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Recent Advances in Our Understanding of the Epidemiology of Melanoma

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Abstract
Purpose of Review This review discusses recent findings involving epidemiologic issues in melanoma, including incidence trends, potential risk factors, and recent studies of skin examination, whether by a physician or by a patient performing self-examination.
Recent Findings Melanoma incidence rates have increased, although not in a uniform fashion throughout the population. Tanning beds have been affirmed as a risk factor for melanoma, while other potential risk factors, such as sildenafil, alcohol, and fruit juice, as well a potential protective effect of coffee, have some interesting preliminary data but have not been consistently demonstrated to be causally linked to melanoma. Further studies are needed. There are promising data from Germany that physician skin examination may have an impact, but the data are not completely clear. Skin self-examination rates are low; several authors have tried to identify methods of improving compliance.
Summary There have been many interesting and provocative papers regarding the epidemiology of melanoma to come out in recent years. While further work is needed to understand fully the issues raised by these studies, these efforts are important elements in the path towards improving our understanding of how to best combat this deadly disease.

Keywords Melanoma · Epidemiology · Self-examination · Tanning

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Introduction

Melanoma is the deadliest form of skin cancer and one of the most frequently diagnosed malignancies in developed countries [1, 2]. In this article, we will first examine the recent literature regarding incidence and mortality trends, as well as potential new risk factors for melanoma. We will then review the current literature regarding the effectiveness of skin screening by physicians for melanoma and examine the impact of large-population screening campaigns. Finally, we will conclude with a discussion of methods to improve compliance in self-exam for melanoma patients, with a focus on incorporating technology for this purpose.

Incidence and Mortality Trends

While many other common cancers have seen a decrease in incidence recently, the incidence of melanoma has continued to rise [1, 3]. Global incidence of melanoma was estimated to be 351,880 new cases in 2015 with 59,782 global deaths [4]. The public health burden of melanoma is a worldwide phenomenon, and the recently completed Global Burden of Disease (GBD) study identified Australasia, North America, Eastern Europe, Western Europe, and Central Europe as the regions with the highest rates of melanoma incidence, mortality, and disability-adjusted life years (DALY) lost [4]. DALY rates were generally higher in males than females and among the elderly [4].

Looking specifically at the USA, it is estimated that in 2017, there will be 87,110 new cases of invasive melanoma and 74,680 cases of in situ melanoma, with an estimated 9730 melanoma-related deaths [1]. Raw incidence rates of melanoma in the USA increased from 22.2 to 23.6 per 100,000 persons between 2009 and 2016 [5•]. Similar increases in incidence were seen when tumors were stratified by thickness,

supporting the idea that increased incidence is not solely the result of increased screening [6•]. In the population less than 60 years of age as a whole, the incidence of melanoma has increased [7, 8•]. However, when further subdivided by age, the incidence of melanoma decreased by approximately 3% per year in both males and females aged 15–29 years of age between 2004 and 2012, which may be a sign that melanoma incidence may decrease in the future as this cohort ages [8•]. While melanoma death rates have decreased for both sexes recently, death rates for males continue to be much higher than that for females, with males having more than double the mortality rate of females between 2009 and 2013 [1].

Advancements in Our Understanding of Risk Factors for Melanoma

There are many well-established risk factors for melanoma, including sunlight or ultraviolet light exposure, atypical nevi, fair skin, red hair, blue eyes, an increased number of "ordinary" nevi, and a personal or family history of melanoma [9–14]. In recent years, the link between tanning bed use and melanoma has been reinforced, and several new potential risk factors or protective factors have been proposed, as described below and summarized in Table 1.

Affirmation that Tanning Bed Use Is a Risk Factor for Melanoma

While exposure to ultraviolet light via indoor tanning beds has been recognized as a risk factor for melanoma for many years, several recent studies have sought to better characterize this link. Colantonio et al. performed a systematic review and meta-analysis to examine the association between melanoma and tanning bed use, with a particular focus on frequency of use and more recent data that would include exposure to newer light bulb technology [15]. Although these authors felt much of the evidence in the published literature was poor to mediocre in quality, they found a statistically significant association between tanning bed use and melanoma, citing an odds ratio (OR) of 1.23 when using studies from North America and an OR of 1.16 when looking at studies from North America, Europe, and Oceania. The authors also found that a minimum of 10 tanning sessions was needed before a significant association was seen, and the association between tanning bed use and melanoma remained unchanged in more recent studies despite newer light bulb technology. Lazovich et al. performed a population-based case-control study comparing tanning bed use in melanoma patients aged 25–49 to that of controls [16•]. They found that women diagnosed before age 40 began tanning at a younger age (16 versus 25 years) and went more frequently (median number of sessions 100 versus 40) than women aged 40–49 years at the time of diagnosis. Adjusted ORs for tanning compared to the control group were 3.5 and 2.3 for women ages 30–39 and 40–49, respectively. ORs for men varied greatly, making it more difficult to draw strong conclusions. Most recently, Ghiasvand et al. identified a strong dose-response relationship between indoor tanning and melanoma risk when they evaluated prospective data from 141,045 participants of the Norwegian Women and Cancer study [17•]. Specifically, they found that a higher cumulative number of tanning sessions was

Table 1 Summary of recent studies investigating potential melanoma risk factors

Risk factor	Proposed mechanism	Summary of data
Tanning beds	Ultraviolet light-induced carcinogenesis	Studies confirm statistically significant association between tanning bed use and melanoma Earlier initiation of tanning and higher cumulative number of sessions seem to be associated with increased risk
Sildenafil	Increased melanoma growth and invasion via activation of cGMP-dependent pathway	Some studies are suggestive of a link between sildenafil and increased melanoma risk but do not account well for potential confounders
Alcohol	Metabolic byproduct- induced DNA damage and photosensitization	Several studies have suggested a weak association between alcohol intake and melanoma risk, but are limited by confounding by sun exposure White wine has been weakly associated with increased risk over other alcohol types
Citrus	Contains photocarcinogenic agents (e.g., psoralens)	Increased frequency of citrus consumption might be associated with an increased risk of melanoma Risk more associated with grapefruit and orange juice. Data are limited
Coffee as a protective factor	Contains bioactive compounds (e.g., caffeine) that may be protective against UVB-induced carcinogenesis, oxidative stress, DNA damage; may also cause cell apoptosis, reduce inflammation in epidermal cells, and inhibit changes in DNA methylation	Limited data suggest caffeinated coffee consumption may have protective effect against melanoma Results are variable and studies have significant limitations

associated with increased risk of melanoma (for highest tertile of use versus never use, the adjusted relative risk (ARR) was 1.32 (95% CI 1.08–1.63)) and that earlier initiation of tanning bed use (<30 years) had a higher risk of melanoma compared to never use (ARR 1.31 (95% CI 1.07–1.59)).

Sildenafil as a Potential Risk Factor for Melanoma

Sildenafil, a phosphodiesterase (PDE) 5A inhibitor, has been studied as a potential melanoma risk factor. Dhayade et al. found that activation of a cyclic guanosine-3′,5′-monophosphate (cGMP)-dependent pathway led to increased melanoma growth and invasion mediated by mitogen-activated protein kinase (MAPK) signaling [18•]. They further showed that sildenafil potentiates this pathway via increased cGMP concentration due to inhibition of PDE 5A, thus suggesting a link between the medication and melanoma risk. Li et al. examined the association between sildenafil use and risk of incident melanoma in male participants of the Health Professionals' Follow-Up Study [19•]. Ultimately, they found a significant association between sildenafil use and increased risk of developing subsequent melanoma after adjusting for many known risk factors (multivariate hazard ratio (HR) 1.84). This result must be interpreted in light of the study's limitations, which include lack of information regarding sildenafil dosage, frequency of use, and use of other PDE 5A inhibitors, as well as possible effects of confounders. Loeb et al. performed a population-based nested case-control study including over 4000 melanoma cases from various Swedish melanoma and prescribed drug registries and, again, found a statistically significant increased risk of melanoma in men taking PDE 5A inhibitors (OR 1.21) [20•]. Interestingly, however, when men were stratified by number of prescriptions filled, the risk was only significant in men who had filled a single prescription, not multiple, thus raising the question whether this association is truly causal. The authors also found an association between higher socioeconomic status, a known association with increased melanoma incidence, and taking PDE 5A inhibitors, which also raised concerns about whether the association between melanoma and PDE 5A inhibitors was causal. Several recent studies, including parallel case-control studies conducted using the Danish Nationwide Health Registries and Kaiser Permanente Northern California electronic medical records as well as a prospective matched cohort study using data from the UK Clinical Practice Research Datalink, found little evidence of an association between PDE 5A inhibitors and melanoma risk [21•, 22•]. For now, the jury is still out whether any possible association between PDE 5A inhibitors and melanoma is indicative of a true increased risk from taking these medications as opposed to an association attributable to confounding. Further investigation is needed on this subject.

Alcohol as a Potential Risk Factor for Melanoma

Alcohol consumption has been previously linked to several malignancies, including those of the aerodigestive tract, colon, rectum, breast, and liver [23, 24]. Alcohol induces carcinogenesis via DNA damage due to the formation of adducts by acetaldehyde, a metabolic byproduct of alcohol, with DNA and proteins [25•]. Alcohol consumption is associated with an increased number of sunburns, and it has also been proposed that alcohol byproducts may lead to increased photosensitization, worsening the effects of UV light exposure, therefore leading to increased carcinogenesis [26, 27]. The literature regarding alcohol consumption and melanoma risk has been equivocal, and several groups have recently sought to further investigate this issue [25•, 28–35]. Rota et al. performed a meta-analysis of 16 case-control and cohort studies and found a pooled relative risk (RR) of 1.20 (95% CI (1.06–1.37)) for any alcohol drinking compared to no or occasional drinking [33•]. However, the authors acknowledge that confounding by sun exposure may have influenced these results. Kubo et al. evaluated nearly 60,000 Caucasian female participants of the Women's Health Initiative Observational study to assess the relationship of alcohol consumption and alcohol type preference with melanoma risk [35]. They found that women who consumed at least seven weekly drinks had a higher risk of melanoma (hazard ratio 1.64, 95% CI (1.09–2.49)) and that a preference for white wine or liquor had an increased risk for melanoma when compared to non-drinkers (white wine hazard ratio (HR) 1.52, 95% CI (1.02–2.27), liquor HR 1.65 (1.07–2.55)). A pooled analysis of eight case-control studies found a weak association (pooled OR 1.3, 95% CI 1.1–1.5) between ever drinking alcohol and melanoma risk after adjusting for possible confounding by sun exposure [34•]. Most recently, an evaluation of data from three prospective cohort studies revealed a modest association between higher alcohol consumption and invasive melanoma (pooled multivariate HR 1.14, 95% CI (1.00–1.29)/drink/day) and again found an increased risk associated with white wine as compared to other forms of alcohol (pooled multivariate HR 1.13, 95% CI (1.04–1.24)/drink/day) [25•]. Interestingly, a stronger association was found for melanoma on UV-spared sites as compared to UV-exposed sites [25•]. A definitive determination of whether there is a causal relationship between alcohol use and melanoma, and of particular types of alcohol, awaits further study.

Citrus Fruit Juice as a Potential Risk Factor for Melanoma

Citrus products, such as fruit juice, contain several photocarcinogenic agents, including psoralens, and thus have attracted attention as potential melanoma risk factors [36]. Wu et al. sought to better characterize the association

between citrus consumption and melanoma risk via a prospective study following 63,810 women in the Nurses Health Study and 41,622 men in the Health Professionals Follow-Up Study over a period of 24 to 26 years [37•]. Overall, they found that consumption of citrus products greater than or equal to 1.6 times per day was associated with a HR for melanoma of 1.36 (95% CI 1.14–1.63) as compared to a consumption of less than twice per week. The association remained after adjustment for confounders. Grapefruit in particular was most strongly associated with increased risk of melanoma, followed by orange juice. Limitations of this study include a lack of ethnic diversity in the study population and reliance on participants' self-reporting of citrus consumption. Further research beyond this study is warranted prior to making formal recommendations regarding dietary modification.

Coffee as a Potential Protective Factor against Melanoma

Coffee consumption has been associated with a lowered risk of several common cancers, including prostate, endometrial, liver, and colorectal cancers [38–41]. In vitro and animal studies have suggested that coffee may have a protective effect against melanoma mediated by various bioactive compounds, such as caffeine. Specifically, these compounds have been shown to protect against UVB-induced carcinogenesis, oxidative stress, and DNA damage, as well as causing cell apoptosis, reducing inflammation in epidermal cells, and inhibiting changes in DNA methylation [42–48]. Several recent studies have sought to better elucidate the association between coffee consumption and melanoma risk. Loftfield et al. examined 447,357 non-Hispanic white participants in the National Institutes of Health (NIH)-AARP prospective study and found that at least four cups of coffee per day was associated with a reduced risk of melanoma (HR = 0.80, 95% CI 0.68–0.93) [49•]. These results were only significant for caffeinated coffee. However, information regarding other melanoma risk factors was unknown and confounding by factors such as smoking, which is associated with heavy coffee consumption, may have influenced results. A meta-analysis involving five cohort and two case-control studies found a pooled RR of melanoma of 0.81 (95% CI = 0.68–0.97) in those with the highest intake of caffeinated, but not decaffeinated coffee [50•]. A meta-analysis performed by Wang et al. found a pooled RR of 0.80 (95% CI = 0.69–0.93) for overall coffee consumption, although the RRs were not statistically significant for caffeinated coffee or for decaffeinated coffee when those two groups were examined independently [51•]. Wu et al. analyzed data from three large cohort studies and found that higher total caffeine intake (≥393 versus <60 mg/day) was associated with a decreased melanoma risk (HR 0.78, 95% CI = 0.64–0.96) [52•]. This association was stronger in women and in melanomas on body sites with more continuous sun exposure. However, a prospective analysis of postmenopausal female participants in the Women's Health Initiative-Observational Study found no significant decrease in melanoma risk with daily coffee intake (HR 0.87, 95% CI = 0.68–1.12) [53•]. Most recently, Caini et al. examined data from the European Prospective Investigation into Cancer and Nutrition (EPIC) trial and found that caffeinated coffee consumption was significantly associated with decreased melanoma risk in males (HR 0.31, 95% CI = 0.14–0.69) but not in females (HR 0.96, 95% CI 0.62–1.47) [54•]. The variation in results from these investigations highlights the need for further research in this domain.

An Examination of the Evidence Regarding Screening for Melanoma by Physician Skin Exam

The US Preventative Services Task Force (USPSTF) recently concluded that evidence remains insufficient to assess the risks and benefits of screening of the asymptomatic general population for melanoma by clinical skin exam [55••, 56]. Skin examinations are non-invasive and relatively inexpensive, and they theoretically could lead to earlier detection of thinner lesions and, thus, improved survival [57–60••]. However, screening may have potential downsides, including the possibility of increased costs and health care utilization without appropriate benefit. First, we will review data from the largest population-based screening program to date, which was conducted in Northern Germany starting in 2003. We will then discuss the possibility of identifying high-risk individuals in the population for targeted screening approaches. Finally, we will examine the current literature on self-examination. Table 2 summarizes the rationale behind and current status of the various methods that are being utilized to improve earlier detection of skin cancer.

The German SCREEN Study

The Skin Cancer Research to Provide Evidence for Effectiveness of Screening in Northern Germany (SCREEN) project is the largest population-based study assessing the impact of screening on melanoma epidemiology. The SCREEN project took place in the German state of Schleswig-Holstein (SH) from July 2003–June 2004 and offered whole-body skin exams, performed by dermatologists or general practitioners to 1.88 million insured local residents aged ≥20 years [61–63]. The project followed several years of public health awareness campaigns, and all participating physicians completed a requisite 8-h training session [61–63]. Overall, 19.2% of all eligible citizens participated in SCREEN, with a disproportionate number (52%) of all melanomas found during the period in SH detected as part of the project [62]. The incidence rate for

Table 2 Methods for improving early detection of skin cancer

Method	Rationale	Current status
Mass screenings of population	Skin exams are relatively quick and non-invasive. They may identify lesions at an earlier stage than otherwise, ultimately leading to improved survival	SCREEN project in Northern Germany was followed by decline in melanoma mortality rate in the 5-year post-study. Mortality rate has since returned to pre-SCREEN levels and a subsequent national screening program in Germany had less compelling results Further studies are needed
Targeted screening of high-risk individuals	More cost-effective and technically feasible than mass screenings	Several risk assessment tools have been developed to identify high-risk individuals for screening and preliminary data for their use have been promising
Physician-performed skin exams, either by dermatologists or by non-dermatologists	Physician-performed skin exams have historically been associated with thinner lesions at diagnosis	Access to dermatologists is limited in many regions There has been a recent focus on developing programs to train non-dermatologist healthcare providers in performing skin exams to assist in screening
Self-skin exams	Increased skin awareness by patients and partners will lead to earlier identification of any concerning skin changes that can then be brought to the prompt attention of a health care provider	Data have shown the value of involving a partner in self-skin exams. Instructional tools to teach patients and partners to perform effective at home exams have been created, and technology has been increasingly utilized for this purpose

invasive melanoma increased by 27% and that for in situ by 48% during the project period, with an overall increase of 32% [61, 62]. Melanoma mortality decreased by 50% in the 5 years following the project, while the mortality rate in neighboring regions and in Germany as a whole did not change. However, there was a later reversion in SH to pre-SCREEN levels [63–65•].

Given these initial promising results, Germany implemented a national screening program in 2008 granting any individual aged 35 or above with statutory health insurance access to a free biennial full body skin exam [66•]. While nationwide screening led to a nearly 30% increase in melanoma incidence in Germany, there was no detectable decrease in melanoma mortality in the 5 years following introduction of the program, and death rates remained similar to those of neighboring countries [65•, 66•].

Much recent work has focused on examining whether SCREEN provided adequate evidence that screening skin examinations are beneficial for the general population and determining the possible underlying factors behind the discrepancy in results between SCREEN and the nationwide program. Several authors have suggested that the decline in mortality seen in the 5 years following SCREEN may not be a reflection of a clinically meaningful and significant decrease attributable to the program. They suggest, instead, that these results may be related to other factors, including random variation, birth cohort effects, and bias given that many of the physicians working in SH were participants in the study and potentially less likely to cite melanoma as a cause of death during this period [65•, 66•, 67•]. The SCREEN study, but not the national program, was preceded by several years of public awareness campaigns, which some feel may have contributed to the mortality decline [66•, 67•].

In addition, it has been suggested that the discrepancy between the results for the national program screening and SCREEN is because the national program screening was less intensive than SCREEN. The national program screened patients beginning at age 35 years instead of 20 years, did not result in as many referrals to dermatologists, and involved a proportionately smaller segment of the physician population as formal participants [66•]. The melanoma incidence seen in SH following SCREEN was higher than the highest point during national screening (24.0 versus 18.0 for women per 100,000), suggesting that national screening may have been less thorough [66•].

While these campaigns in Germany illustrate the potential benefits of screening, data on possible negative effects are limited. In an effort to address this issue, Weinstock et al. examined whether a population-based screening program in Western Pennsylvania led to a large increase in the number of skin surgeries and dermatology visits, a potentially undesirable outcome of screening [68]. They found that the number of melanoma diagnoses increased in a group of patients screened by primary care doctors that had been trained in melanoma detection, but the number of skin surgeries and dermatology visits only increased by about 2% [68].

Further studies investigating the benefits and harms of mass melanoma screenings are needed to provide additional data to inform future decisions regarding screening recommendations.

Targeted Screenings of a High-Risk Population

Since it is unclear whether mass skin cancer screenings are technically feasible or cost-effective in the USA, a targeted approach focused on identifying high-risk individuals has

been advocated [69, 70]. Only 19% of all eligible citizens in SH participated in SCREEN, yet they accounted for approximately half of all newly diagnosed melanomas in the region during this period [63]. If the disproportionate number of melanomas in the participation group is a reflection of the concept that self-identified high-risk individuals are more likely to participate in a free screening, targeted screening approaches may be more cost-effective than screening the general population. Several risk assessment tools have been developed to identify individuals at high risk of melanoma for screening [71–78•]. One of these tools, the Self-Assessment of Melanoma Risk Score (SAM Score), resulted in 11 times fewer patients needing to be screened to detect one melanoma as compared to a non-targeted screening approach [73, 75, 79]. The SAM Score has been used to select high-risk individuals to receive mailed invitations for annual skin examinations by their general practitioner as well as personalized counseling regarding risk reduction behaviors during primary care appointments [80•, 81•]. Similarly, the Brief skin cancer Risk Assessment Tool (BRAT), which is a self-administered measure of skin cancer risk, was used to identify high-risk individuals in a primary care practice to receive tailored mailings containing data on personalized skin cancer risk and information on protective behaviors, such as self-skin exams (SSE) and sunscreen use [82, 83•]. The individuals receiving the tailored materials were found to have improved compliance with risk reduction behaviors, including frequency of both SSE and skins exams with a health care provider, as compared to a cohort of patients who received generic mailings [83•].

Another potential method of identifying high-risk individuals is by determining whether they have an increased number of nevi, a known melanoma risk factor. Several groups have found that a count of nevi on a single extremity is a reflection of the total body nevus count, but simpler to perform. Different groups found that having at least 5 nevi on the right arm [84], 12 nevi on the right arm [85], and 20 nevi on both arms [86•] correlated with a higher overall nevus count. Other mechanisms for identifying high-risk individuals for screening can be anticipated for the future.

The Use of Non-dermatologists for Physician Skin Screening

Once identified, at-risk individuals warrant an initial screening exam and close follow-up. Recent data show that only one quarter of all adults at high-risk for melanoma have had at least one total body skin exam by a physician [87]. Screening may be performed in the office setting by a clinician or via SSE conducted by patients and their families. Historically, physician-performed skin exams have been associated with thinner lesions at diagnosis, and those detected by dermatologists specifically are often the thinnest [88–91•]. Unfortunately, access to dermatologists remains limited in some places in the USA due to a shortage of appropriate providers in some areas, and wait times for appointments may be extensive [92, 93]. Therefore, it may be necessary to utilize non-dermatologist physicians and other health care providers in order to meet the demand for skin exams that will accompany a targeted screening approach. Lack of expertise has been reported as a major barrier preventing general practitioners from performing total body skin examinations, and several groups have focused on the development of training tools to address this concern [94]. Grange et al. recently demonstrated the effectiveness of a general practitioner training campaign in the Champagne-Ardenne region in France [95•]. Specifically, they found that after 32.1% of all local GPs participated in a two and a half hour training curriculum led by dermatologists, the incidence of very thick melanomas in the region dropped from 1.07 to 0.71 per 100,000 habitants (p value 0.01) and the proportion of thin and in situ lesions increased [95•]. While in-person training may be beneficial in some situations, Web-based approaches have recently come into favor given the flexibility that this format affords users [96]. The Internet Curriculum for Melanoma Early Detection (INFORMED) is one such Web-based learning program that was developed by Shaikh et al. for this purpose [96]. INFORMED is a 2-h-long online curriculum aimed at training primary care clinicians in skin cancer detection via material presented in a textbook-like or case-based format depending on the learner's preference [96]. When tested among a group of 54 primary care providers, INFORMED was shown to significantly improve skin lesion diagnosis and management skills, especially of benign lesions [97]. There was a decrease in dermatology referrals and new visits from the participating sites, and the number of biopsies and skin cancer diagnoses remained stable [97]. Thus, screening was not accompanied by over-diagnosis and over-treatment as is often the concern, and instead may have prevented unnecessary dermatology referrals, thereby facilitating increased access for others. A randomized study investigating a novel melanoma detection training program for primary care physicians that incorporates smartphone technology is currently ongoing at Northwestern University [98].

Self-Skin Examinations

An important public health goal is to improve compliance with performing regular SSE, with the ultimate goal of earlier detection of melanomas by patients. Increased skin awareness has been associated with decreased melanoma mortality, and self-skin examinations (SSE) are an important secondary prevention measure [99]. A recent study found that patients who did not perform regular SSE but were the ones who picked up their melanomas had lesions that were thicker at diagnosis and had a higher mortality rate than patients who had lesions identified by dermatologists [91•]. However, a recent systematic

review found that only 14–33% of all melanoma survivors are regularly performing SSE [100•].

Researchers have established the value of involving a partner in SSE for assistance and reinforcement [101]. Robinson and colleagues described in a series of articles a take-home SSE instructional workbook for use by patients and partners that they found, both in hard-copy and electronic (tablet) format, to be effective in increasing SSE when used in combination with reinforcement from a dermatologist every 4 months [102, 103•, 104•, 105•]. Interestingly, partner motivation or agreeability between the partners did not impact results, and the greatest benefit in terms of SSE self-efficacy was seen in those with the lowest relationship quality, which was hypothesized to be the result of providing the pair with an activity to engage in together [105•]. Participating pairs had a significant increase in their self-confidence and no change in their levels of comfort or embarrassment in performing SSE over the 2-year study period [106•].

Utilizing technology to improve adherence to prevention behaviors, such as SSE and sun protection measures, in melanoma survivors has advantages over other methods, including the ability to personalize content, the possibility of creating interactive Web pages, and the opportunity to have a portable system that could be used in multiple settings [107•]. Day et al. recently found that nearly 70% of melanoma patients surveyed would be at least moderately receptive to Web-based interventions, with those most amenable being more likely to be younger, more familiar with the ABCDE signs of melanoma, and more comfortable using the Internet [107•]. A tablet-based intervention incorporating reminders for monthly SSE with instructional videos and electronic communication with a dermatology clinical nurse specialist for triage of changing lesions was recently developed and piloted by Murchie et al. [108]. A larger, randomized clinical trial to further evaluate this intervention is in the planning stages. Bowen et al. developed an interactive website for melanoma survivors and their families aimed at reducing risk of further melanoma [109]. They found that utilizers of their Website significantly improved their SSE and sun protection behaviors as compared to controls. Finally, smartphones have become common in developed countries, and much recent work has focused on how to best incorporate this technology in melanoma prevention and screening [110•]. A variety of smartphone applications have been developed for purposes ranging from melanoma risk assessment to teledermoscopy with further investigation to be performed regarding their effectiveness [110•, 111].

Conclusion

Melanoma remains a significant public health concern given its increasing incidence, and much recent work has focused on improving prevention measures. While several studies have shed light on potential new risk factors, the data have been largely inconclusive. Although official guidelines regarding melanoma screening in the asymptomatic general population are limited by insufficient evidence, a targeted screening approach may be more prevalent in the future. Thus, a continued focus on developing tools for training both physicians and patients in performing total body skin exams as well as incorporating technology for this purpose can be expected.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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Recently published papers of particular interest have been highlighted as:
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- •• Of major importance

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