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Smartphone Mobile Applications to Enhance Diagnosis of Skin Cancer: A Guide for the Rural Practitioner

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Abstract

Primary care physicians occupy a vital position to impact many devastating conditions, especially those dependent upon early diagnosis, such as skin cancer. Skin cancer is the most common cancer in the United States and despite improvements in skin cancer therapy, patients with a delay in diagnosis and advanced disease continue to have a grave prognosis. Due to a variety of barriers, advanced stages of skin cancer are more prominent in rural populations. In order to improve early diagnosis four things are paramount: increased patient participation in prevention methods, establishment of screening guidelines, increased diagnostic accuracy of malignant lesions, and easier access to dermatologists. Recent expansion in smartphone mobile application technology offers simple ways for rural practitioners to address these problems. More than 100,000 health related applications are currently available, with over 200 covering dermatology. This review will evaluate the newest and most useful of those applications offered to enhance the prevention and early diagnosis of skin cancer, particularly in the rural population.

Introduction

Skin cancer is the most common cancer in the United States. More than 3.5 million new cases occur

annually, and these numbers continue to rise.¹ Of the three most common types of skin cancer, melanoma is the most deadly, accounting for more than 75% of all skin-cancer deaths.² The lethality of melanoma is directly dependent upon the stage of the cancer at the time of diagnosis.³ If diagnosed early, almost all skin cancer can be successfully treated. However, those with delayed diagnosis and advanced disease continue to have a grave prognosis.⁴

Many barriers must be overcome in order to increase early detection and survival rates. Low patient participation in prevention methods, a lack of appropriate screening, inaccurate diagnoses, and significant time backlogs for examinations by dermatologists are problems that must be addressed.⁵⁻⁹ Primary care physicians (PCPs) and physician extenders are the first line of defense to address these factors. The demand for effective and efficient delivery of health care by PCPs will become even greater in the near future, as a massive shortage of physicians of more than 91,000 is expected by 2020.¹⁰ All areas will surely be affected; however, the impact on preexisting underserved rural populations will be more severe. Fortunately, new innovations in smartphone mobile technology provide a means to assist PCPs when dermatology referral is limited.

A smartphone is a mobile telephone that functions as a touch screen computer, digital camera, and GPS navigation unit. It also acts as a platform for running software programs called mobile applications, or "apps." A great number of health care providers and future physicians are using mobile apps to deliver more efficient and effective health care.¹¹⁻¹⁴ These apps function as

decision support tools, clinical references, patient-education tools, and provide online consultation to areas where specialists are limited. Recent expansion in app technology offers assistance to rural physicians in the prevention, screening, and management of skin cancer. There are more than 5,860 medical apps currently available, and this review will be evaluating the newest and most useful for dermatological diagnosis in a rural setting (Table 1).¹⁵

Primary Prevention Applications

Ultraviolet radiation (UVR) exposure is a major risk factor for the development of skin cancer.¹⁶⁻¹⁹ Despite being an established carcinogen, many Americans fail to follow sun protection recommendations and a substantial portion of adolescents and young adults continue to engage in indoor tanning.²⁰⁻²¹ Even more disturbing is the fact that only 60% of parents apply sunscreen and only 25% use shade to protect their children.²² People from underserved groups are even less inclined to practice protective behaviors.²³ Accordingly, the U.S. Preventive Service Task force (USPSTF) now recommends PCPs to counsel children and young adults on ways to minimize their exposure to UV radiation.²⁴

The Environmental Protection Agency developed a standard by which the strength of UVR is measured, called the UV index (UVI). Multiple mobile applications for UVI are available, functioning as tools to enhance daily awareness and increase proper sun protection. After review of the apps, the following was the most inclusive and cost efficient.

App: [UV US – Weather Forecast, UV index and Alerts](#)²⁵.

Cost: Free



Overview: The US National Weather Service supplies the current and forecast UVI and weather for the user’s city, which is an advantage over similar apps that require user input of weather conditions and UVI to determine risk of skin damage. The “Time to Burn” function gives an estimated time of allowable exposure based upon the UVI, weather conditions, skin type, environment, and SPF. A “UV Hazard Alert” is also featured, which notifies the user once the UVI exceeds a certain threshold.

Pros

- Provides current and forecast UVI and weather
- Text alert when UVI is forecast to be high
- Provides accurate estimates of allowable sun exposure

Cons

- None

Conclusion: Essential prevention tool for all patients and practitioners.

Screening Applications

One problem limiting early diagnosis of melanoma is the lack of universal skin cancer screening protocols. Most authorities agree that those at high risk for melanoma require regular screening and monitoring (Table 2). Although a consensus and risk factors have been established, more than 40% of physicians fail to routinely perform full body skin examinations on their high-risk patients.^{7,26} Absence of formal resident education may be a contributing factor, as one

study found more than 75% of U.S. residents had never been trained to perform a skin cancer examination, and 55% had never even observed an exam.²⁷

In addition to physician education, patient education and participation also plays a key role in early detection. A substantial portion of melanomas are diagnosed by self skin-examination (SSE).²⁸⁻³¹ Many studies have validated that when performed correctly and routinely, SSEs reduce the mortality and morbidity of skin cancer in high risk patients.³²⁻³⁶ However, the majority of the population does not perform regular SSEs, and those performing SSEs do it incorrectly.³⁷⁻³⁹ The new mobile apps provide a means to overcome these screening limitations by directly facilitating patient participation and supplying quality education, which ensures SSEs are performed regularly and correctly.⁴⁰⁻⁴² Using total body photographs as objective evidence for baseline exams, the apps permit accurate monitoring of suspicious lesions and make physician-patient encounters more efficient with physician examination paramount for suspicious lesions.^{43,44} After review of apps, the following two were the most appropriate for screening applications.

App: [UMSkinCheck](#)⁴⁵

Cost: Free



Overview: Developed by University of Michigan, this app provides easy-to-follow instructions to perform a thorough SSE. The “Full-Body Survey” involves taking 23 photographs in 7 positions, which serves as a baseline for future lesion

comparison. The “Lesion Tracker” photographs and documents the exact location of suspicious lesions. A monthly reminder function ensures follow up. The “Risk Calculator” determines the absolute risk of developing melanoma based upon ten previously determined risk factors.⁴⁶ An introduction to the ABCDE criteria (Asymmetry, Border irregularity, Color variegation, Diameter >6mm, and Evolution) is also included for patient education.

Pros

- Step-by-step instructions for performing SSE
- “Lesion tracker” facilitates direct patient involvement
- Allows quick identification of high risk patients
- Password protection for security

Cons

- Requires a second person to perform the full-body survey
- No way to retrieve password if forgotten; must uninstall the application, resulting in loss of all data

Conclusion: Best overall tool for lesion tracking and SSE for high-risk patients.

App: [Doctor Mole](#)⁴⁷

Cost: \$4.99



Overview: Suspicious lesions are photographed and computer software analyzes lesion for asymmetry, border, and color. User estimates diameter and then evolution by using the photograph comparison function.

Pros

- Provides objective interpretation of ABCDE criteria for skin lesions

- Reminder function ensures follow-up

Cons

- Computer software has not been validated
- Tendency of patients to self-diagnose and delay visit to physician

Conclusion: Potential adjunct for lesion tracking, however, recommendation is reserved due to lack of validity and potential patient misuse.

Clinical Decision Support Applications

Dermoscopy

Lacking advanced training, the diagnostic accuracy of skin cancer diagnosis by PCPs is inferior to that of dermatologists.^{48,49} This discrepancy leads to a higher rate of referral for benign lesions, increased costs to patients, and limits access to dermatologists. Additionally, an increased number of malignancies are overlooked. One solution to this problem is dermoscopy.

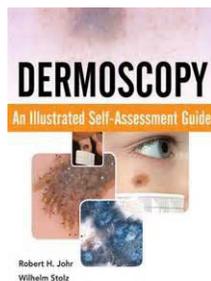
Dermoscopy is a non-invasive clinical examination that utilizes a dermatoscope, a hand-held light magnifier, to visualize skin lesions in detail. This technique can distinguish benign versus malignant lesions based on pattern morphologies of magnified lesions. Multiple studies have documented the clinical usefulness of dermoscopy in aiding the diagnosis of melanoma. In one study, the diagnostic sensitivity of PCPs increased from 54% to 79% after only one day of training.⁵⁰ Another demonstrated that with proper training and experience, dermoscopy increased the diagnostic accuracy by more than 40%.⁵¹ These improvements have been validated by multiple meta-analyses and randomized trials.⁵²⁻⁵⁵ Dermoscopy has also proven useful for triaging skin lesions in areas where access to dermatologists is limited.^{50,56}

In the past, perceived time commitments have been one limiting factor to the use of dermoscopy, as traditional contact non-polarized dermatoscopes (NPD) required lesion immersion with fluid before examination. However, the advent of polarized dermatoscopes (PD) now allows more convenient and efficient evaluation without immersion fluid, and offers better visualizations of deeper structures within the lesion.⁵⁷ Several apps that are compatible with dermatoscopes allow physicians to capture and digitally store high-resolution photographs.

The reviews for dermatoscopes are limited, but several can be purchased for less than \$500. Overall, the new DermLite DL3N⁵⁸ dermatoscope is the most versatile and has superb resolution. It functions as both a polarized and non-polarized dermatoscope, with or without immersion fluid, which allows the visualization of vessels and red areas, as well as recognition of regression areas by enhancing lighter colors and blue-white areas.⁵⁷ It also features new PigmentBoost™ illumination, which allows color temperature selection and improves visualization of pigmented structures.

App: [Dermoscopy: An Illustrated Self-Assessment Guide](#)⁵⁹

Cost: \$94.99



Overview: Based on the textbook version from McGraw-Hill, this app is arranged in 5 chapters of high-yield dermoscopy. The first chapter introduces the core principles of dermoscopy, then explains “The Two-Step Algorithm” used in analysis of a suspicious lesion. The

remaining chapters are organized as a series of cases grouped by anatomical location and major dermoscopic features. Each case presents a history and multiple associated dermoscopy images, followed by a quiz on the criteria, risk level, diagnosis, and management of the lesion in question.

Pros:

- 191 comprehensive cases, including 95 melanoma cases and most likely imitators.
- Detailed dermoscopic images with clear labeling of dermoscopic features.
- Organized layout allows easy navigation of material.

Cons:

- Price

Conclusion: Excellent introductory text to dermoscopy.

App: [Handyscope](#)⁶⁰

Cost: \$6.99



Overview: The user's smartphone is connected to a compatible dermatoscope, creating a high-resolution digital dermatoscope. Each image can be stored on a HIPPA-compliant “FotoFinder Hub” server or emailed to the physician's computer via SSL-encrypted messages. This permits instant documentation and allows for easy consultation to online or local dermatologists. The images can also be stored locally to patient profiles created within the app. For security precautions, a password can be enabled for the app.

Pros

- Quality dermoscopic images
- Secure storage for backup and consultation service

- User-friendly instant documentation and consultation

Cons

- Requires a dermatoscope for premium quality images
- Price

Conclusion: Essential point-of-care tool that will lead to greater efficiency and efficacy in skin cancer diagnosis.

Mobile Teledermatology

The average waiting time for a new patient dermatologist visit is 38 days, and the wait for surgery may be even longer.^{61,62} Teledermatology (TD) may be a viable solution to provide faster dermatologic care, especially in underserved areas.⁶³ TD entails photographing a suspicious lesion, sending these images along with clinically relevant information to an online board-certified dermatologist, or teledermatologist, who then evaluates the lesion, gives the diagnosis, and recommends a treatment plan (medication, biopsy, or referral to a local dermatologist) within 48-72 hours.⁶⁴

The clinical utility of TD depends on the quality of the image, time requirement for consultation, index lesion imaged, and cost. When image quality is poor, the confidence and diagnostic accuracy of teledermatologists are low.^{65,66} However, when dermoscopy is used in conjunction with teledermatology, hence teledermoscopy, the sensitivity and specificity for detecting skin cancer increase to 100% and 90%, respectively.⁶⁷⁻⁶⁹ Studies have shown that teledermoscopy is an effective triage tool with comparable diagnostic accuracy to in-person examinations.^{63,69-72} Teledermoscopy reduces costs, avoids unnecessary biopsies, and decreases the time to initial therapy.^{63,69,74} Patient satisfaction with teledermoscopy is nearly identical to in-person visits.^{75,76}

Although teledermoscopy yields a high degree of diagnostic accuracy for index lesions, referring physicians must not neglect the total body skin examination, as clinically significant lesions could go unnoticed.⁷⁷

In the past, widespread adoption of TD was limited by time requirements for consultation, as some web-based services take up to nineteen minutes for each teleconsultation.⁷⁸ New mobile apps provide a means to compensate for these limitations by using a HIPPA-compliant server for both storage and teleconsultation, allowing physicians to simply store and forward.^{70,71}

Mobile applications for TD exist for both local and international dermatologists. However, most consultations are not covered by insurance, so patients must absorb the cost. Fortunately, AccessDerm-2⁷⁹, an app created by American Academy of Dermatology (AAD), eludes this financial burden.

App: AccessDerm-2⁷⁹

Cost: Free



Overview: AAD-sponsored teledermatology program that gives PCPs who work in participating clinics, free access to AAD dermatologists.

Pros:

- Free and instant access to dermatology expertise for underserved areas

Cons:

- Currently limited to only 16 states

Conclusion: Promising app for future dermatologic care in underserved areas.

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Patient Reference Applications

Many mobile apps provide vast amounts of quality information; however, app content isn't heavily regulated. This creates the potential for patient misinformation. Directing patients toward quality resources will not only eliminate misinformation, but will also fill knowledge gaps not addressed during regular office visits.

App: Dermatology A-Z⁸⁰

Cost: Free



Overview: This app is an excellent patient educational tool that covers many dermatological conditions. A description and image for each disease is provided, as well as the epidemiology and etiology, signs and symptoms, diagnostic workup, treatment, and prognosis. Also featured is the "Find a Dermatologist" function, which locates dermatologists in the surrounding area.

Pros

- Eliminates misinformation
- Simplicity, includes descriptions in terms usable by a layperson
- Quick access to local dermatologist contact information

Cons

- None

Conclusion: Reliable reference tool for all patients.

Conclusion

Mobile application technology offers a simple, inexpensive, and efficient solution in the early diagnosis and treatment of skin cancer. From providing the ability to quickly and efficiently screen suspicious lesions, to obtaining efficient referral and consultation with a dermatologist; these apps provide a convenient platform to be used by both health care professionals and the public. Dissemination and incorporation of these apps into everyday practice and in public awareness campaigns is critical to increase the early diagnosis rate for all skin cancers.

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Appendix

Table 1. Smartphone mobile applications for skin cancer prevention, screening, and management.

Application	Function	Suggested user	Platform	Cost
UV US – Weather Forecast, UV index and Alerts ²⁵	Prevention	All patients	iPhone	Free
UMSkinCheck ⁴⁵	Risk assessment Screening	High risk patients Health care providers Students	iPhone	Free
Doctor Mole ⁴⁷	Screening	High-risk patients	iPhone Android	\$4.99
Dermoscopy: An Illustrated Self-Assessment Guide ⁵⁹	Medical education	Health care providers Students	iPhone	\$94.99
Handyscope ⁶⁰	Clinical decision support tool Online Consultation	Health care providers Students	iPhone	\$6.99
AccessDerm ⁷⁹	Online Consultation	Health care providers Students	iPhone Android	Free
Dermatology A-Z ⁸⁰	Patient Reference	All patients	iPhone Android	Free

Table 2. Guidelines for skin cancer screening.

Authority	Recommendations
United States Preventive Service Task Force ⁸¹	<ul style="list-style-type: none"> • Insufficient evidence to determine whether a decrease in mortality occurs with routine whole body skin examination in low risk patients by PCPs or self-examination. However, physicians should remain alert for skin lesions with malignant features while performing physical examinations. • Recommends that patients at high risk of melanoma, such as those with first-degree family history, be referred to dermatologist for screening examinations and monitoring.
American Academy of Dermatology ⁸²	<ul style="list-style-type: none"> • Recommends all individuals adopt a comprehensive sun protection program and perform regular skin self-examinations; advocates follow up evaluation on any unusual skin changes.
American Cancer Society ⁸³	<ul style="list-style-type: none"> • Recommends skin examination and cancer-related checkup every three years in patients 20-40 years old and annually for those > 40 years of age.
American Medical Association ⁸⁴	<ul style="list-style-type: none"> • Advises skin self-examination monthly and yearly physician skin-examinations in patients at moderately increased risk.



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