Will machines replace dermatologists in the diagnosis of skin disease?

Introduction

With recent advances in artificial intelligence (AI), not a week goes by without an article with a catchy headline stating that a certain medical specialty will soon be replaced by "robots" appearing in the media. But are such claims substantiated? In this essay, I hope to explore this fascinating topic through, firstly, examining recent literature on the role of AI technologies such as *deep learning convolutional neural networks* in the diagnosis of dermatological disease. Secondly, I will outline some of the existing technologies that aim to *complement* contemporary dermatologic practices, including teledermatology, mobile dermoscopy/dermatoscopy and smartphone apps. Finally, I intend to briefly discuss *patient-centred care* as applicable to AI in dermatology. Throughout the essay, I will draw on some relevant personal experiences both as a student doctor and as a patient to, hopefully, provide the reader with additional context for my perspective. Due to the concerningly high rates and thus utmost public health importance of melanoma in the New Zealand realm[1], as well as breath of the topic, for the purposes of this entry I am going to focus on the use of AI and other technological tools in detection of *melanocytic cancer* specifically, while also recognizing that these may be successfully utilized to diagnose other types of skin disease, too.

Recent advances of AI and machine learning in dermatology

As alluded to in the introduction, of particular interest to dermatology is the concept of deep learning convolutional neural networks (CNNs), which are artificial, feed-forward neural networks capable of analysing and learning from visual imagery.[2,3] CNNs are able to improve their future performance according to their previous experiences in image recognition and classification – this process is referred as machine learning.[2,3] The concept of CNNs has become especially topical after the results of a study by Esteva et al. have been published in *Nature* in 2017.[4] In this landmark study (the largest of its kind), over 100000 biopsy-backed clinical photographs were used to teach a deep CNN-based algorithm to discern malignant skin lesions from their benign mimickers.[4] When asked to differentiate between, firstly, melanomas and benign naevi, and, secondly, keratinocyte (i.e. non-melanocytic) carcinomas and seborrheic keratoses, the CNN system performed *comparably* to a cohort of 21 board-certified dermatologists.[4] For the first time, successful utilisation of a computer algorithm capable of expert level of thinking was demonstrated for a (usually rather subjective) task which is of increasing importance in everyday dermatological practice.

Just over a year later, Haenssle et al. reported that a deep learning CNN that was trained specifically to distinguish dermatoscopic images of benign and malignant melanocytic lesions has shown, on average, *superior* performance in terms of both sensitivity and specificity when compared to an international panel of 51 dermatologists, more than half of whom were considered experts with 5+ years of dermatoscopic experience.[5] When additional clinical information was provided to the dermatologists (to simulate the real life setting more closely), their overall sensitivity was improved, yet the algorithm still outperformed clinicians in terms of specificity.[5] Therefore, it was suggested that a competently trained CNN may be a helpful addition to any dermatologist's diagnostic toolbox, regardless of their level of expertise.[5,6]

Earlier this year, I had the privilege of attending and presenting at the NZDSi Annual Conference. Two of the scheduled sessions addressed the topic of machine learning and AI in melanoma diagnosis. These talks, which heavily featured data from the two studies described above, stimulated heated discussion among dermatologists. It soon became obvious that at present, even experts may not necessarily be able to reach an agreement: some were sceptical about the technical abilities of AI or expressed concerns regarding patient satisfaction, whereas others warmly welcomed the idea of incorporating CNN systems into their practice provided it reliably results in fewer missed cancerous lesions and misdiagnosed benign ones.

While, understandably, there is a considerable amount of excitement surrounding CNN, tangible benefits of the demonstrated accuracy and efficiency of this technology may still be distant.[4-6] This is because initial CNN training requires a substantial amount of resources and time, and actual implementation into routine clinical practice is only possible once local medicolegal boundaries are better defined, and security risks are addressed.[4-6]

Other technology for the most visual specialty

It has been postulated that because of the highly visual nature of diagnosis and management of skin conditions, modern technology constitutes an especially valuable addition to dermatology – perhaps, even more so than any other medical specialty.[7,8] The number of now routine dermatological practices that heavily rely on machines of various kinds (not necessarily AI-based) for visual assessment of skin disease in one form or another is vast: among them are whole body photography, dermatoscopy and teledermatology.[7-10]

Given the recent surge of interest in healthcare-related technology, it is not surprising that personal electronic devices are being increasingly utilized by healthcare professionals.[7,8] Indeed, I have personally witnessed

numerous dermatologists regularly utilize their mobile phones in their everyday practice, whether to quickly access reputable reference sources (such as DermNetNZ), or to use convenient smartphone dermoscope attachments, which are becoming increasingly popular (not to mention conventional dermoscopy, which can be considered the gold standard of clinical dermatologic assessment today).[7,8]

With the rise of telemedicine, mobile devices and computers are now becoming increasingly important for patients with skin problems, too, especially those who may struggle to access in-person dermatology advice (for example, individuals from rural/remote or low socioeconomic status communities).[9,10] While both the store-and-forward and live interactive forms of teledermatology have limitations (such as security issues or inability to incorporate palpation, a core component of skin examination), research suggests that, overall, teledermatology is a promising way of efficiently delivering quality dermatological care at a (typically) lower cost compared to conventional face-to-face visits.[8-11]

Smartphone applications

Over the last couple of years, countless smartphone applications and internet websites that aim to educate, diagnose, or even help manage various health conditions, have become available to both the general public and the physician community.[12,13] Among the more popular ones are apps designed specifically to help consumers detect malignant skin lesions (especially melanomas) at home.[14-18] Some of these are designed to be more of a triage tool, whereas others virtually aim to replace a dermatologist's consult; importantly, most have ambiguous legal/regulatory status.[14-18] Because of heterogeneity in the software employed in such apps and in their purpose, the diagnostic accuracy and thus practical utility of this class of apps as a whole is difficult to evaluate.[14-18] According to a large 2018 systematic review conducted by Rat et al., automated smartphone medical apps aimed at melanoma diagnosis are currently considered to be unreliable from accuracy and safety standpoints.[18] Issues commonly reported in the literature include unacceptable rates of false positive results, which could result in unwarranted patient anxiety and increase in demand for unnecessary specialist care, as well as high false negative rates and thus missed opportunities for timely identification and treatment of potentially dangerous skin lesions due to false reassurance.[14-18] The latter especially raises the complex issue of medicolegal liability.[18] Regardless, these tools remain a popular conversation topic among patients: during my time as a student attached to dermatology and GP clinics, discussions around "self-assessment" skin-check apps were a near everyday occurrence.

Way forward

Clearly, considerable efforts to improve melanoma-detecting apps are required before they can become appropriate and widely accepted alternatives for proper clinical skin specialist consultations.[14-18] However, with the impressive results that research groups led by Esteva and Haennsle achieved using deep neural networks in mind, it is not unreasonable to infer that if similar CNN technology could be competently trained and incorporated into a user-friendly phone application, it would represent a major step forward for skin cancer-detecting apps from a diagnostic accuracy standpoint.[4-6,18] It would also be curious to observe the future interplay of fields of whole body photography, mobile dermoscopy, teledermatology and modern AI – a successful fusion of these technologies could facilitate the diagnostic process even further and benefit *everyone* involved in the detection and treatment of skin cancer, from patients themselves to experts.[4-6,8-10,13,14] Uncertainty regarding dermatological diagnoses is prevalent among primary care practitioners: despite skin complaints comprising a considerable portion of general practice, many GPs lack formal dermatological training and/or expertise.[19] Thus, advent of a CNN-based tool for the purposes of decision-making support could be very helpful in the community setting as it could improve system efficiency and reduce the burden of unnecessary referrals to specialists.[6,19] Dermatologists that currently look after the high-risk patients would also benefit from AI-based apps due to streamlined targeted surveillance process, while patients themselves may enjoy the enhanced convenience and reliability of self-skin checks.[6,12,13,18]

Touch and empathy VS technology

Finally, I wanted to touch on some of the more philosophical aspects of the interplay of technology and doctor-patient relationship by reflecting on my own recent experience as a patient evaluated and treated for a pigmented skin lesion suspicious for malignancy. Without going into too much detail, it was a drawn-out, stressful affair comprised of long periods of waiting and uncertainty, multiple referrals, appointments and, finally, surgery. This process could probably be vastly simplified, had the timely utilization of technology such as CNN been possible. However, despite being inefficient and frustrating at times, the overall experience ended up being memorable in a good way because of the wonderful advice, respect, empathy and reassurance offered by the doctors I encountered on my journey as a patient. At the time of writing this, I still do not know the result of the biopsy, but I do know that, no matter the histological outcome, *personally* I would not have traded the excellent in-person care I received for a quicker, definitive diagnosis made by a computer algorithm.

Upon reviewing relevant literature, I discovered that similar sentiments (i.e. valuing compassionate, respectful treatment over efficiency or technical skills in the healthcare setting) are not uncommon among patients.[20-22] Indeed, the positive influence of warm, patient-centric communication and of the act of physical examination on the doctor-patient relationship is a well-documented theme in medical and social sciences literature.[23] Despite claims that traditionally taught "doctoring" and interpersonal skills are losing importance in the age of modern medicine characterized by staggering technological advance, or that the imperfect art of clinical examination is slowly become obsolete, evidence suggests that patient-centred care (which relies heavily on thoughtful utilization of these

long-established modalities) still appears to be the key to patient satisfaction.[21-24] It has even been postulated that biomedical developments may actually widen both the psychological and physical distance between doctors and patients, although further research is needed to explore this effect.[24] While computer-aided diagnostic systems are abundant and have unique, undisputable advantages[25], they obviously cannot (yet!) incorporate empathy and physical touch as powerful ways of connecting with and healing the patients with skin conditions.[5]

Conclusion

In 2018, both clinicians and patients are equipped with a variety of technological tools that may aid them in the diagnosis of skin conditions. These range from the popular self-assessment mobile applications to the more formal use of personal electronic devices for the purposes of communicating with a specialist (as in teledermatology). While CNN-trained AI has recently shown some truly impressive abilities in detection of skin cancers, by no means does this represent a replacement for all aspects of traditional physician consultations such as thorough history taking, physical examination, human touch and empathy. After all, good medical practice is about much more than solely diagnostic accuracy. Furthermore, heavy reliance of medical practices on any technology inevitably brings with it a unique set of concerns (including legality and cybersecurity issues) which must be adequately addressed before widespread implementation is possible.

To conclude, despite significant technological advances in recent years, I do not believe that machines will replace dermatologists in the diagnosis of skin disease (including, but not limited to malignant melanoma) any time soon. In my opinion, the emphasis should be on using the ever-evolving technology to complement and augment the conventional skillset of physicians, rather than to replace doctors altogether. Such "symbiosis" could then, hopefully, help us achieve enhanced rates of access to high-quality, appropriate dermatological care and improved outcomes in patients with melanoma and other skin disease in the most efficient and economical way possible.

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