

experts, biologists, and dermatologists will be required to expand the scope of this research.

The promise of an AI revolution in dermatology also comes with an accompanying fear of black boxes and a concern for how this may affect patient care and patient perceptions of care. Similarly, there is a prevailing fear among physicians that machines will largely replace clinicians in dermatology, as well as in radiology and pathology.¹³ It is our view that ML will not replace dermatologists.¹⁴ Rather, these tools will enable dermatologists to provide a higher quality of care to their patients.¹⁵ In fact, we believe that ML tools, such as downloadable local programs on personal computers, open-source online web-servers, or mobile applications on smartphones, will be tightly integrated into the daily clinical practice of the dermatologist in the near future.

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Interactive skin self-examination digital platforms for the prevention of skin cancer: A narrative literature review



To the Editor: Skin self-examination (SSE) is an important secondary prevention strategy to reduce melanoma deaths.^{1,2} Noninteractive teaching and facilitating aids (eg, brochures, handouts) to promote SSE behaviors have been recently complemented by interactive digital platforms, including mobile health (mHealth) apps. Although digital platforms may provide increased engagement and broader access, their safety and utility for improving health outcomes are unclear.^{3,4} We sought to identify and describe the methodology, teaching and facilitating aids, and outcomes of published SSE intervention studies using interactive platforms.

Table I. Characteristics of included studies*

Study, country	Study design	Key inclusion criteria	Setting	Study time period	Sample size, No.	Age, y	Female sex, %	Types of aids included		
								Teaching	Facilitating	
Nonmobile digital platform	Study 1, USA	<ul style="list-style-type: none"> Type: Randomized controlled trial, 3 mo Intervention group: Skin-safe program administered in a single sitting on a laptop computer, SSE role play tutorial, telecommunication monthly reminders to perform SSE (text, e-mail, phone call, or letter), and SSE brochure Control group: SSE brochure only 	<ul style="list-style-type: none"> Age: ≥ 18 y Patients, family members, caregivers, friends at dermatology clinic 	Outpatient dermatology clinics	2010	210	53 (mean)	61	<i>Integrated in desktop application via modules:</i> <ul style="list-style-type: none"> Educational content on SSE within intervention (module) Personalized content, feedback, advice Risk calculator Quiz to test knowledge gained from educational content 	<i>Through participants' devices:</i> <ul style="list-style-type: none"> Texting reminders Phone call reminders E-mail reminders
	Studies 2-5, USA	<ul style="list-style-type: none"> Type: Randomized controlled trial, 12 mo Intervention group: Website with melanoma prevention messaging and information, personal risk for developing melanoma, a chat room, interactive section for family members, and telecommunication reminders (e-mail every 3 months) to view website Control group: not specified 	<ul style="list-style-type: none"> Age: ≥ 18 y Internet access Family triads: melanoma case, first-degree relative, relative with child age 18 or younger 	SEER Registry at Cancer Center and Regional Site of the Cancer Genetics Network	2005-2007	311 family triads	56 (mean)	56	<i>Integrated into website intervention:</i> <ul style="list-style-type: none"> Personalized content, feedback, advice Risk calculator 	<i>Through participants' devices:</i> <ul style="list-style-type: none"> E-mail reminders
	Study 6, England	<ul style="list-style-type: none"> Type: Cluster-randomized controlled trial, 6 mo Intervention group: Skin-safe program administered in a single sitting on a desktop computer in a waiting room Control group: not specified 	<ul style="list-style-type: none"> Intervention: Prescribed Skinsafe by physician and intended to use it Control: Matched skin/demographic profile 	5 pairs of family practices (1 rural, 1 urban, 3 suburban)	1998	589	38 (mean)	80	<i>Integrated in desktop application via modules:</i> <ul style="list-style-type: none"> Educational content on SSE within intervention (module) Personalized content, feedback, advice Risk calculator 	None

Studies 7-8, USA	<ul style="list-style-type: none"> • Type: Randomized controlled trial with 3 groups, 3 mo • Control group: Not specified • Control website intervention group: Provided Skin Cancer Foundation's website, which included educational topics on prevention, educational information on skin cancer, news, and other relevant topics. Received telecommunication reminders (e-mail) • Experimental website intervention group: Tailored interactive multimedia internet intervention program (UV4.me), which used multiple media formats (text, audio/video, images). Website had educational modules on risk or prevention behaviors with algorithms using data from baseline survey to personalize content and a goal setting section. Received telecommunication (e-mail) reminders 	Online	2014	965	22 (mean)	66	<p><i>Integrated into website intervention:</i></p> <ul style="list-style-type: none"> • Educational content on SSE within intervention • Personalized content, feedback, advice 	<p><i>Integrated into experimental website intervention:</i></p> <ul style="list-style-type: none"> • Goal setting
Studies 9-11, USA	<ul style="list-style-type: none"> • Type: Randomized controlled trial with 3 groups, 24 mo • Control group: Treatment as usual • Intervention groups: Provided laminated ABCDE rule card with scoring information, body map, scorecards, a lighted magnifying glass, a ruler to assess moles, and were given skill quizzes 	Dermatology department at medical university	2011-2015	494	55 (mean)	51	<p><i>Integrated into web intervention delivered via tablet:</i></p> <ul style="list-style-type: none"> • Educational content on SSE within intervention • Quiz to test knowledge gained from educational content 	<p><i>Integrated into web intervention delivered via tablet:</i></p> <p><i>Nondigital aids:</i></p> <ul style="list-style-type: none"> • Laminated ABCDE rule card • Diary • Body maps • Ruler • Lighted magnifying lens

Continued

Table I. Cont'd

Study, country	Study design	Key inclusion criteria	Setting	Study time period	Sample size, No.	Age, y	Female sex, %	Types of aids included	
								Teaching	Facilitating
Study 12, Australia	<ul style="list-style-type: none"> In-person intervention group: A scripted in-person presentation delivered by research team member Take-home booklet intervention group: Read workbook during baseline visit and brought it home Tablet intervention group: Electronic web-based interactive intervention delivered on a tablet in clinic only 	<ul style="list-style-type: none"> Age: ≥ 18 years No personal history of melanoma Not overburdened by disease 	3 urban and 1 rural general medical practices	2016	272	46 (mean)	72	<i>Via web-based application:</i> None <ul style="list-style-type: none"> Personalized content, feedback, advice Risk calculator 	
	<ul style="list-style-type: none"> Type: Randomized controlled trial, 6 wk Control group: Booklet with generic melanoma-prevention information on risk factors and prevention measures Intervention group: Booklet plus real-time, on-screen and printed model-generated melanoma risk assessment with tailored melanoma-prevention advice 								
Studies 13-16, Australia	<ul style="list-style-type: none"> Type: Randomized controlled trial with 3 groups, 12 mo All groups: Received 21 text messages about assigned topic. Messages personalized by participant's name, sex, baseline skin cancer risk factors, and data collected during baseline interview Randomized to text messages on (1) physical activity (control), (2) sun protection, or (3) SSE 	<ul style="list-style-type: none"> No personal history of melanoma Ownership of mobile phone 	Community (Queensland electoral roll or Medicare register)	2012-2013	546	32 (mean)	67	<i>Via texting:</i> None <ul style="list-style-type: none"> Educational content on SSE within intervention Personalized content, feedback, advice 	

Mobile digital Studies 17-20, Australia platform	<ul style="list-style-type: none"> Type: Randomized controlled trial, 5 mo Control group: SSE by naked eye examination alone. Web-based instructions on SSE performance. Telecommunication reminders (e-mail, text, phone call) if SSEs (baseline, 1 mo, 2 mo) are overdue Intervention group: Mobile dermoscopy-enhanced SSE using FotoFinder handyscope patient app. Instructional video. Web-based instructions on SSE performance. Telecommunication reminders (e-mail, text, phone call) if SSEs were overdue (baseline, 1-month, 2-month). Participants photographed suspicious lesions via the study app and e-mailed image to research team for tele-diagnosis by dermatologist. Completed an online body chart to pinpoint the location of lesions identified during SSE 	<ul style="list-style-type: none"> Age: ≥ 18 y ≥ 2 risk factors for skin cancer History of skin excisions or numerous nevi Smartphone compatible with dermoscope Partner, relative, or friend available to assist No history of melanoma in past 5 y 	Online, university, and community	2017-2018	199	41 (mean)	71	<p>Accessed via web (not mHealth app):</p> <ul style="list-style-type: none"> Educational content on SSE within intervention 	<p>Through participants' devices:</p> <ul style="list-style-type: none"> E-mail reminders Phone call reminders Text reminders <p>Nondigital aids:</p> <ul style="list-style-type: none"> Dermoscope
Studies 21-22, Australia	<ul style="list-style-type: none"> Type: Randomized trial with two groups, 4 mo Group 1: Mobile teledermoscopy (FotoFinder handyscope app) without specific SSE instructions Group 2: Mobile teledermoscopy (FotoFinder handyscope app) with 10-step guide on how to conduct thorough SSE 	<ul style="list-style-type: none"> Age: ≥ 18 y ≥ 1 criterion for having high risk of melanoma 	Community	2013	49	Min 50; max 64	51	None	<p>Integrated in mHealth app:</p> <ul style="list-style-type: none"> Photo storage/skin history Ability to write note on photo in app <p>Send photo from app to specialist</p>
Study 23, USA	<ul style="list-style-type: none"> Type: Randomized trial with 4 groups, 6 mo 	<ul style="list-style-type: none"> Age: ≥ 18 y 	Pigmented lesion clinic	2015-2017	69	54 (mean)	64	Integrated in mHealth app:	Integrated in mHealth app:

Continued

Table I. Cont'd

Study, country	Study design	Key inclusion criteria	Setting	Study time period	Sample size, No.	Age, y	Female sex, %	Types of aids included	
								Teaching	Facilitating
	<ul style="list-style-type: none"> App-only intervention group: Mobile app on iPhone/iPad (MelaSight) loaded with patient's total body photographs and instructions on SSE performance plus standard of care (printed photos and CD containing digital total body photograph images) Reminders intervention group: Mobile app plus monthly telecommunication reminders (e-mail and text) plus standard of care Accountability partner intervention group: Mobile app plus accountability partner received monthly report of their skin exam progress plus standard of care Reminders-accountability partner intervention group: Mobile app plus monthly reminders (e-mail and text) plus accountability partner plus standard of care 	<ul style="list-style-type: none"> Ownership of iPhone or iPad Already in possession of total body photographs 						<ul style="list-style-type: none"> Educational content on SSE within intervention Personalized content, feedback, advice 	<ul style="list-style-type: none"> Photo storage/skin history Side-by-side comparisons of photos Ability to write note on photo in app Ability to flag/mark changes on photo for follow-up with clinician Skin exam metrics in monthly performance reports <p><i>Through participants' devices:</i></p> <ul style="list-style-type: none"> Text reminders E-mail reminders
Study 24, USA	<ul style="list-style-type: none"> Type: Randomized controlled trial, 7 mo Control group: Standard of care, including printed photos and CD containing digital copies of total body photographs Intervention group: Total body photographs loaded onto iPhone/iPad in MelaWatch app plus standard of care 	<ul style="list-style-type: none"> Patients new to total body photography 	Pigmented lesion clinic	2015-2016	71	47 (mean)	59	None	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Photo storage/skin history

Studies 25-26, England	<ul style="list-style-type: none"> Type: Randomized controlled trial, 12 mo Control group: Usual care at family practice Intervention group: My-SkinPal app loaded onto participant phone, received verbal and written instructions on how to use app and monthly telecommunication (text) reminders to use app 	<ul style="list-style-type: none"> Age: 18-75 y Identified as increased risk of melanoma based on MelaTools Q risk assessment tool Ownership of a smartphone 	12 family practices	2016-2017	238	55 (median)	55	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Photo storage/skin history Body map Gamification <p><i>Through participants' devices:</i></p> <ul style="list-style-type: none"> Text reminders 	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Photo storage/skin history Body map Gamification <p><i>Through participants' devices:</i></p> <ul style="list-style-type: none"> Text reminders
Studies 27-29, Scotland	<ul style="list-style-type: none"> Type: Nonrandomized study, 6 mo Received three 2-h training sessions on how to use tablet and ASICA app in addition to detailed manuals. Intervention was experimental and complementary to their ongoing care. Tracked changes in app to send report to study staff. Received telecommunication reminders (e-mail, text, or phone call) to perform TSSE 	<ul style="list-style-type: none"> Age: ≥ 18 y Treated for melanoma in past 5 y Currently receiving hospital-based follow-up No nodal involvement or metastases 	6 general practices	NR	20	Min 37, max 83	50	<p><i>Integrated into mHealth app:</i></p> <ul style="list-style-type: none"> Educational content on SSE within intervention Personalized content, feedback, advice <p><i>Through participants' devices:</i></p> <ul style="list-style-type: none"> Text reminders Phone call from overseeing specialist nurse to reassure patient or schedule in-person assessment for flagged changes E-mail reminders 	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Photo storage/skin history Checklist for SSE Ability to write note on photo in app Ability to flag/mark changes on photo for follow-up with clinician Body map
Studies 30-32, Portugal	<ul style="list-style-type: none"> Type: Nonrandomized study HAPPY (Health Awareness and Prevention Personalized for You) cancer prevention smartphone app made available in Portugal in September 2016 to the general population. All data collected between September 2016 and April 2017 analyzed. The app calculated a baseline 	<ul style="list-style-type: none"> Informed consent only 	Online	2016-2017	3326	32.7 (mean)	60	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Educational content on SSE within intervention Personalized content, feedback, advice 	<p><i>Integrated in mHealth app:</i></p> <ul style="list-style-type: none"> Gamification (e.g. ability to send challenges to friends/family, ability to earn badges for reaching milestones) Push notification reminder

Continued

Table I. Cont'd

Study, country	Study design	Key inclusion criteria	Setting	Study time period	Sample size, No.	Age, y	Female sex, %	Types of aids included	
								Teaching	Facilitating
		level/score of cancer prevention using weighted values for different behaviors (physical activity, fruit/vegetable intake, tobacco and alcohol consumption, body mass index, sunburn, SSE, Papanicolaou test, breast self-exam, testicular self-exam, human papilloma virus vaccination). App features included daily questions at bedtime with recalculation of behavioral prevention score, tailored messages via push notifications, integration with social networking (Facebook), challenges designed to give users goals, and milestones/rewards (gamification)							

ABCDE, Asymmetry, border, color, diameter, elevation; *AJCC*, American Joint Committee on Cancer; *ASICA*, Achieving Self-Directed Integrated Cancer Aftercare; *NR*, not reported; *SEER*, Surveillance, Epidemiology, and End Results; *SSE*, skin self-examination; *TSSE*, thorough skin self-examination; *USA*, United States of America.

*Citations of included studies not included due to journal citation constraints and are available from the authors upon request.

Table II. Behavioral, engagement, and psychosocial outcomes of teaching and facilitating aids for skin self-examination in studies using digital platforms

Study type	Study*	Behavioral outcomes [†]				Engagement outcomes [†]				Psychosocial outcomes*		
		SSE frequency [‡]	TSSE frequency [‡]	SSE or TSSE ever performed [§]	Body areas examined	Skin cancer detection (diagnostic accuracy)	Satisfaction with intervention	Feasibility	Usability	Engagement	SSE confidence	Risk perception
Nonmobile digital platform	Study 1			✓						✓	*	
	Studies 2-5			✓	?							
	Study 6			✓			?				X	
	Studies 7-8			✓								
	Studies 9-11	✓			✓	✓			?			
	Study 12						?				X	X
	Studies 13-16	✓	X	✓	?		?		?			
	Studies 17-20	X		X	?	X	?		?		?	?
	Studies 21-22					?		?	?		?	?
	Study 23	?					?					
	Study 24	X					✓		✓			
	Studies 25-26 [§]										X	?
Studies 27-29		?		?			?			?		?
Studies 30-32			?				?	?	?			

SSE, Skin self-examination; TSSE, thorough skin self-examination; ✓, outcome was assessed and a positive statistically significant improvement was reported compared with a control group; X, outcome was assessed, and no statistically significant improvement was reported compared with a control group; ?, outcome was assessed, but results were not reported or not relevant, significance of findings were not reported, results were descriptively reported, results were not compared with a control group (ie, before-after intervention study), or final study results were not yet published; blank cell, outcome was not assessed.

*Citations of included studies not included due to journal citation constraints and are available from the authors upon request.

[†]Not all outcomes were included because only the most frequently overlapping behavioral, engagement, and psychosocial outcomes related to interactive teaching and facilitating aids for skin self-examination are shown.

[‡]Measured by asking participants to report how many times they performed a skin self-examination during the study period.

[§]Measured in a yes/no format.

^{||}Although this is a clinical outcome, we categorized it as under behavioral outcomes for simplicity.

This study did not require ethical approval. A comprehensive search of PubMed/MEDLINE was conducted on March 13, 2020, without date/language restrictions (Supplemental Methods via Mendeley at <https://doi.org/10.17632/9fhmfgx8y5.1>). We considered a platform to be interactive if it responded to a user's input or if it delivered personalized information. Mobile digital platforms (MDP) were defined as applications on smartphones or tablets (ie, mHealth apps). Nonmobile digital platforms (NMDP) were defined as web browsers, desktop applications, or text messages. We identified 487 articles, and 32 were included. These 32 articles described 14 unique studies; 12 were randomized and 2 were nonrandomized (Table I and Supplemental Table D). Seven studies used apps on MDPs.

There were 4 teaching and 16 facilitating digital aids identified (Table I and Supplemental Table D). Studies with NMDP primarily used teaching aids, such as educational content on SSE within an intervention (n = 10). Conversely, facilitating aids were primarily found in studies with MDPs; the most common included photo storage (n = 5), texts (n = 5), and e-mails (n = 5). There was significant heterogeneity in the behavioral, psychosocial, and engagement outcomes reported (Table II). Seven studies (53%) demonstrated a statistically significant improvement in ≥ 1 outcome; most (n = 6) were in studies using NMDPs. Only 1 study demonstrated an improvement in melanoma detection compared with a control group.

Despite the proliferation of interactive digital tools to aid SSE, there is limited literature to gauge the quality and impact of published interventions. Researchers are shifting away from web-based and print-based materials to aids located on devices. With 81% of United States adults owning a smartphone in 2018,⁵ mHealth apps are a promising resource to encourage preventive health behaviors. However, because smartphone ownership varies by age, income, education, and community,⁵ alternative strategies must be simultaneously developed to prevent health care disparities. At this juncture, mHealth apps have used a greater diversity of teaching and facilitating aids than NMDPs.

Despite these possible benefits, our review identified only 1 study using an mHealth app that showed an improvement in an SSE outcome compared with a control group. This finding echoes concerns that there is a mismatch between the promise of mHealth apps and the evidence supporting their validity and utility.^{3,4}

To personalize the delivery of health care to patients, future studies should also aim to better assess the usability and functionality of mHealth apps. Given the variability in the study interventions, it was not possible to determine the effectiveness of

different interventions and compare studies that use non-overlapping measures in different contexts. However, our findings may help standardize future research efforts in this domain.

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