melanomas are attributed to ultraviolet exposure, it is this subsequent behavior change that has the most promise for a positive impact on users’ health.\textsuperscript{11}

The documented primary motivators for undergoing DTC genetic testing for skin cancer were curiosity, perceptions of skin cancer, and anxiety.\textsuperscript{42} However, a clinical distinction presents itself between users who choose to share versus not share their results with a health care provider. A third of users choose to inform their provider of their results. Those who choose to disclose the information provided by their DTC genetic test tend to have better health habits and profiles than their nonsharing counterparts.\textsuperscript{35,36,39} Additionally, choosing to disclose genetic testing results with providers has the potential to improve clinical decision-making and personalized risk feedback for dermatologic patients.\textsuperscript{43} Unfortunately, however, physicians and patients alike report significant difficulty interpreting the results of DTC genetic tests.\textsuperscript{36} In fact, this trend in health care is so new that only recently have some residencies built a specific curriculum for dermatologic trainees to addresses and understand molecular diagnostics, genomics, and personalized medicine.\textsuperscript{44}

Harnessing information in research
Researchers have increasingly been able to capitalize on the vast amount of information that emerging technologies provide. The systematic collection of such data (ranging from health behaviors to biological analyses) has allowed researchers to gain access to large patient disease cohorts, identify new insights, and improve the quality of health care provided to patients.

System-wide capture of web-based searches has allowed researchers to describe patient interest in various health conditions and treatment options. In dermatology, analysis of Google Trends has provided insight into interest in disease-specific conditions such as melanoma,\textsuperscript{345} psoriasis,\textsuperscript{46} acne,\textsuperscript{47} eczema and dermatitis,\textsuperscript{48} hidradenitis suppurativa,\textsuperscript{49} and other dermatologic conditions.\textsuperscript{50,51} Such identification of interests and trends may have important health implications, allowing physicians and public health systems to work together to assess patient concerns on a more macroscopic level. For example, melanoma and related skin cancer search terms were noted to have higher interest in the summer, which may be the most effective time for educational interventions to raise awareness.\textsuperscript{52} Additionally, as search trends analyses can give geographic information on particular search terms, public health initiatives can be tailored to specific areas or be used to track the success of particular health campaigns (ie, searches for sunscreen in a particular geographic region).\textsuperscript{35,52,53}

Social media platforms have become important platforms for research. Researchers have been able to utilize social media platforms such as Facebook or Twitter to recruit patients to participate in clinical trials or disseminate information on emerging research.\textsuperscript{54-57} This has become particularly useful because social media is able to access populations that may be geographically isolated or have lower access to health care. Importantly, research involving social media use has proven useful in analyzing health care behaviors and outcomes. Analyses of Twitter hashtags have been used to shed insight on public perceptions and misconceptions of specific conditions such as acne, which can be used by providers to correct misconceptions about various dermatologic conditions.\textsuperscript{58} Similarly, analysis of Facebook nonprofit organizations related to skin cancer noted ways in which health information about skin cancer was disseminated and which forms may be most effective.\textsuperscript{59} Additionally, mining of social health networks was able to predict adverse skin drug reactions roughly 7 months in advance of literature reporting, representing an important opportunity to utilize information in social media for pharsomusurveillance.\textsuperscript{60}

DTC genetic testing has had important implications for research as researchers have been able to utilize large sources of genetic information and identify correlations for various diseases. For example, an estimated 5 million individuals have had their genome sequenced using 23andMe. As consumers are surveyed for various health behaviors and outcomes such as exposures and cancer, they contribute to a particularly rich information pool. Partnerships between industry and academic researchers in this regard have yielded a number of important findings relevant to dermatology. Analysis of large consumer-based genetic datasets have noted particular genetic associations in the development of dermatologic conditions; specifically, data yielded from DTC genetic tests elucidated 11 loci associated with the pathogenesis of squamous cell carcinoma,\textsuperscript{61} 14 new susceptibility loci for basal cell carcinoma,\textsuperscript{42} and 16 for psoriasis.\textsuperscript{63} These loci occur in pathways involved in tumor biology, telomere maintenance, immune regulation, and pigmentation, highlighting the important role of these processes in skin cancer development. These discoveries also provide potential biomarkers that can be incorporated into risk scores to provide information on an individual’s susceptibility for skin cancer, enabling identification of high-risk groups for early detection and prevention efforts.

Conclusion
Emerging technology is fundamentally changing the ways in which patients interact with the health care system. Web-based searches funnel massive amounts of interest-specific information towards users at incredible rates; mobile technology allows its consumers to carry the Internet, physicians, trusted friends and colleagues, multi-functional applications, and a camera in their pockets; social media enables people separated by any amount of distance to quickly exchange ideas and information; and DTC genetic testing provides users with the means to better understand their genetic composition and possibly flag markers of genetic risk. These newly popularized sources of information have inherent benefits and risks. While they all engage patients and would-be patients in taking more active roles in their health management and education, they run fairly high risks of disseminating incorrect information or even deterring professional health care utilization. Dermatology is
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especially impacted by these technologies because of the visible, chronic, and preventable nature of many of its conditions.

In addition to understanding how users interact with emerging technologies for their health care, it is important for physicians to understand the drawbacks of these modalities. Having been around for fewer than 2 decades, these technologies have few studies that evaluate how they impact health outcomes. There is a wealth of research yet to be done on how to best harness web-based searches, mobile technology, social media, and DTC genetic testing to improving the quality and equity of health care in the US.

References


