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ARTICLE

SUNSCREEN USE IN POPULATIONS OF COLOUR: A COMPREHENSIVE REVIEW OF BARRIERS, EFFICACY, AND CLINICAL RECOMMENDATIONS

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ABSTRACT

Populations with skin of colour (Fitzpatrick IV–VI) contain higher melanin levels that provide natural photoprotection equivalent to approximately SPF 13.4 compared with about SPF 3.3 in lighter skin. Nevertheless, they remain vulnerable to UV-related damage such as post-inflammatory hyperpigmentation (PIH), photoaging, and delayed skin cancer detection. This review summarizes evidence on sunscreen use in these populations, including formulation effectiveness, clinical benefits, barriers to use, and recommended practices. Broad-spectrum sunscreen with SPF ≥30 is consistently recommended. Tinted sunscreens containing iron oxides effectively block visible light, reducing blue-light exposure by up to 86% and preventing PIH in 98–100% of cases. However, higher costs, limited shade availability, and misconceptions about skin cancer risk restrict regular use.

Keywords: Fitzpatrick skin types IV-VI; Skin of Colour; Sunscreen; Photoprotection; Post-nflammatory Hyperpigmentation; Tinted sunscreen; Health disparities

АБСТРАКТ

Население с темной кожей (Fitzpatrick IV–VI) имеет более высокий уровень меланина, который обеспечивает естественную фотозащиту, эквивалентную примерно SPF 13,4, по сравнению с примерно SPF 3,3 у людей с более светлой кожей. Тем не менее, они остаются уязвимыми к повреждениям, связанным с УФ-излучением, таким как поствоспалительная гиперпигментация (PIH), фотостарение и задержка в выявлении рака кожи. В этом обзоре обобщены данные об использовании солнцезащитных средств в этих группах населения, включая эффективность рецептур, клинические преимущества, препятствия для использования и рекомендуемые практики. Постоянно рекомендуется использовать солнцезащитные средства широкого спектра действия с SPF ≥30. Тонированные солнцезащитные средства, содержащие оксиды железа, эффективно блокируют видимый свет, снижая воздействие синего света до 86% и предотвращая PIH в 98–100% случаев. Однако более высокая стоимость, ограниченная доступность оттенков и неправильные представления о риске рака кожи ограничивают регулярное использование.

Ключевые слова: типы кожи по шкале Фитцпатрика IV-VI; цветная кожа; солнцезащитный крем; фотозащита; поствоспалительная гиперпигментация; тонированный солнцезащитный крем; неравенство в области здравоохранения.

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INTRODUCTION

Ultraviolet (UV) radiation exposure represents a major environmental risk factor for acute and chronic skin damage, encompassing sunburn, premature aging, carcinogenesis, and pigmentation disorders (Narayanan et al., 2010). The global burden of skin cancer continues to escalate, with melanoma representing the fifth most common cancer in the United States and projected to affect 97,610 new cases annually (Siegel et al., 2023).

While traditionally considered a disease primarily affecting fair-skinned populations, recent epidemiological data reveal concerning trends in populations of colour. Melanoma incidence among Hispanic individuals has increased by 20% over the past two decades, with patients presenting at younger ages (median 49 versus 58 years in non-Hispanic whites) and more advanced disease stages (Niu et al., 2024). Similarly, non-melanoma skin cancers show increasing prevalence among Hispanic and Asian ethnic groups (Gloster & Neal, 2006).

Recent studies conducted in the coastal areas of Jakarta, Indonesia, have provided further evidence of the impact of chronic sun exposure on skin health. These studies, which focused on populations with Fitzpatrick skin types III-V and significant daily sun exposure, demonstrated a strong correlation between the duration of sun exposure and the severity of photoaging (Sukma et al., 2024; Sutanto et al., 2023). This highlights the vulnerability of coastal communities to the damaging effects of UV radiation, even in individuals with moderately pigmented skin, and underscores the importance of targeted photoprotection strategies in these high-risk environments.

Populations with skin of colour, defined as Fitzpatrick skin types IV-VI, possess unique physiological characteristics that influence their response to UV radiation. These individuals have higher melanin content, larger melanosomes, and dense eumelanin distribution, providing natural photoprotection equivalent to SPF 13.4 compared to SPF 3.3 in lighter skin types (Brar et al., 2025). However, this protection is incomplete, particularly against UVA radiation and visible light, leaving individuals susceptible to post-inflammatory hyperpigmentation and melasma (Sheth & Pandya, 2011).

Despite lower overall skin cancer incidence, populations of colour face unique dermatological challenges that necessitate targeted photoprotection strategies. Post-inflammatory hyperpigmentation (PIH) represents a significant concern, occurring when melanocytes produce excess melanin in response to inflammation (Davis & Callender, 2010). Recent research has highlighted significant disparities in sunscreen use among different racial and ethnic groups, with only 15.79% of African American individuals using sunscreen regularly (Ullman et al., 2024).

MATERIAL AND METHODS

2. Skin of Colour: Physiological Characteristics and Unique Vulnerabilities

2.1. Melanin Biology and Photoprotection Mechanisms

Melanin serves as the primary determinant of skin colour and natural photoprotection. Two distinct types of melanin contribute to skin pigmentation: eumelanin, a brown-black pigment predominant in darker skin, and pheomelanin, a yellow-red pigment more common in lighter skin types (Ito & Wakamatsu, 2008). In darker skin, melanosomes form a protective perinuclear cap around cell nuclei, effectively shielding DNA from UV-induced damage (Brenner & Hearing, 2008).

This architectural arrangement, combined with the superior UV-absorbing properties of eumelanin, provides the natural SPF equivalent of 13.4 in dark skin compared to 3.3 in light skin (Brar et al., 2025). Eumelanin demonstrates remarkable photoprotective capabilities, absorbing UV radiation and converting it to harmless heat while simultaneously scavenging reactive oxygen species (Taylor et al., 2005).

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However, it is crucial to emphasize that this natural protection is not absolute. While melanin provides a degree of defense against UVB radiation, it offers less protection against UVA rays, which penetrate deeper into the skin and contribute significantly to photoaging and the development of certain skin cancers. The inherent SPF of darker skin is also not sufficient to prevent sun damage entirely, especially with prolonged or intense sun exposure. Therefore, the misconception that individuals with skin of colour do not need sunscreen is a dangerous one. Regular use of a broad-spectrum sunscreen is essential for everyone, regardless of skin tone, to protect against the full spectrum of UV radiation and its associated risks.

However, the protective mechanisms of melanin are not complete. While melanin absorbs 50-75% of UVB radiation, its protection against UVA is less complete, particularly in the UVA1 spectrum (340-400 nm) (Kollias & Baqer, 1985). This differential protection explains why individuals with darker skin remain susceptible to UVA-induced effects, including photoaging and pigmentation disorders.

2.2. Post-Inflammatory Hyperpigmentation and Melasma

Despite natural photoprotection advantages, populations of colour face distinct dermatological challenges. Post-inflammatory hyperpigmentation affects up to 65% of individuals with darker skin following inflammatory events such as acne, eczema, or minor trauma (Callender et al., 2011). The pathophysiology involves complex interactions between inflammatory mediators and melanocyte activity.

Melasma represents another significant concern in populations of colour, particularly affecting women of reproductive age. This chronic pigmentary disorder results from complex interactions between hormonal influences, UV exposure, and genetic predisposition (Handel et al., 2014). Unlike PIH, melasma demonstrates a characteristic bilateral, symmetric distribution on the face and shows particular sensitivity to visible light exposure (Mahmoud et al., 2010).

2.3. Delayed Skin Cancer Detection Challenges

While populations of colour have lower overall skin cancer incidence, they face significant challenges in early detection and diagnosis. The natural protective effects of melanin can mask early signs of malignancy, leading to delayed recognition of suspicious lesions (Cormier et al., 2006). Melanoma in darker skin often presents with atypical characteristics, appearing as amelanotic lesions or occurring in areas with less pigmentation (Bradford et al., 2009).

Hispanic patients with melanoma present with thicker tumors (>1.5 mm) more frequently than non-Hispanic whites, correlating with worse prognosis and reduced survival rates (Wu & Santana, 2022). Five-year melanoma-specific survival rates demonstrate persistent disparities: 76.6% for Hispanic men versus 87.0% for non-Hispanic white men (Zell et al., 2008).

RESULT

3. Sunscreen Formulations and Mechanisms of Action

3.1. Chemical versus Physical Sunscreen Filters

Sunscreen formulations utilize two primary categories of active ingredients: chemical (organic) filters and physical (inorganic) filters. Chemical filters, including compounds such as avobenzone, octinoxate, and oxybenzone, function by absorbing high-intensity UV radiation and converting it to lower-energy wavelengths (Serpone et al., 2007). Physical filters, primarily zinc oxide and titanium dioxide, operate through mechanical reflection and refraction of UV radiation away from the skin surface (Smijs & Pavel, 2011).

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For populations of colour, the selection between chemical and physical filters often depends on cosmetic preferences and skin sensitivity considerations. The challenge of white cast, particularly problematic with physical filters, has driven innovation in particle size optimization and surface treatments (Cross et al., 2007).

3.2. Tinted Sunscreens and Iron Oxide Technology

Tinted sunscreens represent a significant advancement in photoprotection for populations of colour, addressing both functional and aesthetic concerns (Zhou et al., 2024). These products incorporate pigmented iron oxides (red, yellow, and black) along with pigmented titanium dioxide to provide visible light protection while offering cosmetically acceptable options for diverse skin tones.

Iron oxides demonstrate exceptional efficacy in blocking visible light, particularly in the blue light spectrum (400-500 nm) that has been implicated in melasma exacerbation and PIH development (Grimes, 2020). Recent research demonstrates that tinted sunscreens containing iron oxides can reduce blue light exposure by up to 86%, providing superior protection compared to traditional UV-only formulations (OneSkin, 2025).

Clinical studies have shown that dark-coloured iron oxide combinations achieve greater than 98% transmission reduction of high-energy visible light (Tanaka et al., 2023). Clinical trials demonstrate that patients using iron oxide-containing sunscreens experience lower melasma recurrence rates compared to those using conventional sunscreens (Boukari et al., 2015b).

DISCUSSION

Barriers to Sunscreen Use in Populations of Colour

Economic and Accessibility Barriers

Economic factors represent the most significant barrier to appropriate sunscreen use among populations of colour. Recent market analysis reveals substantial price disparities between products suitable for different skin types, with tinted sunscreens averaging $24.59 per ounce compared to $6.85 for traditional formulations (Lim et al., 2024). This 3.6-fold price difference creates significant accessibility challenges for individuals and families with limited financial resources.

Geographic accessibility compounds economic barriers, with limited availability of appropriate products in specific retail environments. Research demonstrates that beauty supply stores stock tinted sunscreen options 2.3 times more frequently than traditional pharmacy chains (Lim et al., 2024). Insurance coverage limitations further exacerbate accessibility challenges, as most health insurance plans do not cover sunscreen products (World Health Organization, 2023)

Knowledge and Awareness Deficits

Inadequate knowledge about skin cancer risk and photoprotection needs represents a fundamental barrier to appropriate sunscreen use among populations of colour (Green et al., 2011). Comprehensive surveys reveal that 76% of African American individuals consider their skin cancer risk "low" or "none," reflecting widespread misconceptions about melanin's protective limitations (Green et al., 2011).

Educational deficits extend beyond skin cancer awareness to include limited understanding of other UV-related conditions affecting populations of colour. Research demonstrates that only 34% of individuals with darker skin recognize the connection between UV exposure and post-inflammatory hyperpigmentation (Grimes, 2009).

Cultural and Social Factors

Cultural beliefs and social norms significantly influence sunscreen adoption patterns among diverse populations. Qualitative research among Hispanic populations identifies machismo as a significant barrier to sun protection behaviors among men, with sunscreen use perceived as inconsistent with masculine identity (Niu et al., 2024). Conversely, cultural values such as familismo can serve as facilitators for sun protection behaviors (Niu et al., 2024).

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Aesthetic concerns related to sunscreen use represent another significant cultural barrier, particularly regarding white cast residue and texture preferences. Focus group research reveals that 68% of individuals with darker skin report dissatisfaction with the appearance of traditional sunscreens on their skin (Zhou et al., 2024).

Clinical Evidence and Recommendations

Evidence-Based SPF Recommendations

Current clinical evidence supports differentiated SPF recommendations based on skin type characteristics, while maintaining universal broad-spectrum protection requirements (American Academy of Dermatology, 2024). For individuals with Fitzpatrick skin types V-VI, clinical studies demonstrate that SPF 30 provides adequate protection when combined with appropriate UVA and visible light protection (Brar et al., 2025).

Comparative effectiveness research demonstrates superior outcomes with SPF 50+ formulations in preventing post-inflammatory hyperpigmentation compared to SPF 30 products under real-world conditions (Dermatology Times, 2025). Clinical trials indicate that the effectiveness of sunscreen protection depends not only on SPF values but also on application quantity and frequency (Petersen & Wulf, 2014).

Sunscreen Use and Vitamin D Synthesis

A common concern regarding regular sunscreen use is its potential to interfere with vitamin D synthesis, which is crucial for bone health and immune function. However, multiple studies have shown that, in real-world conditions, the use of sunscreen does not lead to vitamin D deficiency. In fact, some research suggests that individuals who use sunscreen regularly may have higher vitamin D levels, possibly because they spend more time outdoors, confident in their sun protection (Neale et al., 2019). A study on children in a sunny climate found that those who used sunscreen had higher serum 25(OH)D levels than those who did not (Feketea et al., 2021). The consensus from various studies is that the benefits of sun protection in preventing skin cancer and photoaging far outweigh the risk of vitamin D deficiency, which can be effectively managed through diet and supplementation if necessary, especially during months with lower sun exposure.

Clinical Outcomes in Post-Inflammatory Hyperpigmentation Prevention

Post-inflammatory hyperpigmentation represents one of the most common and clinically significant concerns for populations of colour, with sunscreen playing a crucial role in both prevention and treatment (Davis & Callender, 2010). Clinical evidence demonstrates that consistent sunscreen use can achieve 98-100% success rates in preventing PIH development when used for two months following inflammatory events (Dermatology Times, 2025).

Clinical trials comparing different sunscreen formulations for PIH prevention demonstrate superior outcomes with broad-spectrum products containing antioxidant ingredients (Puaratanaarunkon & Asawanonda, 2022). Research shows that sunscreens containing anti-inflammatory agents achieved significantly better PIH prevention compared to standard formulations, with 89% versus 67% success rates, respectively (Puaratanaarunkon & Asawanonda, 2022).

Melasma Management and Visible Light Protection

Melasma management represents a complex clinical challenge requiring comprehensive photoprotection strategies that extend beyond traditional UV protection (Handel et al., 2014). Clinical evidence demonstrates that conventional sunscreens providing only UV protection show limited efficacy in preventing melasma recurrence, with relapse rates exceeding 60% within six months (Boukari et al., 2015a).

Clinical trials evaluating tinted sunscreens containing iron oxides show dramatically improved outcomes in melasma management. A randomized controlled trial demonstrated

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that patients using iron oxide-containing sunscreens experienced 50% lower melasma recurrence rates compared to those using conventional UV-only protection (Boukari et al., 2015a).

Skin Cancer Prevention Outcomes

While populations of colour have lower overall skin cancer incidence, clinical evidence supports the importance of consistent sunscreen use for cancer prevention in these populations (American Cancer Society, 2024). Epidemiological studies demonstrate that regular sunscreen use reduces melanoma risk by 50-73% across all skin types, with similar relative risk reductions observed in darker-skinned populations (Green et al., 2011).

Healthcare Provider Recommendations

Effective sunscreen counseling for populations of colour requires culturally competent approaches that address specific concerns and barriers (Agbai et al., 2014). Clinical guidelines recommend individualized counseling that considers skin type, lifestyle factors, cultural preferences, and economic constraints (American Academy of Dermatology, 2024).

The comprehensive analysis of sunscreen use in populations of colour reveals a complex landscape of physiological advantages, unique vulnerabilities, and persistent barriers that require targeted interventions to optimize photoprotection outcomes. While individuals with Fitzpatrick skin types IV-VI possess natural photoprotection equivalent to SPF 13.4 through enhanced melanin content, this protection remains incomplete and insufficient to prevent UV-induced damage, particularly from UVA radiation and visible light exposure.

Current clinical evidence strongly supports the universal recommendation for broad-spectrum sunscreen use with SPF 30 or higher, regardless of natural skin pigmentation. The misconception that darker skin does not require photoprotection has contributed to significant health disparities, including delayed skin cancer diagnosis, increased post-inflammatory hyperpigmentation, and suboptimal melasma management.

The development of tinted sunscreens containing iron oxides represents a significant advancement in photoprotection for populations of colour, addressing both functional and aesthetic concerns that have historically limited product adoption. Clinical evidence demonstrates that these formulations provide superior protection against visible light-induced pigmentation while offering cosmetically acceptable options for diverse skin tones.

Economic barriers remain the most significant obstacle to appropriate sunscreen use among populations of colour, with tinted formulations costing 3.6 times more than traditional products. This price disparity creates substantial accessibility challenges that disproportionately affect underserved populations who may benefit most from specialized photoprotection.

Cultural factors play complex roles in sunscreen adoption, serving as both barriers and facilitators depending on specific beliefs and social norms. Healthcare providers must develop cultural competency in addressing these factors to optimize patient counseling effectiveness. The clinical evidence for sunscreen efficacy in preventing post-inflammatory hyperpigmentation and melasma provides compelling justification for consistent use in populations of colour.

Future research priorities should focus on developing more affordable tinted sunscreen formulations, expanding shade ranges to accommodate the full spectrum of skin tones, and investigating novel delivery mechanisms that improve accessibility and adherence. Healthcare system improvements, including provider education programs and care delivery innovations, represent essential components of comprehensive approaches to reducing photoprotection disparities.

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CONCLUSION

In conclusion, optimizing sunscreen use in populations of colour requires a multifaceted approach that addresses individual, community, and systemic factors simultaneously. The combination of evidence-based clinical recommendations, culturally competent counseling, improved product accessibility, and targeted educational interventions offers the potential to significantly reduce health disparities in dermatological care.

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Author contribution. Sarah Qanita Edwar conceptualized the study and contributed to manuscript drafting and supervision. Devi Arofah contributed to literature collection, data synthesis, and manuscript preparation. Irma Bernadette, Lili Legiawati, Sondang P. Sirait, Ika Anggraini, and Shannaz Nadia Yusharyahya contributed to critical review of the literature, scientific discussion, and manuscript revision. All authors read and approved the final version of the manuscript.

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