Dermatology skin cancer applications: the future of healthcare provision?

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Abstract

With 6.3 billion smartphone subscriptions estimated to be in use by 2021, the field of telemedicine and specifically teledermatology has begun a period of evolving growth and there is now widespread availability of skin cancer-related dermatology applications (apps). The aim of this review is to evaluate the benefits and limitations of skin cancer apps and teledermatology.

A variety of apps are available for public download. Examples of apps include teledermatology, photo storage, risk calculation, and educational apps. Apps that sent images directly to a dermatologist had the higher specificity and sensitivity (97% and 88% respectively). The second most effective apps (73% sensitivity and 83% specificity) use fractal theory analysis algorithms.

The benefits of teledermatology include education, encouragement of personal responsibility, effective triage, and provision of equitable services to remote areas. Early diagnosis results in up to 99% five-year survival, compared with 20% when diagnosed at stage four. However, there is a lack of validation, regulation and scientific input into apps. Studies are required to evidence a safe and efficient teledermatology service in the UK.

As suggested by the British Association of Dermatologists, teledermatology apps have benefits when integrated in care as a first step in early detection. Concerns regarding encryption of images and accountability for inaccurate diagnoses made by apps should be addressed. According to NICE, patients with potential skin malignancy should be seen in person by specialists. Therefore, apps can currently supplement but not substitute standard medical care.

1 Introduction

In the UK, 50% of dermatology referrals relate to skin cancer, with melanoma being the fifth most common cancer, accounting for 4% of incident cancers (Cancer Research UK, n.d.; Levell, Jones, & Bunker, 2013). Timely diagnosis results in 99% 5-year survival, compared with 20% if diagnosis occurs at stage four (Cancer Research UK, n.d.). Consequently, the early detection of skin cancer is central to improving prognosis. With 6.3 billion smartphone subscriptions estimated to be in use by 2021, the field of telemedicine and specifically teledermatology has begun a period of growth and there is now widespread availability of skin cancer-related dermatology applications (apps) (Perednia & Brown, 1995; Senior, 2011). Although promising advancements are being made, the British Association of Dermatologists is concerned about their overall
effectiveness (British Association of Dermatologists, 2010). Acknowledging and evaluating the benefits and limitations of such apps is paramount to their future development.

2 Overview of applications available for download

A variety of melanoma-detecting apps are available for download by non-specialist users, ranging from teledermatology, photo storage/monitoring, melanoma risk calculation and skin cancer education (Kassianos, Emery, Murchie, & Walter, 2015). Studies report that diagnostic accuracy and sensitivity of melanoma diagnosis differs depending on the way the image is interpreted, with sensitivity ranging from 6.8-91.8% (Wolf et al., 2013). The methods with the higher sensitivity and specificity for melanoma diagnosis were those that sent the image directly to a dermatologist for analysis (88% sensitivity, 97% specificity) (Wolf et al., 2013). The second most effective apps (73% sensitivity and 83% specificity) used fractal theory analysis algorithms to assess the risk of pigmented moles by identifying geometric features of irregular shapes, including the number of distinct regions with different textures (Brewer et al., 2013; Maier et al., 2015). The algorithm recognises ‘low-risk’ lesions as having regular patterns compared to the varying textures and irregular borders of higher risk lesions (Brewer et al., 2013). These apps can subsequently advise those who score at least a ‘medium-risk’ to obtain a consultation and those with ‘low-risk’ to archive the mole and observe any changes (Brewer et al., 2013).

In the UK, the use of store-and-forward teledermatology has been proposed as a service delivery model to manage capacity demands as real-time teledermatology is not cost-effective (Wootton et al., 2000). TELEDerm is being increasingly implemented around the UK and following patient consent, general practitioners or nurses record a clinical history using the TELEDerm App and upload and send a dermatoscopic image to a secure server over Wi-Fi to be assessed by dermatologists or skin specialist general practitioners (Soyer et al., 2005).

3 Benefits of skin cancer applications

Teledermatology can educate users on skin cancer, encourage personal responsibility, and provide equitable services to remote areas, allowing primary care professionals to refer patients to secondary care from a distance (Perednia & Brown, 1995). As limited dermatologic expertise in rural areas increases the risk of skin-related death, the development of such apps means that patients could receive dermatologic advice and education without great travel expenses (Perednia & Brown, 1995).

Studies show that when high quality images taken by trained personnel (trained practising dermatologists or dermatology specialist nurses) are accompanied by a clear clinical history, teledermatology is an effective triaging tool (Halpern, 2010; Tan, Yung, Jameson, Oakley, & Rademaker, 2010). TELEDerm apps require a clinical history, which increases diagnostic accuracy from 57% to 70% (Oztas et al., 2004). The process is also time effective, taking four minutes with 95% of reports being issued the following day (Soyer et al., 2005). Therefore, considering 88% of two-week wait referrals for suspected skin cancers are non-malignant, patients with suspicious skin lesions can be seen in the most appropriate setting at first appointment via the two-week wait, ensuring timely treatment and alleviating NHS pressures, especially with the current deficit of dermatologists (Cox, 2004; Tan et al., 2010). This integrated method of teledermatology using teledermatoscopy is the most effective way of using apps in care and is accessible for less technologically aware elderly, who have the highest rates of skin cancer (Garcovich et al., 2017; Halpern, 2010).

Apps focused on patient education are useful public health tools that can be used to raise awareness around skin cancer and administer prevention advice (Finch, Janda, Loescher, & Hacker, 2016). Photoaging apps have also been designed for melanoma prevention (Brinker et al., 2017). However, specific studies examining the effectiveness of such apps within risk groups from a range of cultural backgrounds are required (Brinker et al., 2017). Photo storage apps allow for monitoring of suspicious skin lesions, which can be useful to assess change over time.

With regards to future advancements, deep convolutional neural networks can be as effective as dermatologists at differentiating between benign naevi and malignant melanomas, providing promising opportunity for this mechanism to be incorporated into future apps (Esteva et al., 2017). The use of these apps could result in cost effective, early diagnosis, if they are implemented and regulated appropriately. For example, if the algorithm identifies the lesion as suspicious or is uncertain, users can subsequently be advised to gain expert advice via a consultation, leading to patients presenting to their dermatologist earlier (Brewer et al., 2013).

Additionally, mobile apps can also be used to aid physicians in clinical practice. The American Academy of Dermatology launched a mobile app to provide users with evidence-based guidance on which types of skin cancer cases are most appropriate for Mohs surgery, used to treat basal and squamous cell carcinomas (American Academy of Dermatology, 2017). Patient and tumour characteristics and risk are considered, whilst also providing an opportunity for patient education (American Academy of Dermatology, 2017). This ensures that the highest quality care can be delivered to those who will benefit most from Mohs surgery (American Academy of Dermatology, 2017).

4 Limitations of skin cancer applications

First and foremost, there are no rigorous UK published trials to confirm that teledermatology does indeed provide a safe, efficient service and so, it remains less advantageous than a face-to-face consultation with a dermatologist in the assessment of malignant potential (Gilmour et al., 1998; Piccolo et al., 2000, 1999). Despite studies reporting high rates of diagnostic accuracy using teledermoscopy for suspected skin malignancy, uncertainty still exists in the diagnosis of melanoma using teledermoscopy alone (Levin & Warshaw, 2009; Moreno-Ramirez et al., 2007; Warshaw et al., 2009). According to the National Institute for Health and Care Excellence, the current practise for skin cancer diagnosis involves a thorough history and examination, dermatoscopic analysis...
and histopathology (The National Institute for Health and Care Excellence, 2010).

There are issues surrounding the lack of validation, regulation, scientific and specialty input of the apps available for non-specialist users to download, leading to concerns about delayed and misdiagnosis, especially when a naevus is falsely identified as ‘low-risk’ (Levin & Warshaw, 2009). For example, amelanotic melanomas may not be correctly identified by the colour and pattern recognition software. Therefore, suboptimal app implementation and reliance on apps can severely compromise patient health, especially if users mistakenly believe that the app’s evaluation is a substitute for professional medical advice (Maier et al., 2015).

Importantly, evidence surrounding the effectiveness of these apps is only focused on melanoma detection, limiting the extent of conclusions drawn. As pattern recognition apps are currently unable to recognise scaly, crusted or ulcerated areas, if the app reports that the patient is ‘low-risk’ for skin cancer, it is purely excluding a melanoma, without considering the possibility of basal and squamous cell carcinomas (Maier et al., 2015). Therefore, the diagnosis of these cancers may be missed, and treatment delayed, especially since users may not be aware of different types of skin cancer. Research has shown that such delay or failure in diagnosis combined with a lack of timely inclusion of a Mohs Surgeon, are the most common reasons for liability claims for Mohs Surgery (D’Souza et al., 2015). Closer coordination of care between non-Mohs and Mohs surgeons has been suggested to improve patient outcomes and reduce liability claims, but teledermatology apps could further hinder effective coordination, delaying diagnosis (D’Souza et al., 2015).

The inability of apps to construct differential diagnoses and recognise pre-cancerous conditions such as actinic keratoses and Bowen’s disease, means that they will be reported as ‘low-risk’ by the app (Maier et al., 2015). Ignoring these lesions may postpone treatment and increase the likelihood of the patient developing a more advanced and difficult to treat cancer. Apps do not have capacity to differentiate non-cancerous pigmented lesions such as seborrheic keratosis, which may risk a false positive result (Maier et al., 2015). This will lead to pressures on the two-week wait system and create unnecessary anxiety for the patient (Wolf et al., 2013).

Apps which send images to dermatologists for review are limited in accuracy by the experience of the teledermatologist and user error (Brewer et al., 2013), whilst app algorithms only give reliable results when all disturbing factors, including poor lighting and low image quality, were excluded (Maier et al., 2015). Specifically, large, ulcerated lesions or lesions surrounded by mottled skin or other naevi are difficult to evaluate, with ulcerated lesions inducing glowing (Maier et al., 2015). Additionally, users may also be concerned with the wrong naevi, focusing on those that are more noticeable and in exposed areas rather than more discrete lesions, which would be identified during full body clinical examination in a dermatology appointment (Kantor & Kantor, 2009). Therefore, the possibility of human error limits the accuracy of apps.

5 Conclusions

As suggested by the British Association of Dermatologists, the development of apps using teledermatology and fractal analysis has benefits when integrated into care as a first step in early detection, if they are used in a regulated, validated manner, with a focus on patient education (Maier et al., 2015). To avoid harm to users, apps should be reviewed to ensure that they do not deceptively claim accurate diagnosis or calculation of melanoma risk, and that scientific evaluation of apps is published. Concerns regarding accountability for inaccurate diagnoses made by apps need to be addressed. Encryption of images, patient consent to photographic documentation and strict adherence to European guidelines on information collection are essential considerations for teledermatology (British Association of Dermatologists, 2010; The European Commission and EU Member States, 2008). Further UK-based research into the efficacy, acceptability, and economic viability of teledermatology is required before it can be recommended as a widespread method for skin cancer triage (British Association of Dermatologists, 2010; Eedy D J, 2001).

According to the National Institute for Health and Care Excellence, patients with potential skin malignancy should be seen in person by specialists (The National Institute for Health and Care Excellence, 2010). Therefore, apps can currently supplement but not substitute standard medical care.

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No conflicts of interest have been declared by any authors.

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