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Misconceptions of photoprotection in skin of color

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Terrestrial sunlight is the portion of electromagnetic radiation that is emitted by the sun and reaches Earth's surface. It encompasses 3 major components: UV radiation (290-400 nm), visible light (400-700 nm), and infrared radiation. The deleterious effects of UV radiation have been appreciated for decades, particularly among those with light skin tones (Fitzpatrick skin types I-II) who primarily manifest with burns of varying degrees of severity with sun exposure. In recent years, studies have increasingly shown the negative impact of visible light on skin health, particularly in individuals with skin of color (Fitzpatrick skin types IV-VI), including the exacerbation of hyperpigmentation disorders such as melasma and post-inflammatory hyperpigmentation, as well as induction of the former. Recommendations from medical societies and the US Food and Drug Administration for photoprotection have been evolving along with the knowledge base. Yet, misconceptions about skin damage related to sunlight and the benefits of photoprotection (particularly among those with Fitzpatrick skin types V-VI) are still prevalent among both clinicians and patients. Among patients with skin of color, disorders of hyperpigmentation and other consequences from sun exposure have been associated with impaired skin health and negative burden on quality of life. This review summarizes currently available evidence of the impact of both UV and visible wavelengths and the low utilization of photoprotection measures among people with skin of color, with the goal of providing recommendations to help educate patients. (J Am Acad Dermatol 2022;86:S9-17.)

Key words: photoprotection; skin of color; sunscreen; ultraviolet light; visible light.

PHOTODAMAGE IN SKIN OF COLOR

It is well documented that exposure to sunlight induces skin damage and pigment changes, ranging from sunburn, tanning, and hyperpigmentation to DNA damage associated with malignancies.[1] Research attention has primarily focused on the negative impact of UV radiation with wavelengths of 290 to 400 nm.[2] However, it is now becoming increasingly clear that the spectrum of light that can damage skin encompasses visible light (VL) wavelengths (400-700 nm) as well as UV wavelengths (Fig 1).[3] This may seem somewhat paradoxical, because dermatologists have successfully employed VL as therapy for inflammatory and neoplastic conditions and have typically perceived VL to be benign compared to other wavelengths.[3,4]

Misconception: UV radiation has the most negative impact on skin for all FSTs

As our understanding of how the different light wavelengths can damage the skin has grown, our knowledge about the effects of sunlight on dark skin types (Fitzpatrick skin types [FSTs] IV-VI) has advanced. Changes in the skin that occur after exposure to solar radiation, or photodamage, may be more readily assessed in individuals with light skin types (FSTs I-III), but it is now appreciated that all skin types are susceptible to sunlight-related injury.[2] The Fitzpatrick scale is intended as a gauge of a person's ability to burn or tan from solar radiation and not as an indicator of or proxy for racial, ethnic, or phenotypic features.[5] Nonetheless, because it is a standard that most dermatologists use to classify skin tone, the FST

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scale may serve as a foundation for discussions of skin of color (SOC). For the purposes of this publication, people with SOC will be defined as those with FSTs IV to VI. Like those with light skin, individuals with SOC could benefit by incorporating photoprotective measures against sun damage (eg, seeking shade when outdoors, wearing sun-protective clothing, and using protective sunscreen), particularly to guard against pigmentation problems, as will be discussed.[6]

This review summarizes information on the susceptibility of individuals with SOC to various forms of photodamage, including pigmentary disorders and malignancy. This review demonstrates that updated education is needed to enhance sun protection practices in patients with SOC; specifically, these patients need to be informed about the impact of VL on the risk of dyspigmentation, which is associated with a negative impact on quality of life.[7-10] Misunderstandings about appropriate sun protection in people with SOC are also discussed, along with the reported use of photoprotection in this demographic group, with the goal of improving patient education.

CAPSULE SUMMARY

- Evidence for the impact of sunlight, both ultraviolet and visible wavelengths, and low utilization of sunscreen among people with skin of color is summarized.
- Misconceptions about the importance of photoprotection in this population are highlighted, along with specific recommendations to help guide patient education.

Misconception: the clinical presentation of photodamage is consistent across FSTs

The manifestations of sun damage in individuals with SOC (FSTs IV-VI) display both similarities and differences from those seen in FSTs I to III. People with FSTs IV to VI are susceptible to the negative effects of sun exposure. In those with higher FSTs, photodamage is less likely to appear as lines and wrinkles and more likely to present as pigmentary-related problems, including uneven skin tone, post-inflammatory hyperpigmentation (PIH), melasma, or any combination of these characteristics.[11] Evidence suggests that these differences may occur because FSTs IV to VI offer some degree of protection against UV-B but is more likely to develop dyspigmentation induced by VL and UV-A1.[12]

RESPONSE OF SKIN COLOR TO SUNLIGHT EXPOSURE

Misconception: endogenous melanin provides complete photoprotection for FSTs IV to VI

Melanin, produced and packaged into melanosomes by melanocytes, is transferred into neighboring keratinocytes and serves as an important determinant of cutaneous pigmentation.[13] People with FSTs IV to VI skin have larger, more melanized melanosomes, which are distributed individually within the keratinocytes rather than in aggregates (Fig 2).[2,14] These melanosomes can absorb more UV energy than those in FSTs I to III. Research has shown that melanin in SOC can filter approximately 2 to 5 times more UV radiation than melanin in skin of lower FSTs.[15,16] Kaidbey et al[17] reported that the epidermis of FSTs V to VI has an intrinsic sun protection factor (SPF) of 13.4 versus SPF 3.3 in light phototypes. In 2014, the American Academy of Dermatology's recommendations for photoprotection in SOC summarized research into melanin biology in individuals with SOC by stating, "exposure to UV radiation plays a lesser role in heightening the risk for skin cancer" due to the photoprotection provided by increased epidermal melanin.[2,17]

Other factors that differ between FSTs

Although individuals with SOC may have some level of intrinsic photoprotection, melanin content does not tell the complete story of response to sunlight in higher FSTs. This is because exposure to UV radiation can cause DNA damage in all skin types and DNA damage does not appear to be solely related to the degree of pigmentation.[18] Oxidative stress, sun-induced immunosuppression, and other factors also contribute to the pathophysiology of photodamage in this population.[19] A lower risk of DNA damage in FSTs IV to VI from UV radiation is also thought to be related to both an increased capacity to repair DNA and the reduced depth of penetration of UV radiation compared with light skin tones.[20] In high FSTs, DNA damage after UV exposure occurs mainly in the upper layers of the dermis; in contrast, DNA damage in low FSTs can occur in all layers of the skin, including basal layers, and can affect stem cells.[12]

Response of SOC to VL

Over the past decade, the role of VL in stimulating erythema, skin pigmentation, thermal damage, and production of reactive oxygen species (ROS) has been recognized.[21] Lim et al[22] present a more complete discussion of the impact of VL in their article, *Impact of Visible Light on Skin Health: The Role of Antioxidants and Free Radical Quenchers*.

Abbreviations used:

cSCC:	cutaneous squamous cell carcinoma
FST:	Fitzpatrick skin type
PIH:	post-inflammatory hyperpigmentation
ROS:	reactive oxygen species
SOC:	skin of color
SPF:	sun protection factor
VL:	visible light

Independently from the effects of UV radiation, VL exposure induces both transient and long-term cutaneous pigmentation in a dose-dependent manner.[23] Further, more intense and persistent VL-induced pigmentation occurs in subjects with dark skin (FSTs V-VI).[24] In human skin explants, the action of VL induces sustained redistribution of melanin granules from the basal layer of the epidermis to layers closer to the surface, inducing melasma and pigmentary problems in SOC.[25]

CLINICAL PRESENTATIONS OF PHOTODAMAGE IN SOC

Misconception: disorders characterized by excess pigmentation on the face and other body areas only have a cosmetic impact on patients

Melasma. Melasma is an acquired hypermelanosis, appearing as irregular brown patches, primarily on sun-exposed areas of the face, neck, and arms.[26,27] Melasma is most common in women, particularly those of reproductive age and those with FSTs IV to VI skin. It results after UV radiation and VL stimulates hyperactivity of melanocytes and pigment production,[27,28] with a subsequent increase in tyrosine-mediated melanogenesis and increased transfer of melanosomes to epidermal keratinocytes, resulting in pigmented patches of skin.[28] This may be exacerbated by estrogen-associated release of melanocyte-stimulating hormone, explaining why most melasma cases occur in women.[28]

The role of light in melasma is further demonstrated by the histopathologic findings of solar elastosis and ultrastructural alteration of the basement membrane at the dermal-epidermal junction.[26] Similar to other pigmentary disorders, melasma is challenging to manage, with patients often experiencing inconsistent treatment results and a long-lasting and/or relapsing course, with most exacerbations occurring during the summer months.[26,29] Melasma has a significant negative effect on social life and interactions, emotional well-being, and self-esteem.[27] Further, successful treatment of melasma correlates with a marked increase in self-esteem; indeed, Jiang et al[27] recommend that "physicians who treat patients with melasma should be aware of its profound psychosocial effects." Özkesici Kurt et al[30] studied 55 patients with melasma and found that internalized stigma, or the acceptance of negative societal stereotypes, was a primary factor responsible for the psychological burden of melasma. Although existing treatments can be effective, they are not curative and do not impact the relapsing nature of the disease. Because there are few reliably efficacious treatments for melasma at the current time, preventative strategies, such as photoprotection, are very important in managing this condition.[31,32]

PIH. PIH is another acquired hypermelanosis, which occurs after cutaneous inflammation.[31,33] PIH can occur in skin types of a light complexion but is more prevalent in people with SOC (FSTs IV-VI). Hyperpigmented macules or patches occur at the site of the original injury or inflammatory insult after healing, with colors ranging from light brown to black. Sunlight exposure (both UV and VL) is thought to exacerbate the condition (Fig 3). Like melasma, PIH can have a significant negative impact on quality of life. It is often more bothersome to patients than the initiating disease or insult, which has been reported in several diverse acne populations.[34] In a study of 324 patients in 7 Asian countries, Abad-Casintahan et al[35] observed that PIH lasted longer than 1 year in 65.2% of patients and 5 years or longer in 22.3%, exacerbating its overall impact on quality of life. In fact, even mild forms of facial pigmentation can be detrimental to quality of life, particularly for women.[34] Epidemiologic studies have shown that pigmentary disorders, including PIH and melasma, are among the most common complaints from patients with high FSTs who consult dermatologists.[33,36-38]

Misconception: individuals with SOC have negligible risks associated with skin cancer

Skin cancers are significantly less prevalent in persons with SOC relative to those with light skin[15,39] and occur in about 5% of Hispanics, 4% of Asians, and 2% of Blacks.[39] However, skin malignancies in people with SOC are often detected at a more advanced stage and are associated with a worse prognosis.[40-42]

In people with SOC, UV radiation does not appear to be a major risk factor for melanoma.[15] In fact, most melanomas in SOC patients affect areas not typically exposed to sunlight, including palmar, plantar, and subungual skin, as well as mucous membranes, with acral lentiginous melanoma being the most common type of melanoma.[2] Along with the locations that differ from people with light skin tones, differentiating normal variants, such as benign melanonychia

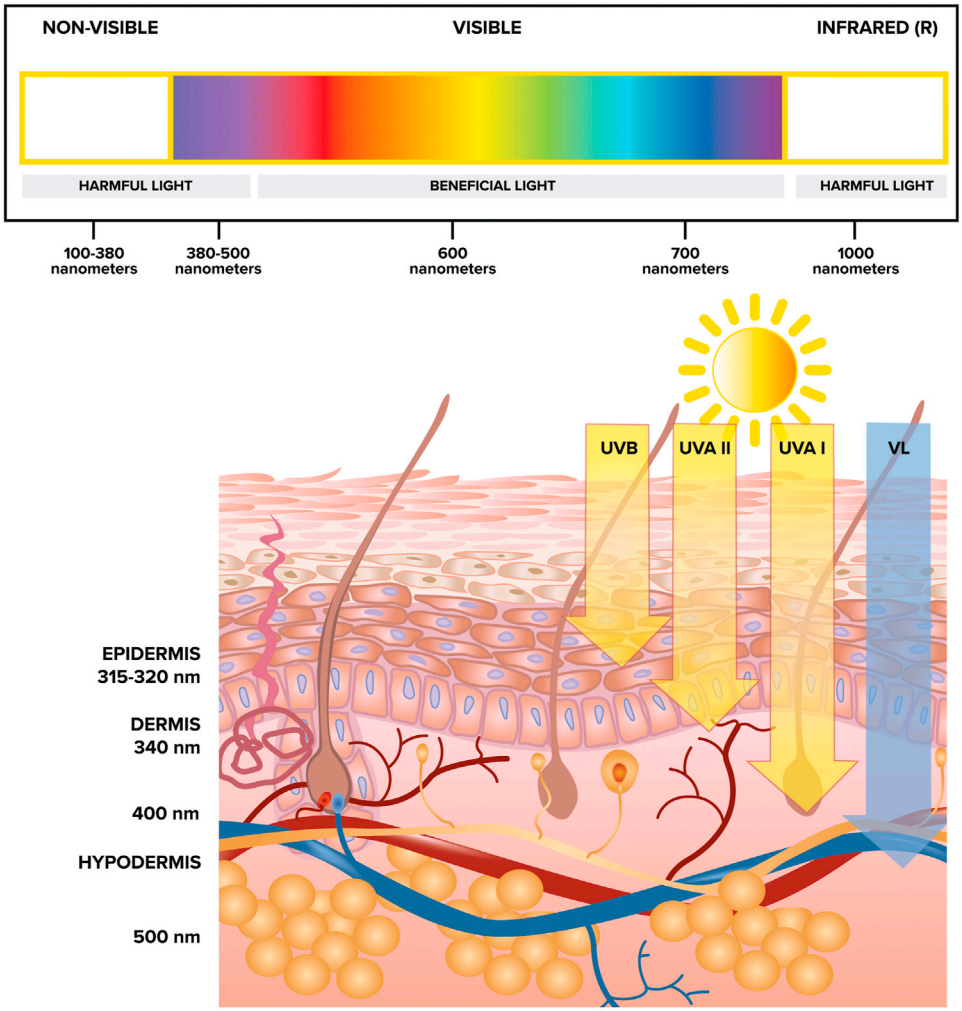

Fig 1. Spectrum of light and impact on skin. *R*, radiation; *VL*, visible light.

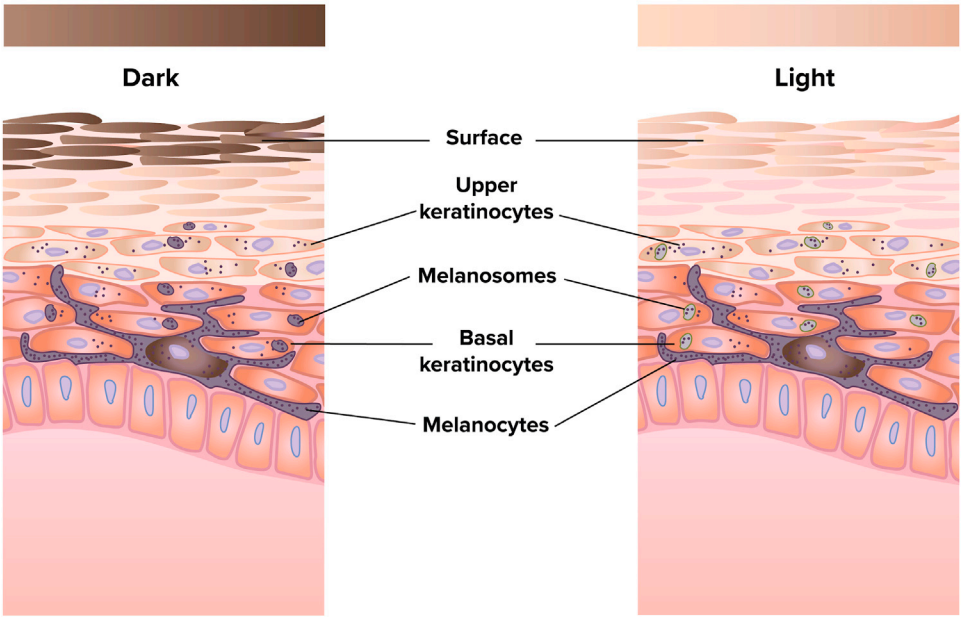

Fig 2. Differences in skin pigmentation due to melanosome distribution within epidermal keratinocytes.

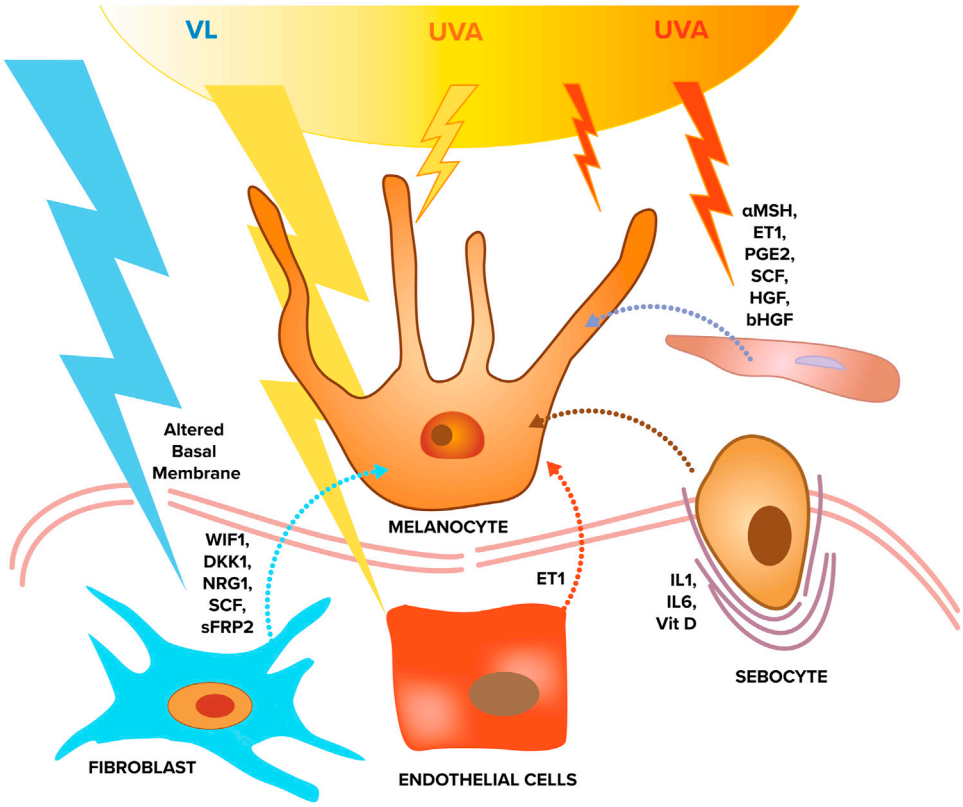

Fig 3. Solar radiation from ultraviolet to visible light triggers pigmentation in melasma and postinflammatory hyperpigmentation. *αMSH*, Alpha-melanocyte-stimulating hormone; *βHGF*, beta chain hepatocyte growth factor; *DKK*, dickkop; *ET*, endothelin; *HGF*, hepatocyte growth factor; *IL*, interleukin; *NRG*, neuregulin; *PGE*, prostaglandin; *SCF*, stem cell factors; *sFRP*, secreted frizzled-related protein; *VL*, visible light; *WIF*, Wnt inhibitory factor. Reprinted from Passeron et al[29] with permission from John Wiley & Sons, Inc.

or benign pigmented lesions on acral sites, can be challenging in people with dark pigmentation. Furthermore, low public awareness and less access to medical care for some populations contribute to delays in diagnosis.[43]

Cutaneous squamous cell carcinoma (cSCC) is the most commonly diagnosed skin cancer in some populations of SOC.[2] As with melanomas, cSCC in SOC often presents in areas not exposed to sunlight, including the lower extremities and anogenital area.[2] Basal cell carcinoma is also less common in individuals with dark pigmentation but does occur and can result in significant morbidity.[44] Unlike melanomas and cSCC, basal cell carcinoma usually occurs in sun-exposed areas of skin. In people with SOC, both cSCC and basal cell carcinoma tend to be pigmented. Dermatologists should be familiar with the clinical presentations of cutaneous malignancies in individuals with dark skin to adequately educate patients about risks and preventative strategies.[44] Many patients and physicians still incorrectly perceive that dark pigmentation translates to complete protection from skin cancer and sun damage.[44]

SUN PROTECTION RECOMMENDATIONS FOR PERSONS WITH SOC

Misconception: broad-spectrum sunscreens provide photoprotection against all wavelengths of light that cause skin damage

Currently available broad-spectrum sunscreens in the United States provide 90% of their protection at wavelengths shorter than 370 nm. The American Academy of Dermatology recommends the use of broad-spectrum sunscreens with SPF 30 or higher as a cornerstone of photoprotection with a focus on UV radiation.[45] However, broad-spectrum sunscreens are not protective against VL and UV-A1, which contribute to diseases of hyperpigmentation, as discussed above.[3,12] Confusion persists among both clinicians and patients regarding need for protection against VL wavelengths.[3]

Misconception: sunscreen use does not result in similar benefits in all FSTs

Many patients with SOC tell clinicians that they believe their dark skin color means that they do not need to use sun protection. One study showed that

Blacks who had experienced severe sunburns were 7 times less likely to use sunscreen than Whites with a similar experience.[46] When sunscreens are used, they are often applied insufficiently and not reapplied with adequate frequency.[46]

In 2020, Grimes et al[11] reported that 12 months of daily photoprotection with a sunscreen of SPF 30 and persistent pigmentation darkening rating 20, an indicator of UV-A protection, in patients with FSTs IV to VI improved signs of photoaging and pigmentary concerns. A total of 24 patients used daily sunscreen, and results were compared with 16 individuals of the same age and phototypes who did not use sunscreen. While pigmented lesions in the control group worsened, particularly in summer months, there were significant clinical improvements in hyperpigmentation and dark spots in the group using photoprotection that blocked UV-A.[11] In addition, Wanitphakdeedecha et al[47] reported the incidence of PIH was significantly reduced by use of a broad-spectrum sunscreen of SPF 60 or greater that contained the anti-inflammatory agents licochalcone A and glycyrrhetinate in FST IV treated with ablative fractional skin resurfacing. Patients with FSTs IV to VI should be counseled to incorporate a broad-spectrum sunscreen that includes VL protection, as part of their overall photoprotective practices, to minimize the risk of dyspigmentation.[29]

Educating patients to dispel myths

Educating patients with SOC about the need for photoprotection is imperative and targeting young people may be particularly effective. In a study of 3710 children in 4th and 5th grade, educational intervention increased photoprotective behaviors by 30%.[48] Different educational programs may be needed for specific population groups. It should be noted that adults are most prone to dyspigmentation, so it is important to educate all ages.

DIFFERENTIATING AMONG SUNSCREEN TYPES

Misconception: a broad-spectrum sunscreen with SPF 30 or higher is adequate for all skin types

The assessment of the efficacy of sunscreens in protecting skin from harm is reflected in the SPF and, in the United States, the critical wavelength test.[49] SPF primarily indicates protection against UV-induced skin erythema (burning), which is due primarily to UV-B.[49] To be labeled broad-spectrum, the Food and Drug Administration requires that sunscreens have a critical wavelength of 370 nm or above; namely, products would have to be able to absorb 90% of the UV photons at 370 nm or above.

Table I. Recommendations for the use of sunscreen

Daily sunscreen photoprotection is beneficial for all skin phototypes. The type of sunscreen should be adapted both to skin phototype and to the extent of daily sun exposure (occupational, geographic)
Protection against UV-A wavelengths is important for all skin types, especially for those with FST IV-VI
For FST IV-VI, broad-spectrum sunscreen with SPF of 30 or above should be recommended
Tinted sunscreens, which contain iron oxide pigments, protect against VL and are recommended for prevention and treatment of pigmentary disorders in FST IV-VI

FST, Fitzpatrick skin type; *SPF*, sun protection factor; *VL*, visible light.

No specific guidance on VL protection has been developed by the Food and Drug Administration or any other regulatory agency worldwide; however, this is clearly needed in view of the now known photobiologic effects of VL.

Strategies to target VL

As discussed by Lim et al[22] in their article, *Impact of Visible Light on Skin Health: The Role of Antioxidants and Free Radical Quenchers in Skin Protection*, elsewhere in this supplement, UV radiation greatly increases the number of ROS in the skin.[49] This oxidative stress contributes to dyspigmentation, because ROS stimulate melanogenesis and activate a number of other pathways involved in photodamage that lead to increased skin pigmentation.[49]

As a result, sunscreens have been formulated with antioxidants to scavenge ROS and prevent the harmful consequences of these molecules. Supplemental antioxidants include vitamin E (α-tocopherol), vitamin C, licochalcone A, and diethylhexyl syringylidenemalonate. As examples of the actions of these ingredients, vitamin E both scavenges free radicals and prevents formation of ROS during lipid oxidation.[50,51] Furthermore, vitamin E is protective of fatty acids and phospholipids in cutaneous membranes.[52] Vitamin C, which is optimized when used in combination with vitamin E, also protects membranes by limiting oxidative damage.[53,54] Licochalcone A has antioxidant properties and induces Nrf2, a master regulator of antioxidant defenses and cellular redox signaling. Optimally, antioxidants in sunscreens should demonstrate excellent biologic activity when applied, along with good photostability.[49] There is a need for controlled clinical trials to demonstrate the potential benefits of antioxidants in sunscreen products.

Another strategy is to reflect sunlight.[55] Minor particles (micro- or nanoscale) act through the absorption of UV radiation, and larger particles also act by reflecting UV or VL photons. Larger particle sizes offer greater protection against VL, but also deposit a whitish appearance on the skin that can be unappealing to individuals, particularly those with dark skin types.[56] Inorganic sunscreens (non-carbon–based) containing ingredients such as zinc oxide, iron oxide, or titanium dioxide act via absorption, reflection, and scattering of solar radiation.[18] The SPF value of inorganic sunscreens is partly related to the opacity of the product.[57] Tinted sunscreens containing iron oxides and pigmentary titanium dioxide have been shown to be effective in preventing and treating dyspigmentation by reflecting the long UV-A and high-energy VL ranges.[58] The addition of colored tint to inorganic sunscreens can enhance their cosmetic acceptability, but patients with SOC may still experience difficulty matching their skin tone. Patients should be encouraged to apply these products thoroughly as a way to diminish the whitish cast and enhance the cosmetic appearance of the products.

SUMMARY AND CONCLUSION

Disorders of dyspigmentation, such as melasma and PIH, are common and have been associated with a marked negative impact on quality of life and increased disease burden among patients with FSTs IV to VI. Photoprotection measures (Table I), including seeking shade when outdoors, using photoprotective clothing, and applying broad-spectrum, tinted sunscreens that protect against UV and VL may be beneficial for the prevention and treatment of these conditions. Although the incorporation of antioxidants into formulations is a promising new approach, there is a need for additional research into novel strategies to address VL damage, in addition to UV damage, in patients with SOC.

Many individuals with dark skin may see themselves as exempt from needing sun protection and misunderstand how sunscreens can be beneficial for them when incorporated into overall photoprotection strategies. Furthermore, skin cancers in patients with SOC often appear in locations different from non-SOC patients. Educational interventions tailored specifically to the needs of patients with SOC are lacking and are urgently needed. It is therefore recommended that efforts on patient education regarding sun protection and skin cancer prevention may be best directed toward the individual's skin color based on FSTs or until more objective measures are developed that may allow clinicians to better estimate the proportion of melanin content for each individual patient.

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Conflicts of interest

Dr Taylor has served as an investigator for Concert Pharmaceuticals, Croma-Pharma GmbH, Eli Lilly and Company, Immune Tolerance Network, and Pfizer; as a consultant/speaker/advisory board member for AbbVie, Arcutis, Beiersdorf Inc, Biorez Inc, CannTec, Evolus, Galderma Laboratories, GloGetter, Inc, L'Oreal USA, Inc, LuminDX, Medscape/WebMD, Johnson & Johnson Consumer Products, Scientis, and Vichy Laboratories; and has received book royalties from McGraw Hill. Dr Alexis has received grant/research support from Leo, Novartis, Almirall, Bristol Myers Squibb, Amgen, Menlo, Galderma, Valeant (Bausch Health), Cara, and Arcutis; has served as a consultant/speaker for Leo, Galderma, Pfizer, Sanofi-Regeneron, Dermavant, Beiersdorf Inc, Valeant, L'Oreal, Bristol Myers Squibb, Bausch Health, UCB, Vyne, Arcutis, Janssen, Allergan, Almirall, AbbVie, Sol-Gel, Amgen, Regeneron, Sanofi-Genzyme, Pfizer, and Astra Zeneca. Dr Armstrong has served as a research investigator and/or scientific advisor to AbbVie, ASLAN, Boehringer Ingelheim, Bristol Myers Squibb, EPI, Incyte, Leo, UCB Pharma, Janssen, Lilly, Novartis, Ortho Dermatologics, Sun, Dermavant, Dermira, Sanofi, Regeneron, Pfizer, and Modmed. Dr Chiesa Fuxench has served as a consultant for the Asthma and Allergy Foundation of America and the National Eczema Association, Pfizer, Incyte, and AbbVie for which she received honoraria for work related to atopic dermatitis; she has also served as consultant for Beiersdorf Inc, which supported this work, has received research grants from Regeneron, Sanofi, Tioga, Vanda, Menlo Therapeutics, Leo Pharma, and Eli Lilly for work related to atopic dermatitis; and has received honoraria for continuing medical education work in atopic dermatitis sponsored by educational grants from Regeneron and Sanofi. Dr Lim has served as an investigator (grant to institution) for Incyte, L'Oreal, Pfizer, and PCORI; as a consultant for Pierre Fabre, ISDIN, Ferndale, La Roche-Posay, and Beiersdorf Inc; and as a speaker in a general education session for La Roche-Posay and Cantabria Labs. Evince Communications has served as scientific consultants for Beiersdorf, Inc, on educational initiatives and the dermMentors Resident of Distinction Award program.

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