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Photoprotection for people with skin of colour: needs and strategies

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Abstract

Skin of colour or pigmented skin has unique characteristics: it has a higher eumelanin-to-pheomelanin ratio, more mature melanosomes, an increased amount of melanin distributed in the upper layers of the epidermis, and more efficient DNA repair compared with lighter skin. However, individuals with skin of colour are at a significant risk of skin damage caused by ultraviolet radiation, including the development of photodermatoses and photoageing changes such as uneven skin tone, and are predisposed to pigmentary disorders. In fact, one of the most common conditions leading to dermatology consultations by patients with skin of colour is photoexacerbated pigmentary disorders. Unfortunately, individuals with skin of colour may be less prone to engage in photoprotective measures, including the use of sunscreens. Physicians are also less likely to prescribe sunscreens for them. There is thus a clear need for better education on photodamage and for more efficient and suitable photoprotection in populations with skin of colour. However, this need has thus far only partially been met, and the development of sunscreen products designed to provide optimal photoprotection for people with skin of colour remains a challenge. Targeted sunscreens for individuals with skin of colour require optimal cosmetic appeal (leaving no white residue and not disrupting skin tone). They should include broad-spectrum [ultraviolet (UV)B/UVA] protection with high sun protection factor, as well as protection against long-wave UVA (UVA1) and visible light, as these wavelengths are capable of inducing or augmenting pigmentary disorders. They may also contain depigmenting agents for patients with pigmentary disorders.

Populations with skin of colour constitute a broad range of different ethnic groups that present with widely varying skin tones. According to the Fitzpatrick classification they mainly have skin types IV–VI, but they might also include people with type III.[1] Recently, more objective and precise classification systems have been developed such as the individual typology angle (ITA).[2] Skin of colour could be considered to have ITA < 28°. Populations with darker skin tones are most frequently living in geographical areas located closer to the equator, as these areas receive higher amounts of ultraviolet (UV)B radiation. Populations with lighter skin tones are typically present in regions closer to the poles.[3] However, as a result of migratory movements, both populations also live in regions far away from their original home areas, and interracial mixtures have evolved giving rise to complex skin tones.[4] Data from the most recent census show that the non-Hispanic White population now comprises the minority of new births in the USA, and it is estimated that they will account for < 50% of the population by 2060.[5]

Skin of colour has some unique characteristics. Its skin barrier function is enhanced and its susceptibility to superficial infections is decreased.[6] It has a higher eumelanin-to-pheomelanin ratio, more mature (i.e. stage IV) melanosomes, and an increased amount of melanin distributed in the upper layers of the epidermis.[1] However, people with skin of colour are also at significant risk of photodamage, including photoageing and photodermatoses, and are predisposed to pigmentary disorders.[7] Polymorphous light eruption and chronic actinic dermatosis were more common in skin of colour in a four-institution study ($n = 1080$),[8] and one of the most common conditions leading to dermatology consultation by patients with skin of colour is photoexacerbated pigmentary disorders.[9]

Unfortunately, people with skin of colour may be less prone to taking photoprotective measures, including the use of sunscreens. Physicians are also less likely to prescribe sunscreens to patients with skin of colour. White individuals are nine times more likely to be counselled on sunscreen use.[10] In a recently published survey among African American adults with skin of colour, < 20% had discussed sun protection with their physician.[11] There is a clear need for photoprotection and education on photodamage in people with skin of colour. Public education on photoprotection in skin of colour needs to be enhanced, and the development

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of sunscreens designed to provide optimal photoprotection to individuals with darker skin tones remains a challenge.[9]

The aims of this review are to discuss the unique characteristics of skin of colour regarding photocarcinogenesis, photoageing and pigmentary disorders, to highlight the need for photoprotection in this population, and to discuss the challenges and future strategies relevant to the development of photoprotective and sunscreen products targeted for skin of colour.

Methods

We conducted a narrative review of the literature. We performed literature searches with PubMed and Google Scholar from January 1990 to November 2021 using the keywords (non-MeSH) 'dark skin', 'ethnic skin', 'non-white skin', 'skin of color', 'black skin', 'skin cancer', 'photocarcinogenesis', 'photoaging', 'melasma', 'postinflammatory hyperpigmentation', 'pigmentary disorders', 'ultraviolet radiation', 'visible light', 'photoprotection' and 'sunscreens'.

The search was limited to articles in English, Spanish and French. Articles were selected depending on their relevance.

Assessing skin phototype

The Fitzpatrick classification is a subjective scale that requires a trained observer. It was originally developed for categorizing light skin according to ultraviolet radiation (UVR) sensitivity, and it is less useful in darker skin tones, particularly in people of African descent, those of Arab or Middle Eastern descent, Asian populations, and Hispanic groups. Self-reported race and pigmentary phenotypes are weak predictors of individual sunburn risk.[12]

Recently, more objective classification systems have been developed, which are based on measuring skin pigmentation with precise criteria to define skin colour. These include direct measures such as reflectance spectrophotometry and colorimetry and visual inspection measures such as skin colour identification charts, which can be used without specialized training.[13,14] ITA measures constitutive pigmentation, while the Fitzpatrick classification is based on sun reactiveness.[15] ITA assessed by colorimetry measurement is calculated using the equation: $ITA = [\arctan(L^* - 50)/b^*)] \times 180/\pi$, where L* represents luminance ranging from black (0) to white (100) and b* ranges from yellow to blue.[2] The differences along the luminance axis and along the yellow–blue axis determine the intensity of skin pigmentation. In general, the higher the ITA, the lighter the skin. An ITA $< 28°$ corresponds to darker skin phototypes (Figure 1).

Similarly to the Fitzpatrick classification, ITA categorizes skin types into six categories from very light to dark skin: very light ($> 55°$), light ($41°$ to $< 55°$), intermediate ($28°$ to $< 41°$), tan ($10°$ to $< 28°$), brown ($-30°$ to $< 10°$) and dark ($< -30°$).[2] Correlation between the six objective ITA categories and the subjective Fitzpatrick skin phototype categories can be poor.[15] While ITA can be more appropriate to objectively standardize skin type classifications and predict skin responses for all skin phototypes,[15] it should be considered that ITA is based on small studies, is not widely used, and probably presents with bias towards individuals with darker skin tones similarly to the Fitzpatrick classification.

Sunlight-induced skin damage in populations with skin of colour

Skin damage secondary to UVR affects not only individuals with light skin tones, but also people with darker skin tones. However, it affects them differently, as we will review in the next sections. Detrimental effects of UVR include acute effects such as sunburn, chronic damage such as photocarcinogenesis and photoageing, and photodermatoses such as polymorphic light eruption, chronic actinic dermatitis and actinic prurigo. UVR and, as discovered in recent years, visible light are also relevant for pigmentary disorders.

Photocarcinogenesis in skin of colour

Skin of colour presents unique features that provide better protection against UVR damage compared with lighter skin: it has a higher amount of melanin in the upper layers of the epidermis, and thus basal keratinocytes and the dermis below are better protected from the damaging effects of UVR. Also, DNA repair is more efficient in darker skin (Table 1).[16] After UVB exposure, DNA damage occurs mainly in the upper layers of the epidermis in darker skin. Melanin in darker skin protects against the formation of cyclobutane pyrimidine dimers, the most mutagenic DNA photolesions, in the basal epidermis.[17] Furthermore, this skin pigment distribution appears to increase the threshold dose at which UVR induces cutaneous inflammatory responses such as the presence of neutrophilic infiltrate, proteolytic enzymes such as matrix metalloproteinases, and activation of keratinocytes.[16] While individuals with skin of colour are better protected against photodamage, UVR exposure still represents a risk factor for skin cancer in populations with skin of colour, including American, Asian and Hispanic groups.[1] However, a recent meta-analysis has shown that UV exposure is not a critical risk factor for developing melanoma in patients with skin of colour.[18]

Skin cancer accounts for approximately 40% of all neoplasms in individuals with light skin, but only 1–4% in individuals with darker skin. The role of photoprotection in reducing photocarcinogenesis in individuals with skin of colour remains controversial. Photoprotection may not significantly alter carcinogenesis risk in individuals with skin of colour, as skin cancers in patients with skin of colour are frequently detected on non-sun-exposed sites: acral lentiginous melanoma on the sole, mucosal melanoma, and squamous cell carcinoma (SCC) on the perianal area. While skin cancer is less frequent in people with skin of colour, outcomes are poorer in these individuals. African Americans are four times more likely to be diagnosed with advanced-stage melanoma,[19] and can have two- to threefold higher risk of mortality than patients with light skin overall.[20]

When SCC develops in chronic scarring processes in African Americans, the metastatic rate is 20–40%, compared with a rate of 1–4% when SCC develops from sun exposure in non-Hispanic White populations.[21,22] Basal cell carcinoma (BCC) represents 12–35% of skin cancers in Black Americans,[22] and can lead to significant morbidity.

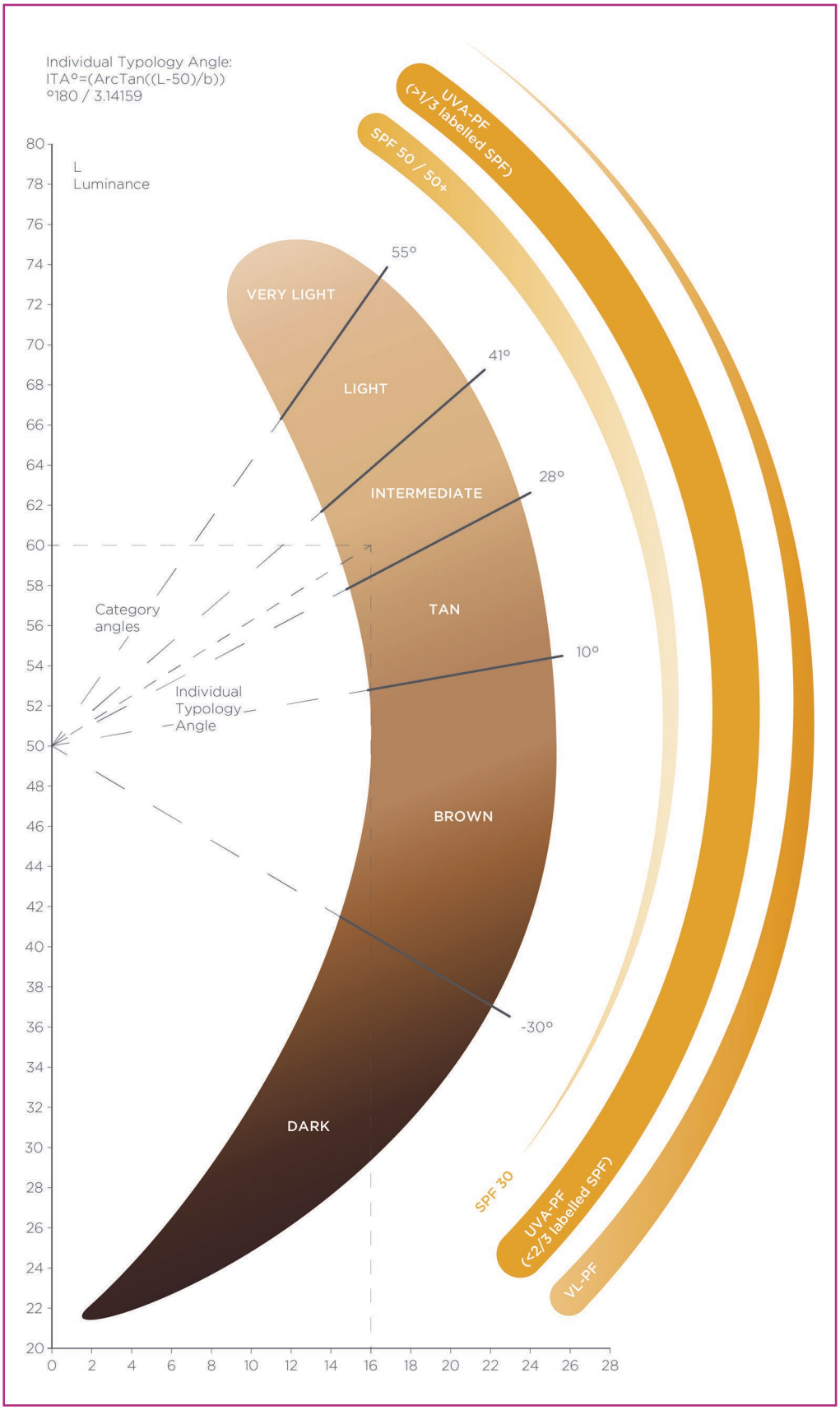

Figure 1 Individual typology angle (ITA) and sunscreen recommendations. ITA measures constitutive pigmentation and is assessed by colorimetry measurement. ITA categorizes skin types into six categories, from very light to dark skin. The higher the ITA, the lighter the skin: very light (>55°), light (41° to <55°), intermediate (28° to <41°), tan (10° to <28°), brown (−30° to <10°) and dark (<−30°). An ITA <28° corresponds to darker skin phototypes. People with skin of colour require more intensive protection against ultraviolet A radiation and visible light. SPF, sun protection factor; UV, ultraviolet; VL, visible light.

Table 1 Characteristics of dark skin in comparison with light skin

Enhanced skin barrier function
Decreased susceptibility to superficial skin infections
Greater amount of melanin in the upper layers of the epidermis
Increased eumelanin-to-pheomelanin ratio
More mature (i.e. stage IV) melanosomes
More efficient DNA repair
Predisposition to develop pigmentary disorders
Long-wave ultraviolet A (UVA1) and high-energy visible light exposure induces skin pigmentation in skin phototypes III–VI, but not in skin phototypes I and II
Higher incidence of polymorphous light eruption and chronic actinic dermatitis
People with skin of colour are less likely to practise photoprotection, including the use of sunscreens
Healthcare providers are less likely to prescribe sunscreen products to people with skin of colour

Delayed diagnoses and poorer outcomes can be frequent.[23] Pigmented BCCs can be present in > 50% of tumours, compared with only 5–6% of BCCs in non-Hispanic White populations, and they can be misdiagnosed as a seborrhoeic keratosis or melanocytic naevus.[23]

Photoageing in populations with skin of colour

Photoageing typically results from chronic UVR exposure, and manifests as wrinkles, elastosis, uneven pigmentation, pigment spots and telangiectasia. There is a major concern about facial photoageing, as it has been linked to social acceptance, status and beauty.[24] Solar elastosis is induced by both UVB and UVA, and is the hallmark of photoageing.[25] The distribution and quantity of melanin in dark skin provide better protection against photoageing than in light skin, and dark skin has been found to have a thicker dermis together with more numerous, larger and more nucleated fibroblasts, which synthesize key structural dermal elements.[26] Moderate-to-severe solar elastosis was seen in 80% of individuals with light skin and in 34% of individuals with darker skin tones in a multicentre study ($n = 287$).[25]

Individuals with light skin showed significantly more wrinkles, laxity and overall photodamage than individuals with dark skin tones.[24,27] Individuals with darker skin tones develop clinically apparent signs of photoageing usually in the fifth and sixth decades, later in life than in individuals with lighter skin, and typically present with skin laxity and pigmentary changes such as hyperpigmentation and uneven skin tone,[24,27] and with deeper pores.[24] Skin with homogeneous colour distribution has been rated as looking younger and more attractive than uneven skin tone in elderly people with both light and dark skin, and uneven skin colour distribution can account for up to 20 years of perceived age difference.[26] In patients with darker skin tones from East Asia, flat seborrhoeic keratosis and solar lentigines are observed.[26]

Pigmentary disorders in skin of colour

Patients with skin of colour have an increased susceptibility to developing pigmentation disorders such as melasma and postinflammatory hyperpigmentation (PIH).[28] The impact of melasma on quality of life must be emphasized, as these patients can have a higher impairment in quality of life than patients with vitiligo.[29] Pigmentary disorders have been ranked among the top five dermatological consultations by individuals with skin of colour,[30,31] and were not even listed in the top 10 dermatological diagnoses among patients with lighter skin.[30] People with darker skin from East Asia and South Asia were reported to be more susceptible to pigmentation disorders than other ethnic groups.[32] In a large descriptive Indian study ($n = 1204$), 30% of women aged 40–65 years presented with facial melasma.[33] South Americans are also prone to developing hyperpigmentary disorders. Melasma accounted for 4–10% of new dermatology hospital referrals, and affected up to 50% of pregnant women in Mexico.[34] In Latino men a prevalence of 7–36% has been reported.[35] In a cross-sectional study in a large urban setting in South Africa, 304 patients presented with pigmentary disorders. Regarding ethnicity, 73% were Black African, 21% were Indian and only 2% were White.[36] In a cross-sectional Brazilian study, the association between genetic ancestry and facial melasma was evaluated. African but not European ancestry was associated with melasma.[37]

Regarding PIH, in a large survey of new dermatological outpatients ($n = 7029$) the rate of PIH was sevenfold higher in patients with darker-toned skin than with lighter skin.[38] Common causes of PIH in patients with skin of colour include acne vulgaris, atopic dermatitis and impetigo. A study of acne in individuals with skin of colour showed that 65% of African American and 53% of Hispanic patients developed acne-induced PIH.[39] Pseudofolliculitis barbae can lead to PIH in 40–90% of individuals with skin of colour.[39] High rates of melasma and PIH in individuals with skin of colour might be explained by the recent discovery that visible light, specifically high-energy visible light from violet to blue light, contributes to skin pigmentation in individuals with dark skin, but not light skin. It has been demonstrated that exposure to long-wave UVA (UVA1) and visible light induces skin pigmentation in skin phototypes III–VI,[40,41] but not in skin phototypes I and II. The proposed molecular mechanism for visible light-induced skin pigmentation is through the activation of opsin 3, a photoreceptor that mediates the expression and activity of the rate-limiting enzyme tyrosinase in melanocytes.[42]

Regarding hypopigmentary disorders, pityriasis alba can be particularly bothersome for patients with darker skin,[43] and vitiligo can cause a significant detrimental effect on quality of life.[29] This impact can be even greater in individuals with skin of colour, and worse in Eastern cultures than in Western cultures.[44] The contrast between healthy, pigmented and lesional nonpigmented skin can be more easily seen. In a study of 53 individuals in India, major depressive disorder was reported in 57% of cases, and suicidal ideation in 28%.[45] Photoprotection to avoid sunburn and thus koebnerization is widely recommended for these dermatoses.[29,46]

Climate change and air pollution

Climate change is one of the greatest threats to public health. Some studies have suggested that global warming, stratospheric ozone depletion and ambient air pollution could be associated with an increasing frequency of skin cancer in people of all skin tones.[47] Also, they have been linked to photoageing and lentigines in populations with light skin and Asian populations, and air pollution has emerged

as a potential risk factor for the development of melasma.[48] Photoprotection should be encouraged in areas with high levels of air pollution.

Photoprotection in skin of colour

Photoprotective practices among people with skin of colour

Photoprotective measures include minimizing sun exposure during its peak UVR (10.00–14.00 h); seeking shade; wearing sunglasses, wide-brimmed hats and photoprotective clothing; and applying sunscreen. Furthermore, individuals with skin of colour should also be protected against UVA1 and visible light, which are much more constant through the year and through the day. Multiple studies have shown that patients with skin of colour are less likely to follow photoprotective recommendations.[9,11] A large study ($n > 18\,000$) from 25 countries confirmed that light skin tone was associated with more frequent use of photoprotective measures.[49] Lack of public education on this subject, economic factors, popular myths – 'people with darker skin do not get sunburnt' – and limited representation of skin of colour in medical student resources,[50] among other factors, could explain this situation.

A recent survey ($n = 151$) performed among African Americans revealed that only 5% had discussed how to prevent or treat photoageing with a physician, and > 40% would have liked more information on sun protection.[11] In an anonymous survey ($n = 77$), more than half of the dermatologists answered that they counsel patients with skin of colour less on sunscreen use than patients with light skin, and that they never, rarely or only sometimes take patients' skin phototype into account when prescribing a sunscreen.[9] Information from the internet about photoprotection, which rarely incorporates input from a board-certified dermatologist, can be different for individuals with dark or light skin. Websites with recommendations on sunscreens for skin of colour are more likely to recommend chemical sunscreens (70% vs. 36%), products with lower sun protection factor (SPF) and more expensive sunscreens.[9]

Targeted sunscreen formulations for individuals with darker skin tones

Compared with populations with light skin there are limited data about populations with skin of colour in the dermatological literature.[51] This also includes available evidence on photoprotection in skin of colour.[7,9] As personalized or targeted photoprotection seems to be the future for prevention of photodamage,[52] there is a clear need for further research on photoprotection in populations with skin of colour. While skin of colour intrinsically presents with increased protection against UVB, these populations are at increased risk for hyperpigmentary skin disorders. Sunscreens for skin of colour should protect not only against UVB and UVA2, but also against UVA1 and visible light (Table 2) to minimize hyperpigmentation. UVA1 can induce photoageing, and a recent review showed that visible light could also be involved in the photoageing process, with shorter-wavelength blue light having the most noticeable effects.[53]

Several studies have shown that sunscreens with a high UVA protection factor offer better protection against pigmentation, photoageing and DNA damage than those with a low UVA protection factor.[54] Sunscreens offering good coverage in the UVB, and also for UVA and high-energy visible light, have demonstrated their efficacy in several hyperpigmentary conditions, including melasma.[55] Sunscreens may contain zinc oxide, titanium dioxide and iron oxides, because they have shown up to 85% attenuation across the tested wavelengths of 415–465 nm.[56] On the other hand, these ingredients can leave a white residue on the skin, and may reduce compliance. Protection against infrared A is also required to prevent photoageing. Broad-spectrum sunscreens containing antioxidants could help to reduce infrared A damage, until specifically designed sunscreens against this radiation are available.[7]

The cosmesis of sunscreens is a key factor to ensure compliance. A recent survey revealed that dermatologists valued cosmetic elegance as the least important factor when making recommendations for patients with skin of colour.[9] People with skin of colour can find the white residue from physical sunscreen unappealing and this may reduce its application.[9] Formulas with ultralight textures, sprays and nongreasy formulations can be excellent alternatives for encouraging the regular use of sunscreens by people with skin of colour. Tinted sunscreens can also be a good choice as they combine a coloured base with UV filters. The pigments have a double function: to camouflage uneven skin tone in pigmentary or inflammatory disorders, and to protect from visible light.[56]

There are concerns about the impact of photoprotection on vitamin D synthesis in people with darker skin tones, as some of these populations can have lower serum 25-hydroxyvitamin D levels than people with lighter skin tones.[1] A recent review of the literature showed that the regular use of sunscreen did not have a detrimental impact on vitamin D status in healthy individuals, and vitamin D screening should be restricted to those at risk of hypovitaminosis, such as

Table 2 Characteristics of recommended sunscreens in people with skin of colour

Sun protection	At least sun protection factor 30
	Ultraviolet B + ultraviolet A + high-energy visible light
Formula texture	High-tolerance water-based formulas, easy-to-apply and nongreasy formulations, with no white residue on the skin
Other ingredients	Should contain antioxidants, anti-inflammatories and/or immunomodulators
	Depigmenting agents (resorcinol derivatives, Tetrapeptide-30, niacinamide) could improve results in patients with hyperpigmentary disorders
Coloured formulations	Suitable tinted sunscreens should be considered as they can impact positively on the cosmesis
	Tinted sunscreens containing formulations of iron oxides and pigmentary titanium dioxide can protect against visible light
	Tinted sunscreens matching as far as possible the colour for each skin subtype

patients with photosensitivity disorders using strict photoprotection.[54]

Sunscreens containing depigmenting agents for patients with pigmentary disorders

Several nonfilter ingredients such as antioxidants, peptides and depigmenting agents could improve the depigmenting properties of sunscreens in pigmentary disorders. Resorcinol derivatives such as hexylresorcinol, phenethyl resorcinol, isobutylamido thiazolyl resorcinol and 4-*n*-butylresorcinol have been found to be potent inhibitors of tyrosinase.[57–60] A study showed that 4-*n*-butylresorcinol was more effective than 4-hexylresorcinol and 4-phenylethyl resorcinol, and by far a more potent inhibitor of human tyrosinase than kojic acid.[59] A recent clinical trial ($n=50$, 86% with phototypes III–IV) performed with 0.2% isobutylamido thiazolyl resorcinol or 4% hydroquinone in the treatment of melasma revealed no differences between clinical outcomes in the groups.[61]

Tetrapeptide-30 is a synthetic peptide consisting of glutamic acid, lysine and proline, which also inhibits tyrosinase. Several studies have demonstrated that Tetrapeptide-30 is able to improve skin tone evenness in Asian skin,[62] and to reduce melasma and PIH in people with phototypes V and VI.[62] Niacinamide, or nicotinamide, displays antioxidant effects, blocks melanosome migration and suppresses skin pigmentation. A randomized clinical trial ($n=27$) of niacinamide 4% vs. hydroquinone 4% in the treatment of melasma in people with phototypes IV and V did not find differences between the treatments in clinical response. Good or excellent improvement was observed with niacinamide in 44% of cases.[63] Combinations with niacinamide and liquorice extract also proved to be safe and effective in the management of melasma.[64]

All of the previously mentioned ingredients are potentially suitable for use as part of a sunscreen formulation. Further studies in pigmentary disorders in individuals with skin of colour are needed in order to make evidence-based recommendations. Active depigmenting agents incorporated into sunscreen products represent an interesting avenue of investigation for the future management of these conditions.

Oral photoprotection in individuals with skin of colour and in pigmentation disorders

Antioxidants, anti-inflammatories and/or immunomodulators are currently used for oral photoprotection.[52] Examples are vitamins such as l-ascorbic acid (vitamin C), tocopherol (vitamin E) and carotenoids (vitamin A derivatives). Vitamins C and E are natural nonenzymatic antioxidants with a synergistic action. Beta-carotene and lycopene are the main carotenoids present in the blood and tissue capable of modulating cutaneous properties. These supplements can enhance cutaneous defence against solar erythema and photodamage,[65] and recent evidence suggests that mixed carotenoids can significantly protect against UVA1 radiation-induced skin pigmentation.[66]

Pinus pinaster bark extract has been shown to strengthen physiological antioxidant skin defences, to protect the skin from photoageing, and to improve skin appearance.[67] A prospective study including 30 women with melasma (phototypes I–V) showed a significant reduction in the Melasma Area and Severity Index with the use of an oral nutritional supplement containing *P. pinaster* and grape seed extract, vitamins and minerals, concomitantly with a high-SPF sunscreen.[67] *Polypodium leucotomos* is a tropical fern, extracts of which have been shown to have photoprotective properties inhibiting UVR-induced generation and release of reactive oxygen species, thus preventing DNA damage.[68] *P. leucotomos* exhibits significant anti-inflammatory properties against UVB-induced damage, and can reduce UVB-induced erythema.[69] This extract may also decrease persistent pigment darkening after exposure to visible light.[70] A food supplement containing *P. leucotomos* and carotenoids, vitamins and selenium was capable of increasing the minimal erythema dose and upregulating the antioxidant capacity of the skin, and ameliorated skin parameters related to skin ageing.[71,72] Conversely, a randomized clinical trial concluded that *P. leucotomos* was not significantly better than placebo as an adjunct to topical sunscreen in the treatment of melasma in Hispanic women.[73]

Oral photoprotection might represent a further option when treating patients with skin of colour with pigmentary disorders or with a high risk of developing PIH. However, evidence is still limited, and oral supplementation should not replace the use of other protective measures, including adapted sunscreens.

Conclusions

Skin of colour is constitutively better protected against photocarcinogenesis and photoageing than lighter skin. However, individuals with skin of colour present with higher rates of pigmentary disorders, which significantly impact quality of life. While more research is needed on photoprotection in skin of colour, public education on photoageing and pigmentary disorders should be emphasized. Dermatologists should be aware of the impact of UVB, UVA, visible light and infrared A in people with skin of colour and instruct them on photodamage and associated risks. They should prescribe photoprotective measures, including regular use of well-tolerated and cosmetically acceptable sunscreens with high SPF, a broad spectrum and protection against UVA1 and visible light.

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Conflicts of interest

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics statement

Not applicable.

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