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REVIEW ARTICLE

Australian Sunscreens: The Price of Protection for Skin of Colour With Pigmentary Disorders

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ABSTRACT

Australia experiences some of the highest ultraviolet radiation (UVR) levels globally, known for causing sunburn, skin cancers, photoageing and immunosuppression. While effects of UVA and UVB are well-studied, visible light (VL; 400–700 nm) is the driving force behind pigmentary disorders, especially in skin of colour (SOC) patients. Nearly 50% of Australians are affected, with significant impacts on appearance and psychological well-being. Tinted sunscreens containing iron oxides and pigmentary-grade titanium dioxide are the only effective options for blocking VL. However, Australia's stringent Therapeutic Goods Administration (TGA) regulations limit the availability of colour-matched tinted sunscreens, significantly impacting SOC patients. SOC patients may also underestimate their need for photoprotection, believing their skin provides sufficient natural protection. In dermatological practice, tailored sunscreen recommendations for darker skin tones may sometimes be overlooked. This review explores the barriers to effective treatment and the cost implications for SOC individuals suffering from pigmentary disorders in Australia. The goal is to guide both patients and dermatologists in making informed decisions on VL protection and skin tone matching.

1 | Introduction

Australia is renowned for experiencing some of the highest levels of ultraviolet radiation (UVR) worldwide, with extensive research highlighting the roles of UVA (320–400 nm) and UVB (290–320 nm) in sunburn, photoageing, skin cancers and immune suppression. However, visible light (VL; 400–700 nm), the primary driver of pigmentary disorders [1] (Table 1), remains an under-recognised factor in dermatology. This gap in awareness affects both dermatologists and patients, creating challenges in managing pigmentary disorders, especially for skin of colour (SOC) individuals.

A recent international survey revealed that pigmentary disorders affect 50% of the global population, disproportionately impacting women (59%). These disorders significantly impact physical appearance, mental health and social well-being [9]. SOC individuals (Fitzpatrick skin types III–VI) are especially vulnerable to VL-induced hyperpigmentation due to genetic factors such as the Opsin-3 (OPN3) gene, which drives pigmentation responses to blue light by upregulating tyrosinase and dopachrome tautomerase and stabilising tyrosinase activity [7]. Although their higher melanin content and larger melanosomes provide SOC individuals with natural protection against UVB, this defence does not extend to VL [10]. Consequently, SOC individuals experience more persistent hyperpigmentation, immediate pigment darkening (IPD) and delayed tanning (DT), effects that are typically absent in lighter skin tones [3, 8].

Untinted broad-spectrum sunscreens containing physical and chemical blockers are highly effective against sunburns and skin cancers [11]. However, effectively managing VL-induced

TABLE 1 | Implications of UVR and VL on pigmentation.

Sources and penetration	
UVR	**VL**
Wavelength	
UVA (315–400 nm), UVB (280–315 nm)	Blue (400–490 nm), green (490–570 nm), yellow (570–595 nm), red (630–770 nm)
◦ **Primary source:** Sunlight (UVB: 5% of UVR, UVA: 95% of UVR reaching the Earth's surface) [1] ◦ **Penetration:** UVB penetrates the epidermis, while UVA reaches the dermis [2]	◦ **Primary source:** Sunlight, contributing approximately 50% of total electromagnetic radiation (EMR) to the Earth's surface [1] ◦ **Penetration:** Deeper penetration than UVR due to its longer wavelengths [1] ◦ **Artificial sources of VL** • Flashlights, fluorescent lights, lasers, LEDs • Electronic devices (computers, smartphones) emit high-energy violet (HEV) light, a blue-violet VL component
Effects on pigmentation	
◦ **UVA1 (340–400 nm):** Causes hyperpigmentation, photoageing, skin cancer, DNA damage and photo-dermatoses [2] ◦ **UVA1 interaction with VL** enhances pigmentation in SOC individuals [3]	◦ **VL below 470 nm** Induces more potent and longer-lasting hyperpigmentation than UVA1 [3] ◦ **Indoor VL** may interact with photo allergens to exacerbate pigmentation [4] ◦ **HEV light** from devices has low irradiance (100–1000 times lower than UVR), **insufficient** to induce pigmentation [5]
Mechanisms of pigmentation	
◦ **UVR and VL:** • Stimulate melanogenesis via reactive oxygen species (ROS) production • Promote plasminogen activator synthesis and plasmin activity in keratinocytes [6]	◦ **Blue and Green VL:** · Trigger melanin oxidation, melanosome maturation and increased melanin synthesis · Lead to immediate pigment darkening (IPD), persistent pigment darkening (PPD) and delayed tanning (DT) [7] · OPN3 gene in darker skin senses blue light and triggers hyperpigmentation [7]
Exposure and pigmentation effects	
◦ Short-term UVB exposure causes sunburn; prolonged UVA exposure leads to pigmentation and DNA damage [2]	◦ Blue light (415–467 nm) exposure for 90 min during summer (38–62.5 J/cm^2) can induce significant darkening within 3 h in SOC individuals [7] ◦ Lighter-skinned individuals experience erythema from VL wavelengths but not hyperpigmentation [3, 8]

pigmentary disorders requires tinted sunscreens containing iron oxides and pigmentary-grade titanium dioxide [12]. These formulations not only protect against VL, but also meet the cosmetic preferences of SOC individuals, such as avoiding a white cast and ensuring colour-matching [13].

In Australia, several barriers limit the use of tinted sunscreens, including gaps in dermatological recommendations [14]. A 2014 national survey revealed that 85% of Australian dermatologists lacked confidence in managing cosmetic concerns in SOC individuals, with over 80% expressing the need for greater education and training on SOC during their postgraduate studies [14]. These challenges are not unique to Australia but are also observed in the US, UK and Europe [15–17]. In these settings, dermatologists often overlook skin tone when recommending sunscreens, with surveys indicating that 42.9% of US dermatologists do not consistently consider skin tone in their advice [17]. Moreover, they are less likely to counsel dark-skinned patients on sunscreen use compared to lighter-skinned patients. In addition, dermatologists often adopt a cost-conscious approach when recommending sunscreens to patients. This can lead to suggestions of sunscreens that fail to address the specific needs of SOC individuals. For instance, dermatologists typically recommend sunscreens based on their SPF rating and broad-spectrum UVA/UVB protection, which are essential for preventing sunburn, photoageing and reducing skin cancer risk. However, this approach often overlooks the specific photoprotection needs against VL, particularly for individuals with SOC or those prone to pigmentary disorders [17]. Misconceptions among SOC patients about their natural photoprotection further compound these challenges, as many believe their skin provides adequate protection against UV damage, overlooking the effects of VL [18].

This article highlights the unique barriers SOC individuals face in accessing effective photoprotection for pigmentary disorders in Australia. It brings to attention the high cost and limited availability of colour-matched tinted sunscreen, in part due to

stringent Therapeutic Goods Administration (TGA) regulations governing sunscreen availability. Understanding that SOC individuals have unique sunscreen requirements compared to their lighter-skinned counterparts is essential to improving care standards and advancing photoprotection strategies for this underserved population.

2 | Pigmentary Disorders: Prevalence and Psychosocial Impact in Australia

Pigmentary disorders such as melasma (Figure 1), PIH (Figure 2), acquired dermal macular hyperpigmentation, including ashy dermatosis (AD), erythema dyschromicum perstans (EDP) and Lichen planus pigmentosus (LPP) (Figure 3), as well as solar lentigo and vitiligo, are characterised by changes in skin pigmentation with an action spectrum primarily within the VL range [8, 19–21]. VL also contributes to autoimmune-mediated photodermatoses, such as chronic actinic dermatitis, systemic lupus erythematosus and polymorphous light eruption by increasing ROS, activating inflammatory pathways and promoting melanocyte activity [1]. This review focuses on hyperpigmentary disorders commonly affecting SOC individuals and their current management strategies (Table 2).

In Australia, 48% of the population is affected by pigmentary disorders, with solar lentigo being the most common condition (37%) [9]. While solar lentigo is more prevalent in lighter skin types, it also appears earlier and more prominently in Asian populations compared to Europeans [34]. Melasma (8%) and PIH (11%) represent a significant proportion of remaining cases. Australia's multicultural demographic includes a diverse population, with 27.6% of Australians born overseas [35]. Migrants and First Nations people constitute a substantial part of the SOC group, making them particularly vulnerable to these conditions.

Survey data indicate that 28% of Australian respondents reported a Dermatology Life Quality Index (DLQI) score above 10/30, with the highest burden observed among those with solar lentigo (15%) and vitiligo (47%). Solar lentigo had a notable impact on quality-of-life (QOL), contributing to feelings of embarrassment, physical discomfort and influencing clothing choices. Additionally, 44% of respondents reported stigmatisation, often concealing visibly affected areas.

3 | Sunscreen Recommendations in Australia

The Australasian College of Dermatologists (ACD) recommends using sun protection factor (SPF) 50+ sunscreen, applying 2 mg/cm^2 (about 35 mL for full-body or 5 mL for the face and neck) for optimal protection [36]. The "teaspoon rule" simplifies this to 1 teaspoon for the face, head and neck, 2 teaspoons for each arm, 2 teaspoons for the torso and 2 teaspoons for each leg. However, most individuals underapply sunscreen, using only ¼ to ½ of the recommended amount [37]. For instance, a 0.5 mg/cm^2 application may reduce the effective SPF by approximately 75% [38].

Notably, SPF ratings in Australia primarily measure UVB protection and some UVA2, without accounting for UVA1 or VL protection. Australia currently relies on the "broad-spectrum" label to indicate efficacy against both UVA and UVB radiation. To qualify as broad-spectrum, a sunscreen's UVA protection factor (UVA-PF) must be at least one-third of its SPF,

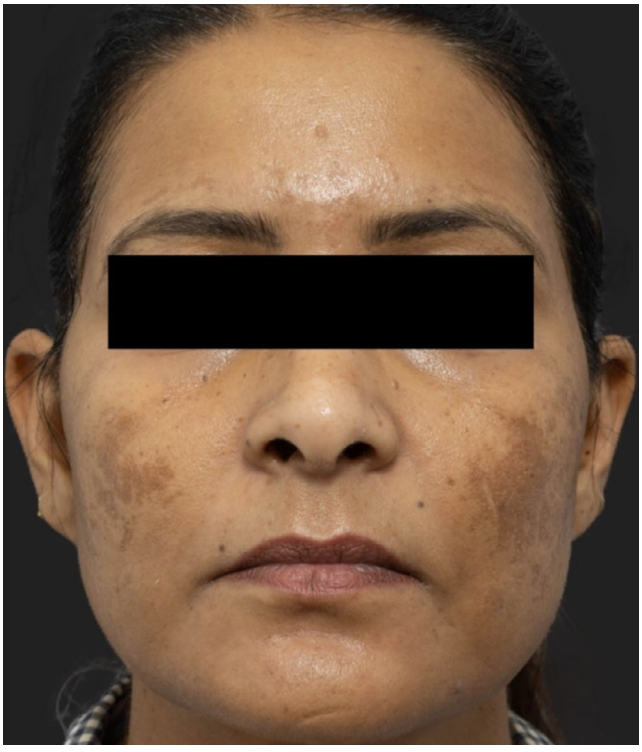

FIGURE 1 | Melasma.

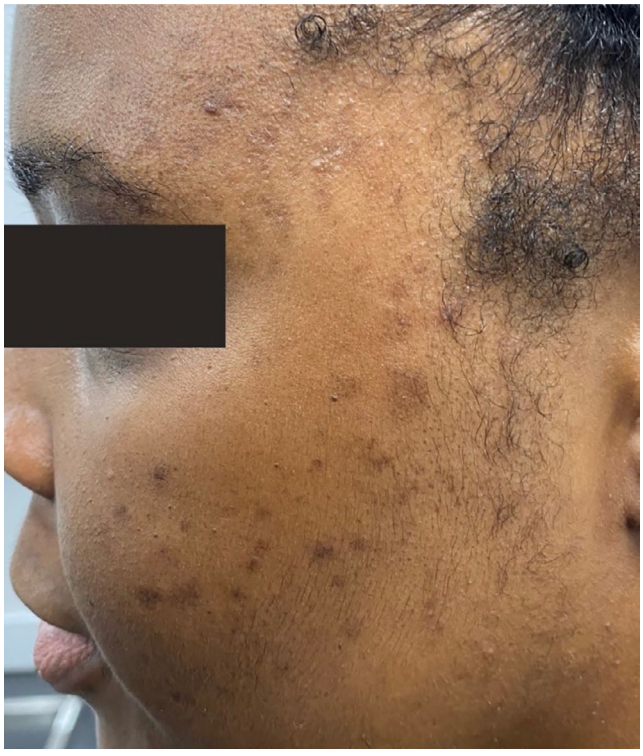

FIGURE 2 | Post-inflammatory hyperpigmentation from acne scarring.

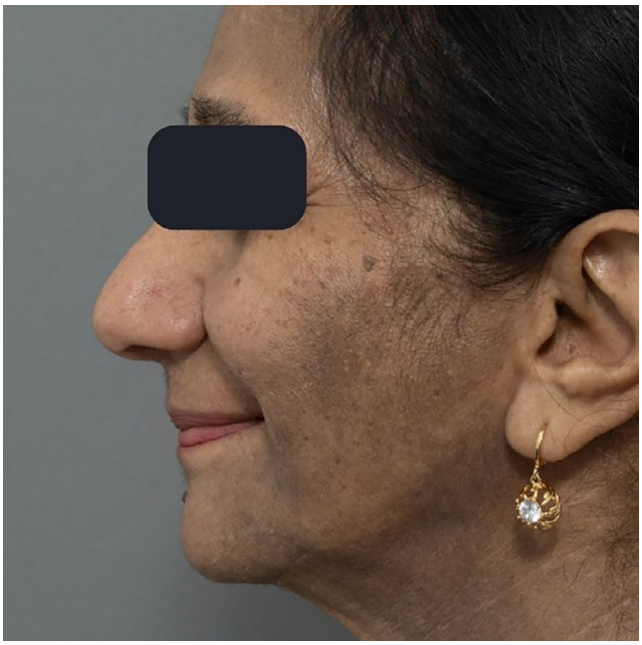

FIGURE 3 | Erythema dyschromicum perstans/ashy dermatosis.

with a critical wavelength exceeding 370 nm [39]. However, this pass/fail system does not provide a numerical rating about the level of UVA protection, leaving gaps for those prioritising concerns like hyperpigmentation or photoageing. In contrast, Japan's Protection Grade of UVA (PA) rating and United Kingdom's Boots UVA star rating quantify UVA protection more explicitly. However, the lack of a standardised global approach complicates the adoption of similar methods in Australia [40].

4 | Sunscreen UV Filter Types

Sunscreens are available as lotions, creams, aerosol sprays and sticks. Aerosol sprays often provide inadequate coverage and are not recommended. Gels and lotions are better for oily skin, while thicker creams may aggravate acne [41].

Sunscreen UV filters are either organic (chemical) or inorganic (mineral), with their approval processes and availability varying across regions worldwide [42]. In Australia, 27 organic and two inorganic sunscreen ingredients are approved under the Australian Regulatory Guidelines as therapeutic goods (Table 3) [39]. Organic filters like oxybenzone absorb UVB and short UVA but do not protect against VL [11]. Inorganic filters, such as zinc oxide (ZnO) and titanium dioxide (TiO2), can absorb, reflect or scatter EMR [11]. When nanosized (< 100 nm), they act like chemical sunscreens, absorbing UV photons without providing VL protection. In contrast, non-nanosized filters (100 to > 1000 nm) offer better VL protection by reflection. Although nanosized or micronized formulations are cosmetically elegant, they offer less UVA and VL protection. Larger opaque pigments provide better VL protection and is non-toxic and non-allergenic [11]. However, they may leave a chalky residue, affecting cosmetic appeal for SOC individuals.

5 | TGA Regulations of Sunscreens

The TGA regulates primary sunscreens and some secondary sunscreens like SPF 15+ moisturisers and skin care products. Primary sunscreens are specifically designed for UVR protection and generally offer greater coverage than cosmetic sunscreens. Some cosmetic sunscreens, such as lip products and tinted base make-up, are excluded in TGA regulation as therapeutic goods. These products often have lower SPF, lack broad-spectrum protection and are not water-resistant. With the growing availability of overseas sunscreens through online sales, consumers may be drawn to products with high SPF and cosmetic appeal [43]. However, they are not TGA-approved and their efficacy remains unverified. Although the TGA conducts random and targeted post-market reviews, certain regulatory gaps persist.

6 | Tinted (Coloured) Sunscreens: The Key to VL Protection

Tinted sunscreens are particularly effective for darker skin types, offering protection against the action spectrum of VL and long-wave UVA1. They reduce VL transmission by 93%–98% through a combination of UV-blocking and VL-absorbing properties, achieved with titanium dioxide (TiO_2) and iron oxide (Fe_2O_3) pigments [12]. Iron oxides (yellow, red or black) are particularly effective, with yellow iron oxide being beneficial for SOC individuals to prevent VL-induced pigmentation. The shade of tinted sunscreens depends on the ratio of iron oxides to titanium dioxide, with darker shades containing more iron oxides. Some makeup foundations with iron oxides provide multiple shade options to even skin tone, conceal blemishes and protect against blue light. Consistent use can improve dyschromia within 60 days and prevent relapse after 6 months [44].

Globally, no standardised guidelines exist for VL photoprotection. Iron oxides are not considered UVR filters and are classified as "inactive ingredients" from a regulatory perspective [45]. Schalka et al. proposed a new measure, pigment protection factor (PPF), to assess UVA and VL protection. Sunscreens with tinted pigment products scoring above 7 offer the best protection. However, further research is needed to validate PPF across a broader range of tinted sunscreen products and confirm its biological relevance [46].

7 | Innovative Sunscreen Ingredients for Pigmentation

Visible light exposure accounts for 50% of ROS generation, contributing to skin damage [6]. Adding antioxidants and free radical scavengers to sunscreens may help prevent some of the harmful effects of VL and protect against infrared radiation (IR). Topical antioxidants like L-ascorbic acid (Vitamin C), Vitamin E and thiamidol, as well as oral antioxidants such as Polypodium leucotomos extract (PLE), have shown promise in improving pigmentation by reducing reactive oxygen species (ROS) [25, 47]. However, stabilising these antioxidants in sunscreens remains a challenge and further research is needed to confirm their effectiveness [48]. Although antioxidants are beneficial, they cannot replace physical protection of iron oxides, which effectively

TABLE 2 | Characteristics, prevalence, action spectrum and management of common hyperpigmentary disorders in SOC individuals.

Conditions	Characteristics	Prevalence	Spectrum	Current management
Melasma	Sharply demarcated brown or grey-brown macules and patches **Location:** • Predominantly on face and neck • Centrofacial (most frequent), malar and mandibular	Populational prevalence varies: • **Global:** Approximately 1% of the population [22] • Higher prevalence in Southeast Asians, Middle East Asians, Mediterranean Africans, Hispanic Americans and Brazilians [10] **Gender and risk factors** [23]: • More prevalent in women • Associated with pregnancy, oral contraceptive (OCP) use and hormonal therapy • Strong family history	• VL (HEVL) • Long-wave UVA1, • UVB	Refractory disorder, no single therapeutic approach proven to be effective [24, 25] 1. **Removal of triggers** such as OCP and provide alternative if possible 2. **Topical hydroquinone** • **Various Composition:** hydroquinone (4%–5%), mild potency topical steroids: fluocinolone acetate (0.01%) or hydrocortisone (0.5%–1%), tretinoin (0.025%–0.05%), ascorbic acid (1%) and kojic acid (4%) • **Cons:** ○ May cause irritation, colloid milium or ochronosis ○ Not suitable for use during pregnancy • **Recommendation:** Approved for short-term use up to 8 weeks. Limit continuous use to 3–6 months, then switch to non-hydroquinone maintenance products to prevent complications **3. Topical or oral tranexamic acid (TXA)** • **Dosage:** Up to 5% topical or 500–1500 mg oral • **Cons:** ○ Mixed efficacy for topical TXA ○ Hyperpigmentation often recurs after stopping oral TXA ○ Risks of thromboembolic events in high-risk patients **4. Tinted sunscreens** • May enhance the depigmenting efficacy of topical hydroquinone • A study found that 4% hydroquinone plus sunscreen (with or without VL protection) reduced the MASI score by 78% and 62%, respectively [26] **5. Other cosmeceutical agents and novel treatments** Includes azelaic acid, ferulic acid, kojic acid, retinol, resorcinol, niacinamide, Vitamin C, cysteamine **6. Procedural treatments (for refractory cases)** • **Chemical peels** ○ **Cons:** Risk of post-inflammatory hyperpigmentation (PIH) • **Microneedling** ○ May be a viable alternative to chemical peels and laser treatments in patients with minimal PIH risk ○ **Cons:** Requires multiple treatments, mixed efficacy • **Laser and light therapy** ○ **Intense pulsed light (IPL)** Wavelength: 500–1200 nm ○ **Q-Switched nanosecond and picosecond lasers** Wavelength: 1064 nm ○ **Non-ablative fractionated lasers** Wavelengths: 1440, 1550, 1540, and 1927 nm Cons: Not recommended as first-line treatment due to high recurrence rates and risk of PIH, particularly in darker skin types

(Continues)

TABLE 2 | (Continued)

Conditions	Characteristics	Prevalence	Spectrum	Current management
Post-inflammatory hyperpigmentation (PIH)	Develops following an inflammatory event such as acne, eczema, injury or laser treatments	More common in SOC patients, especially those with pre-existing hyperpigmentation	• VL • UVR • Ambient light alone can trigger PIH in dark skin phototypes [19]	Similar to melasma treatment with use of topical, chemical peels and lasers for skin lightening [27] 1. **Opaque dressings:** Use up to 15 days until inflammation subsides [28] 2. **Sunscreens** [29] **Broad-spectrum tinted sunscreen:** ○ Apply for at least 2 weeks before any procedure that can induce inflammatory dermatoses ○ Continue use for 15–30 days on treated areas after inflammation resolves **Sunscreens with anti-inflammatory agents:** ○ Products containing lichochalcone-A and glycyrrhetinate have been shown to reduce PIH a week after laser treatments **Higher SPF sunscreens:** ○ Sunscreens with SPF 60 are more effective compared to SPF 30
Acquired dermal macular hyperpigmentation (ashy dermatosis/ erythema dyschromicum perstans/Lichen planus pigmentosus)	Small and large macules or patches of hyperpigmentation with histopathological evidence of active or resolved interface dermatitis and pigment incontinence, but without a clinically significant preceding inflammatory phase [30] Overlap between AD/EDP and LPP is frequently observed **AD/EDP:** Ashy, blue-grey macules are characteristic and may be surrounded by a rim of elevated erythematous border **LPP:** Dark-brown macules that merge to form patches **Location** [31]: • Face, neck, limbs and trunk • AD/EDP involves the trunk more than LPP • Rare cases of "unilateral" EDP reported [32]	Darker skin phototypes [31] • Latin Americans, Asians, South Asian and Middle Eastern origin **Gender and risk factors** [31] • Unknown aetiology • Genetic susceptibility • More prevalent in women • Medications • Cosmetics Sun exposure	• VL [21] • UVR (23)	1. **Avoidance of triggers if known** [31] 2. **Medications for LPP** [31] • Topical tacrolimus 0.03% ointment twice daily for up to 12 weeks • Topical corticosteroids • Oral isotretinoin • Oral tranexamic acid • Oral mycophenolate mofetil 3. **Medications for AD/EDP** [33] • Dapsone ○ 100 mg daily for 8–12 weeks can lighten pigmentation and potentially cause complete resolution • Clofazamine ○ 100 mg daily showed some efficacy in a small study 4. **Other treatments shown some but not significant improvement** [31, 33]: • Chloroquine • Fractionated laser treatment 5. **Tinted Sunscreens** [8, 21] Tinted sunscreens with VL protection may be particularly valuable to prevent worsening of pigmentation, especially since acquired dermal macular hyperpigmentation is more common in darker skin phototypes
Solar lentigines (sunspots)	1–3 cm, well circumscribed small patches, vary in colour from light yellow to dark brown [27] **Location:** Face, hands, forearms, chest, back, shins	• Lighter skin phototypes • Occur as photoageing earlier in Asians compared to Europeans [34]	• VL • UVR [20]	Similar to melasma treatment with use of topical, chemical peels and lasers for lightening skin [27]

TABLE 3 | UV filters regulated as therapeutic drugs in Australia, tested to Australian Standards (AS/NZS 2603) for SPF. Details on global regional differences are provided at the end of the table.

TGA-approved ingredients in Australia	Synonyms	Maximum concentration (%)
Chemical (organic) filters		
Bemotrizinol	Bemotrizinolum	10%
Benzylidene camphor sulfonic acid	Alpha-(2-oxoborn-3- ylidene)toluene-4-sulphonic acid	6% (as acid)
Butyl methoxydibenzoylmethane	BMDM 4-tert-butyl-4′-methoxy dibenzoylmethane avobenzone	5%
Camphor benzalkonium methosulfate	*N*,*N*,*N*-Trimethyl-4-(oxoborn-3- ylidenemethyl) anilinium methyl sulfate camphor benzalkonium sulfate	6%
Cinoxate	2-ethoxyethyl para-methoxycinnamate cinoxate anhydrous	6%
Diethylamino hydroxybenzoyl hexyl benzoate	—	10%
Dioxybenzone	Benzophenone 8	3%
Disodium phenyl dibenzimidazole tetrasulfonate	1H-benzimidazole-4,6-disulfonic acid, 2,2′-(1,4-phenylene)bis-, disodium salt bisimidazylate	10%
Drometrizole trisiloxane	—	10%
Ecamsule	Terephthalylidene dicamphor sulfonic acid	10%
Ethylhexyl triazone	Octyl triazone	5%
Homosalate	Homomethyl salicylate	15%
Isoamyl methoxycinnamate	Amiloxate isopentenyl-4 methoxycinnamate	10%
Menthyl anthranilate	Menthyl 2-aminobenzoate 5-methyl-2-(1-methylethyl) cyclohexanol-2-aminobenzoate meradimate anthranilic acid, *p*-menth-3-yl Ester cyclohexanol, 5-Methyl-2-(1- Methylethyl)-,2-Aminobenzoate menthol anthranilate menthyl o-aminobenzoate	5%
4-Methylbenzylidene camphor	3-(4-methylbenzylidene)-di- camphor Enzacamene neo heliopan 1,7,7-trimethyl-3-[(4- methylphenyl)-methylene]bicyclo [2.2.1] heptan- 2-one	4%
Methylene bis-benzotriazolyl tetramethylbutylphenol	—	10%
Octyl methoxycinnamate	Ethylhexyl methoxycinnamate octinoxate	10%
Octyl salicylate	Ethylhexyl salicylate 2-Ethylhexyl salicylate octisalate	5%
Octocrylene	2-Ethylhexyl-2-cyano-3,3 diphenylacrylate	10%
Oxybenzone	Benzophenone 3	10%
Padimate O	Ethylhexyl dimethyl PABA 4-(Dimethylamino)benzoic acid 2-ethylhexyl ester	8%
PEG-25 PABA	Ethoxylated ethyl 4-aminobenzoate	10%
Phenylbenzimidazole sulfonic acid	2-Phenylbenzimidazole-5- sulfonic acid 2-Phenyl-5-sulfobenzimidazole ensulizole	4%

(Continues)

TABLE 3 | (Continued)

TGA-approved ingredients in Australia	Synonyms	Maximum concentration (%)
Polysilicone-15	Diethylmalonylbenzylidene oxypropene dimethicone dimethicodiethylbenzalmalonate diethylbezylidene malonate dimethicone	10%
Sulisobenzone	Benzophenone 4	10%
Sulisobenzone sodium	Benzophenone 5	10%
Tris-biphenyl triazine	—	10%
Trolamine salicylate	Triethanolamine salicylate TEA-salicylate	12%
Mineral (inorganic) filters		
Zinc oxide	Pigment white 4	Not available
Titanium dioxide	E171 Titanium dioxide anhydrous	25%

Australia, Europe and United States share 11 common UV filters, but the approved concentrations and regulatory standards for these filters vary across regions [42]

- **Australia:** 29 UV filters are regulated by TGA as therapeutic goods
- **Europe:** 30 UV filters are regulated by European Commission as cosmetics
- **United States:** UV filters are regulated by FDA as over the counter drugs. Only 16 UV filters are FDA-approved, with no new approvals since the 1990s

reduce the severity of hyperpigmentary disorders and prevent relapses [49].

8 | Challenges in Managing Hyperpigmentary Disorders

Patients with hyperpigmentary disorders often see their condition worsen with sun exposure even with regular sunscreen use. This occurs because many are unaware that broad-spectrum sunscreen alone does not sufficiently protect against these conditions as the action spectrum for these disorders lies within the VL range [17]. In addition to using tinted broad-spectrum sunscreen, other protective strategies (Box 1) are still essential to address the UVR effects of hyperpigmentation disorders [50]. Effective treatment remains elusive and ongoing studies are investigating ways to improve VL protection.

BOX 1 | Summary of other photoprotective strategies.

Other important photoprotective strategies [51]

- Wide-brimmed hat:
  - Provides an SPF of about 7
- Clothing:
  - Tightly woven, dark fabrics offer varying UV protection:
    - UPF 15–24: good protection
    - UPF 25–39: very good protection
    - UPF 40–50: excellent protection
- Minimising UV exposure:
  - Seek shaded areas
  - Avoid outdoor activities when UV index is 3 or higher
- Sunglasses:
  - Blue lenses absorb visible light (VL) between 400 and 500 nm
  - Yellow and red lenses offer protection against both UV and VL

9 | Other Barriers to Sunscreen Compliance

Compliance with sunscreen application remains a significant challenge. In Australia, only 38% of individuals utilised sun protection measures year-round, despite its critical role in preventing worsening pigmentation [9]. Sunscreen use is impacted by demographic factors such as male gender, older age and lower socioeconomic status, where these individuals are less likely to apply sunscreen regularly [52, 53]. Many individuals are also unaware of the recommended dosage and its reduced effectiveness after 2 hour, excessive sweating or swimming. Other consumer concerns, including chemicals, nanoparticles, allergies, vitamin D deficiency and environmental impacts, also affect adherence. Behavioural factors like forgetfulness and lack of routine play a significant role [54, 55].

Gaps in dermatological practice, such as limited training in addressing the unique needs of SOC individuals and insufficient awareness of the importance of VL protection, further hinder effective sunscreen compliance in these patients [14]. Particularly for SOC individuals, misconceptions about their sunscreen needs, poor availability of colour-matching options and the high cost of tinted sunscreens are major hindrances to compliance [17, 18]. Studies indicate that dermatologists are nine times more

likely to counsel lighter-skinned patients on sunscreen use than those with SOC, often due to the perceived lower incidence of skin cancer in darker skin tones [56, 57]. While higher melanin content in SOC provides some UV protection, it does not fully protect against the harmful effects of UVR or VL exposure. Importantly, emerging evidence highlights that tinted sunscreens offer superior protection against pigmentary disorders caused by VL in SOC individuals compared to untinted formulations [20, 26, 44, 49].

To address these barriers, targeted education initiatives are essential. These should focus on helping both dermatologists and patients understand the importance of VL protection and guide the selection of tinted sunscreens that not only offer effective photoprotection but also provide optimal cosmetic elegance for SOC individuals (Box 2) [58]. Education should also be tailored for SOC populations, including the importance of proper reapplication frequency and adequate application amounts to improve compliance.

BOX 2 | Practical tips to correctly select and apply broad spectrum tinted sunscreens.

Selecting the correct shade:

- Match tinted broad spectrum sunscreen to both skin tone (fair, light, medium, deep) and undertone (warm, cool, neutral).
- Undertones remain consistent regardless of sun exposure.
- "Universal" shades are not ideal for very fair or deep skin tones.
- Brands with various shades are preferred for achieving an optimal match.

Cosmetic considerations:

- Easy to apply, non-comedogenic, non-greasy, water-based formulas are ideal.
- Consider ingredients such as antioxidants (Vitamins C and E), depigmenting agents (niacinamide) and emollients/humectants.

Application guidelines:

- Apply to clean and dry skin.
- Apply 15–30 min before sun exposure for optimal protection.

(Time for sunscreen to bond with skin and reduce likelihood to be compromised by sweat, water or physical contact).

- Use a minimum of 2 mg/cm^2 for effective coverage.
- Ensure sunscreen is applied liberally and evenly.
- Sunscreen should be applied as last step in skin care before make up.
- Reapply every 2 hour when outdoors, after swimming, excessive sweating, or towel drying.

Staining and removal:

- May stain clothing, towels and facial masks.
- Stains can be removed with regular laundry detergents.

10 | Cost, Accessibility and Media Misinformation

In the age of media, information about sunscreens can further complicate patient understanding. Websites and beauty magazines targeting SOC individuals often recommend chemical sunscreens that are more expensive than those suggested for lighter skin tones, frequently without dermatologist input [17]. Adding to this, recent concerning trends involve social media influencers spreading misinformation about sunscreens, including claims of toxicity [59]. Dermatologists must stay informed about such content on these platforms to effectively educate patients and address these misconceptions.

Cost is a major factor affecting sunscreen use. Many SOC individuals prefer sunscreens with cosmetic elegance; those that absorb well, feel pleasant on the skin, provide moisture and avoid a white cast [13]. However, most commercially available products are not formulated in a range of shades that adequately match darker skin tones, leading to a noticeable white cast that discourages usage. Studies in the US have shown significant differences in annual sunscreen costs, with lighter skin types spending an average of $61 compared to $182 for darker skin tones [17, 52]. This higher cost may result from a smaller customer base, fewer manufacturers and higher production and distribution expenses [13, 17].

To assess the cost of tinted sunscreens in Australia, a Google search was conducted using the terms "tinted sunscreen," "popular," "SPF 50" and "Australia". Social media platforms and public forums, such as TikTok and Reddit, were excluded. Results were filtered to include brands offering a single or universal shade and those providing more than two shades, with a maximum of 10 brands per category. Only sunscreens recommended by at least two unique websites were included. Product size and price were obtained from the brand's official website or a reputable retailer (Table 4). Sunscreens that were not commercially available were excluded from the study. A similar approach was used to analyse US tinted sunscreens for comparison (Table 5). Sunscreens with an SPF of 30 or higher were included, in line with the American Academy of Dermatology's recommendation of at least SPF 30 for photoprotection [60].

Both tables highlight similar and significant cost disparities among tinted sunscreens, with products offering multiple shades and superior cosmetic elegance being substantially more expensive than those with fewer shades. Tinted sunscreens like the IT Cosmetics CC+ SPF50 cream are better suited to the needs of SOC individuals but rank among the most expensive options. In contrast, universal or single-shade options, such as SunSense, are more affordable but often lack the shade variety needed to appeal to SOC individuals. Prices range from AUD 20 to AUD 80 per product, with sunscreens designed for lighter skin tones typically being more affordable. These cost barriers are particularly challenging for SOC individuals, who require frequent reapplication for effective photoprotection.

TABLE 4 | The cost of popular tinted sunscreens in Australia (prices for each sunscreen brand were sourced from the company websites and are accurate as of the time of writing this article).

Tinted sunscreens with multiple shades					
Sunscreen brands	**Shades available**	**Key ingredients against VL**	**Packaging in mL/ cost per mL**	**Cost annually (face and neck application: 5 mL, twice a day)**	**ACD's recommendation of 2-hourly reapplication (4 times a day)**
IT Cosmetics Your Skin But Better CC+ Cream SPF50	21 shades	**Titanium dioxide**: 9.0% **Zinc oxide:** 6.3% **Niacinamide (Vitamin B3)** **Vitamin C and Vitamin E** **Iron oxides**	Number of mL: 32 Price: AUD 80.00 Cost per mL: AUD 2.5/mL	Annual cost: AUD 9125	Annual cost: AUD 18250
Naked Sundays BeautyScreen SPF50 Peptide Foundation Tint	13 shades	**Zinc oxide:** (12%) **Niacinamide (Vitamin B3) iron oxides**	Number of mL: 30 Price: AUD 54.95 Cost per mL: AUD 1.83/mL	Annual cost: AUD 6680	Annual cost: AUD 13360
Uvidea Anthelios Tinted BB Cream SPF 50+	2 shades	**Titanium dioxide:** 10%–15% **Mexoryl XL (Drometrizole trisiloxane):** Organic filters for additional UVA/UVB/ Long UVA protection **Carnosine** **Vitamin E** **Iron oxides**	Number of mL: 30 Price: AUD 40.95 Cost per mL: AUD 1.37/mL	Annual cost: AUD 4982	Annual cost: AUD 9964
Naked Sundays CabanaGlow SPF50 Mineral Glow Serum Drops	4 shades	**Titanium dioxide:** 3.3% **Zinc oxide:** 14.9% **Pink algae extract:** rich in antioxidants **Iron oxides and mica**	Number of mL: 40 Price: AUD 45.00 Cost per mL: AUD 1.13/mL	Annual cost: AUD 4106	Annual cost: AUD 8212
Ultra Violette Daydream Screen SPF50 Tinted Veil	15 shades	**Zinc oxide:** 9.8% **Iron oxides** **Pentavitin:** A hydrating ingredient that helps maintain skin moisture	Number of mL: 50 Price: AUD 55.00 Cost per mL: AUD 1.10/mL	Annual cost: AUD 4015 As this is a secondary sunscreen, primary sunscreen supplementation is required which Increases cost	Annual cost: AUD 8030

(Continues)

TABLE 4 | (Continued)

Tinted sunscreens with multiple shades

Sunscreen brands	Shades available	Key ingredients against VL	Packaging in mL/ cost per mL	Cost annually (face and neck application: 5 mL, twice a day)	ACD's recommendation of 2-hourly reapplication (4 times a day)
UnSun Cosmetics Mineral Tinted Sunscreen	2 shades	**Zinc oxide:**6.5% **Titanium dioxide:** 5.5% **Iron oxides**	Number of mL: 50 Price: AUD 44.00 Cost per mL: AUD 0.88/mL	Annual cost: AUD 3212	Annual cost: AUD 6424
Invisible Zinc Tinted Daywear SPF 50+	2 shades	**Zinc oxide:** 27% **Iron oxides**	Number of mL: 50 Price: AUD 34.99 Cost per mL: AUD 0.70/mL	Annual cost: AUD 2555	Annual cost: AUD 5110
Australian Gold Botanical Tinted Face Sunscreen SPF 50	3 shades	**Titanium dioxide:** 4% **Zinc oxide:** 4% **Iron oxides**	Number of mL: 90 Price: AUD 45.00 Cost per mL: AUD 0.50/mL	Annual cost: AUD 1825	Annual cost: AUD 3650
Natio tinted moisturiser SPF 50+	3 shades	**Zinc oxide** **Iron oxides**	Number of mL: 50 Price: AUD 21.95 Cost per mL: AUD 0.44/mL	Annual cost: AUD 1606	Annual cost: AUD 3212
Cancer Council Face Day Wear BB Cream SPF50+	2 shades	**Acai berry extract, chamomile extract, kakadu plum extract, green tea extract**: Rich in antioxidants properties **Other ingredients:** Tocopheryl Acetate (Vitamin E) **Iron oxides**	Number of mL: 50 Price: AUD 20.99 Cost per mL: AUD 0.42/mL	Annual cost: AUD 1533	Annual cost: AUD 3066
Sukin SPF30 Sheer Touch Tinted Sunscreen Lotion	2 shades	**Zinc oxide:** 21.5% **Iron oxides**	Number of mL: 60 Price: AUD 25.00 Cost per mL: AUD 0.42/mL	Annual cost: AUD 1520	Annual cost: AUD 3040

Tinted sunscreens with universal or single shade

Sunscreen brands	Key ingredients against VL	Packaging in mL/ cost per mL	Cost annually (face and neck application: 5 mL, at least twice a day)	ACD's recommendation of 2-hourly reapplication (4 times a day)

(Continues)

TABLE 4 | (Continued)

Tinted sunscreens with multiple shades					
Sunscreen brands	**Shades available**	**Key ingredients against VL**	**Packaging in mL/ cost per mL**	**Cost annually (face and neck application: 5 mL, twice a day)**	**ACD's recommendation of 2-hourly reapplication (4 times a day)**
SkinCeuticals Facial Defence SPF 50		**Zinc oxide:** 5% **Titanium dioxide:** 6% **Artemia Salina:** Plankton extract which increases skin resistance to UV- and heat-induced stress **Tocopherol (Vitamin E)** **Iron oxides**	Number of mL: 30 Price: AUD 68.00 Cost per mL: AUD 2.27/mL	Annual cost: AUD 8285	Annual cost: AUD 16570
INIKA Organic Tinted Natural Sunscreen SPF50+		**Zinc oxide:** 22.75% **Pink algae extract:** Antioxidant **Iron oxides**	Number of mL: 50 Price: AUD 59.00 Cost per mL: AUD 1.18/mL	Annual cost: AUD 4307	Annual cost: AUD 8614
Aspect Sun Tinted Physical Protection SPF50+		**Zinc oxide** **Titanium dioxide** **Iron oxides**	Number of mL: 75 Price: AUD 59.00 Cost per mL: AUD 0.79/mL	Annual cost: AUD 2883	Annual cost: AUD 5767
La Roche-Posay Anthelios Tinted Fluid SPF50+		**Titanium dioxide** **Zinc oxide** **Iron oxides**	Number of mL: 50 Price: AUD 35.95 Cost per mL: AUD 0.72/mL	Annual cost: AUD 2628	Annual cost: AUD 5256
Avene Sunsitive Tinted Mineral Fluid SPF50+		**Titanium dioxide:** 11.4% **Zinc oxide:** 14.6% **Iron oxides** **Vitamin E**	Number of mL: 50 Price: AUD 36.00 Cost per mL: AUD 0.72/mL	Annual cost: AUD 2628	Annual cost: AUD 5256
Bondi Sands Hydra UV Protect SPF50+ Tinted		**Iron oxides**	Number of mL: 50 Price: AUD 15.95 Cost per mL: AUD 0.32/mL	Annual cost: AUD 1168	Annual cost: AUD 2336
NIVEA SUN UV Face BB Cream SPF50+		**Titanium dioxide:** Around 10% **iron oxides**	Number of mL: 50 Price: AUD 14.99 Cost per mL: AUD 0.30/mL	Annual cost: AUD 1095	Annual cost: AUD 2190
MooGoo Tinted Face Sunscreen SPF40		**Zinc oxide** **Iron oxides**	Number of mL: 50 Price: AUD 13.50 Cost per mL: AUD 0.27/mL	Annual cost: AUD 985	Annual cost: AUD 1970

(Continues)

TABLE 4 | (Continued)

Tinted sunscreens with multiple shades					
Sunscreen brands	**Shades available**	**Key ingredients against VL**	**Packaging in mL/ cost per mL**	**Cost annually (face and neck application: 5 mL, twice a day)**	**ACD's recommendation of 2-hourly reapplication (4 times a day)**
QV Face Tinted Moisturising Day Cream SPF30+	**Titanium dioxides** **Iron oxides** **Vitamin B3 (Niacinamide)**		Number of mL: 75 Price: AUD 16.00 Cost per mL: AUD 0.21/mL	Annual cost: AUD 766	Annual cost: AUD 1533
SunSense Anti-Ageing Face SPF50+ Tinted	**Nicotinamide (Vitamin B3)** **Iron oxides**		Number of mL: 100 Price: AUD 20.00 Cost per mL: AUD 0.20/mL	Annual cost: AUD 730	Annual cost: AUD 1460

11 | Limitations

This review article has several limitations that should be noted. Firstly, it does not account for the diverse formulations of sunscreens, such as milks, creams and lotions, which can vary significantly in their effectiveness and application. The millilitre (mL) quantities required to achieve the equivalent of 2 mg/cm^2 may differ between these formulations, suggesting a need for further research in this area. This review also does not comprehensively cover all Australian tinted sunscreen recommendations and lacks input from social media, internet forums and the availability of overseas sunscreen brands. It does not consider perspectives from Australian print media or magazines, which may offer insights into sunscreen options and consumer preferences. Furthermore, no statistical analysis was conducted to compare single shade tinted sunscreens, typically suited for lighter skin tones, with multi-shade options designed for SOC individuals. Without such analysis, differences in availability, pricing and other attributes between these categories remain unquantified. Future studies should address these gaps to provide a more detailed understanding of sunscreen use and preferences among SOC populations in Australia.

12 | Conclusion

1. **Visible light (VL) protection:**
   - VL plays a major role in hyperpigmentary disorders.
   - Most sunscreens provide insufficient VL protection.
   - Only tinted sunscreens (iron oxides) are most effective for VL attenuation, alongside pigmentary-grade, non-micronized titanium dioxide and zinc oxide.
   - Sun avoidance, shade-seeking and photoprotective clothing are essential.
2. **Colour matching:**
   - Limited options for affordable and cosmetically elegant-tinted sunscreens in Australia for SOC individuals.
   - Poor colour matching is one of the key barriers to patient compliance.
3. **Affordability:**
   - Tinted sunscreens range from AUD 3040 to 18,250 annually (per Australasian College of Dermatologists' 2-hourly reapplication guidelines), making this highly cost-ineffective for SOC individuals.
   - Innovation is needed to make affordable and effective sunscreens for all skin tones.
   - Clinicians should consider patient budgets when making recommendations.
   - One practical, cost-effective strategy is combining iron oxide-rich makeup foundation with physical sunscreens to enhance protection without leaving a white residue [17].
4. **Patient education:**
   - Patient education on correct sunscreen use and selecting the right product for their condition is crucial.
   - Be aware that patients may seek overseas products for better colour matching and lower costs, even if not TGA-approved.

TABLE 5 | The cost of popular tinted sunscreens in United States (prices for each sunscreen brand were sourced from the company's websites and are accurate as of the time of writing this article).

Sunscreen brands	Shades available	Key ingredients against VL	Packaging in mL/ cost per mL	Cost annually (face and neck application: 5 mL, at least twice a day)	AAD's recommendation of 2-hourly reapplication (4 times a day)
Tinted sunscreens with multiple shades					
Ilia Super Serum Skin Tint SPF 40	30	**Non-nano zinc oxide 12%** **Titanium dioxide** **Iron oxide**	Number of mL: 30 Price: USD 48 Cost per mL: USD 0.82/mL	Annual cost: USD 5840 Approximately AUD 8760	Annual cost: USD 11680 Approximately AUD 17520
Supergoop! Protec(tint) Daily Skin Tint SPF 50	14	**Zinc oxide 13.58%** **Iron oxides**	Number of mL: 35 Price: USD 44 Cost per mL: USD 1.26/mL	Annual cost: USD 4588 Approximately AUD 6882	Annual cost: USD 9177 Approximately AUD 13764
MDSolarSciences MD Mineral BB Crème SPF 50	4	**Titanium dioxide 2%** **Zinc oxide 17%**	Number of mL: 36 Price: USD 42 Cost per mL: USD 1.17/mL	Annual cost: USD 4258 Approximately AUD 6387	Annual cost: USD 8517 Approximately AUD 12775
Colorescience Sunforgettable Total Protection Face Shield Flex SPF 50	4	**Zinc oxide 12%** **Iron oxide**	Number of mL: 55 Price: USD 54 Cost per mL: USD 1.02/mL	Annual cost: USD 3717 Approximately AUD 5575	Annual cost: USD 7435 Approximately AUD 11150
Supergoop! CC Screen 100% Mineral CC Cream SPF 50	14	**Titanium dioxide 4%** **Zinc oxide 20%** **Iron oxide**	Number of mL: 47 Price: USD 44 Cost per mL: USD 0.94/mL	Annual cost: USD 3417 Approximately AUD 5125	Annual cost: USD 6834 Approximately AUD 10250
Tower 28 SunnyDays Tinted Sunscreen SPF 30	17	**Non-nano Zinc Oxide 12.6%** **Iron oxide**	Number of mL: 30 Price: USD 32 Cost per mL: USD 0.94/mL	Annual cost: USD 3417 Approximately AUD 5125	Annual cost: USD 6834 Approximately AUD 10250
Saie Slip Tint Broad Spectrum SPF 35 Tinted Moisturiser	14	**Non-nano Zinc Oxide 15%** **Titanium dioxide** **Iron oxide**	Number of mL: 40 Price: USD 36 Cost per mL: USD 0.90/mL	Annual cost: USD 3285 Approximately AUD 4927	Annual cost: USD 6570 Approximately AUD 9854
EltaMD UV Clear Tinted Broad-Spectrum SPF 46	2	**Zinc oxide 9%** **Iron oxide**	Number of mL: 50 Price: USD 44 Cost per mL: USD 0.88/mL	Annual cost: USD 3212 Approximately AUD 4818	Annual cost: USD 6424 Approximately AUD 9636
EltaMD UV Daily Tinted Broad-Spectrum SPF 40	2	**Zinc oxide 9%** **Iron oxide**	Number of mL: 50 Price: USD 41 Cost per mL: USD 0.82/mL	Annual cost: USD 2993 Approximately AUD 4489	Annual cost: USD 5986 Approximately AUD 8978

(Continues)

TABLE 5 | (Continued)

Sunscreen brands	Shades available	Key ingredients against VL	Packaging in mL/ cost per mL	Cost annually (face and neck application: 5 mL, at least twice a day)	AAD's recommendation of 2-hourly reapplication (4 times a day)
Drunk elephant Umbra Sheer Mineral Cream SPF 30	3	**Zinc oxide 20%** **Iron oxide**	Number of mL: 60 Price: USD 36 Cost per mL: USD 0.60/mL	Annual cost: USD 2190 Approximately AUD 3285	Annual cost: USD 4380 Approximately AUD 6570
CeraVe Hydrating Mineral Sunscreen SPF 30	3	**Titanium dioxide 5.5%** **Zinc oxide 10%**	Number of mL: 50 Price: USD 15 Cost per mL: USD 0.94/mL	Annual cost: USD 1095 Approximately AUD 1642	Annual cost: USD 2190 Approximately AUD 3284
Tinted sunscreens with universal or single shade					
Sunscreen brands	**Key ingredients against VL**		**Packaging in mL/ cost per mL**	**Cost annually (face and neck application: 5 mL, at least twice a day)**	**AAD's recommendation of 2-hourly reapplication (4 times a day)**
Eryfotona Ageless Ultralight tinted mineral sunscreen SPF 50	**Zinc oxide: 11%** **Iron oxides**		Number of mL: 50 Price: USD 50 Cost per mL: USD 1/mL	Annual cost: USD 3650 Approximately AUD 5365	Annual cost: USD 7300 Approximately AUD 10730
Alastin HydraTint Pro Mineral Broad Spectrum Sunscreen SPF 36	**Titanium dioxide: 8.9%** **Zinc oxide: 3.4%** **Iron oxides**		Number of mL: 95 Price: USD 76 Cost per mL: USD 0.80/mL	Annual cost: USD 2920 Approximately AUD 4292	Annual cost: USD 5840 Approximately AUD 8584
La Roche-Posay Anthelios Mineral Tinted UltraLight Face Sunscreen Fluid SPF 50	**Titanium dioxide**: 6% **Iron oxides**		Number of mL: 50 Price: USD 39 Cost per mL: USD 0.78/mL	Annual cost: USD 2847 Approximately AUD 4185	Annual cost: USD 5694 Approximately AUD 8370
MDSolarSciences MD Crème SPF 50	**Zinc oxide**: 17% **Titanium dioxide**: 2% **Iron oxides**		Number of mL: 50 Price: USD 32 Cost per mL: USD 0.64/mL	Annual cost: USD 2336 Approximately AUD 3433	Annual cost: USD 4672 Approximately AUD 6866
Neutrogena Purescreen Tinted Sunscreen	**Titanium dioxide**: 3.5% **Zinc Oxide**: 6% **Iron Oxides**		Number of mL: 32 Price: USD 19 Cost per mL: USD 0.59/mL	Annual cost: USD 2167 Approximately AUD 3185	Annual cost: USD 4334 Approximately AUD 6370
EltaMD UV Physical Broad-Spectrum SPF 41	**Zinc oxide**: 9% **Titanium dioxide**: 7% **Iron oxides**		Number of mL: 89 Price: USD 44 Cost per mL: USD 0.50/mL	Annual cost: USD 1825 Approximately AUD 2682	Annual cost: USD 3650 Approximately AUD 5364
Eucerin Tinted Age Defence SPF 50 Face Sunscreen	**Titanium dioxide: 5%** **Zinc oxide: 10%** **Iron oxides**		Number of mL: 75 Price: USD 32 Cost per mL: USD 0.43/mL	Annual cost: USD 1557 Approximately AUD 2413	Annual cost: USD 3115 Approximately AUD 4826

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The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data supporting this study are available from the corresponding author upon reasonable request.

Declaration Use of AI

None.

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