New Insights About Infant and Toddler Skin: Implications for Sun Protection

abstract

The skin is increasingly recognized as a component of the innate immune response, in addition to its role as a physical barrier. Although the deleterious effects of solar ultraviolet radiation (UVR), including immunosuppression and cutaneous tumorigenesis, are widely acknowledged, most studies to date have concentrated on adult skin. Despite the more sensitive nature of infant and toddler skin, little is known about its responses to UVR exposure, whether acute or long-term. Accumulating evidence suggests not only that the skin's barrier protection remains immature throughout at least the first 2 years of life but also that accumulation of UVR-induced changes in the skin may begin as early as the first summer of life. Such evidence not only affirms the importance of sun protection during the infant and toddler years but underscores the need for more research to establish evidence-based standards of care in this area. In this article we review recent studies in which differences between the skin properties of infants and young children and those of adults were compared, and we discuss the implications of these differences for sun-protection practices. *Pediatrics* 2011;128:92–102

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KEY WORDS

sun protection, epidermis/metabolism/physiology, sunscreening agents/administration, dosage/therapeutic use, sunburn/prevention control/therapy, skin neoplasms/prevention, control, melanoma/prevention, control, child/preschool, infant, newborn, humans, skin absorption, skin physiological phenomena

ABBREVIATIONS

UVR—ultraviolet radiation
SC—stratum corneum
SPF—sun protection factor
AAP—American Academy of Pediatrics
FDA—Food and Drug Administration

www.pediatrics.org/cgi/doi/10.1542/peds.2010-1079

doi:10.1542/peds.2010-1079

Accepted for publication Mar 3, 2011

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: *Dr Stamatas and Ms Mack are employees of Johnson & Johnson, which makes sunscreens; Dr Honig has served as a speaker for Johnson & Johnson; and Dr Paller has been an investigator for Johnson & Johnson, although not related to its sunscreens. All authors not employed by Johnson & Johnson were provided with honoraria to compensate time spent at a roundtable on infant sun protection (supported by Johnson & Johnson) that preceded this article, but no author was compensated for conceptualizing, planning, or writing this article.*

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Compelling evidence now links excessive sun exposure in early childhood to skin cancer later in life. Environmental changes and cultural trends that increase exposure to ultraviolet radiation (UVR) make sun protection an even greater concern for children.[1–5] Rates of all forms of skin cancer have been rising; an estimated 3 507 693 new cases of nonmelanoma skin cancer and 60 000 new melanomas were diagnosed in the United States in 2008.[6,7] Newborns today have a projected 1:33 risk of melanoma versus the 1:1500 chance of children born in 1935.[8] Infants (younger than 1 year) and toddlers (1–3 years of age) are thought to be unusually vulnerable to UVR because of lower levels of protective melanin, a thinner stratum corneum (SC), and a higher surface area/body mass ratio. Current sun protection approaches, however, have largely been determined by extrapolating studies on adults and reflect limited knowledge about skin function in these infants after the first month of life.

RADIATION AND ITS EFFECTS

Sunlight contains 3 types of UVR, grouped according to evoked biological effects and wavelength: UVA (320–400 nm); UVB (290–320 nm); and UVC (100–290 nm). Although the upper atmosphere filters out UVC, both UVA and UVB penetrate the atmosphere and can damage human skin. Epidemiologic evidence, including from case-control studies, links both intense and intermittent exposure to UVR and sunburn during childhood and adolescence[9] to increased risks of melanoma[1,2,10,11] and basal cell carcinoma[3,4] later in life. The risk of developing melanoma is particularly high in families with dysplastic nevi and/or a strong history of melanoma. Squamous cell carcinoma seems related to UVR exposure over longer periods.[12,13] Early exposure to ultraviolet light, especially intermittent, has also been linked to an increased risk of developing pigmented nevi,[14–16] and exposure of neonates to blue light as treatment for hyperbilirubinemia increases the risk of development of common and atypical melanocytic nevi,[17] although not of skin cancer.[18] Additional effects of solar UVR exposure on adult skin include summertime hyperpigmentation and subsequent wintertime recovery, local immunosuppression, and long-term risks of accelerated aging.[19–22]

UVB, which causes acute inflammation, including sunburn, and chronic dermal matrix degradation, has been strongly linked to basal and squamous cell carcinomas through directly damaging DNA. UVA, the major light emitted in tanning booths and once considered relatively innocuous, is now known to suppress cutaneous immune function[23,24] and generate excess reactive oxygen species, which indirectly damage DNA, accelerate the aging process, and facilitate UVB-induced carcinogenesis.[25,26]

Although sunburn risk varies according to geographical location, genetics, underlying medical conditions, and medication use, time spent outdoors puts children at risk. Photoprotective measures, therefore, are widely advocated for all children regardless of skin type. These measures include protective hats and clothing, limited sun exposure during peak intensity hours, and, for infants older than 6 months, regular use of sunscreen products with a sun protection factor (SPF) of at least 15 (see "Sunscreens as Photoprotection").[27] Although minor sun exposure induces skin to produce vitamin D_3, oral supplementation easily prevents vitamin D_3 deficiency, and the American Academy of Pediatrics (AAP) recommends a minimum daily intake of 400 IU for infants beginning soon after birth.[28]

INCREASED VULNERABILITY OF INFANT AND TODDLER SKIN TO UVR

The significant structural and functional differences between adult and infant skin suggest a greater susceptibility of infants to both percutaneous absorption of sunscreens and penetration of UV light. However, few studies have been performed to address UVR-induced responses in infants or specifically the kinetics of melanogenesis.

The outermost layer of epidermis, the SC, protects skin from adverse environmental conditions, including UVR penetration and systemic absorption of topically applied materials such as sunscreens (Fig 1).[29–33] Although the SC is present at birth, it gains thickness, hydration capacity, and acidification throughout infancy as it increases its capacity to adapt to the extrauterine environment.[30,32–43] On the basis of in vivo Raman confocal spectroscopic studies, infants and toddlers (to 33 months) show a higher water content throughout their SC than adults despite a lower concentration of natural moisturizing factors.[44] Skin capacitance, transepidermal water loss, and water absorption-desorption rates (both absorption and loss of water) showed consistently higher values throughout the first year of life in comparison with older subjects (up to 4 years of age), particularly with adults.[44] These factors not only reflect compromised barrier integrity but also influence skin surface morphology, desquamation, and epidermal expression of keratins and other proteins.[45–50] Corneocytes and keratinocytes of the granular layer of skin are smaller and denser in infant skin than those of their mothers, which leads to a thinner SC and total epidermis and suggests that faster turnover rate and greater surface area contribute to the increased water absorption (Table 1). In addition, studies with diffuse reflectance spectroscopy have shown a rel-

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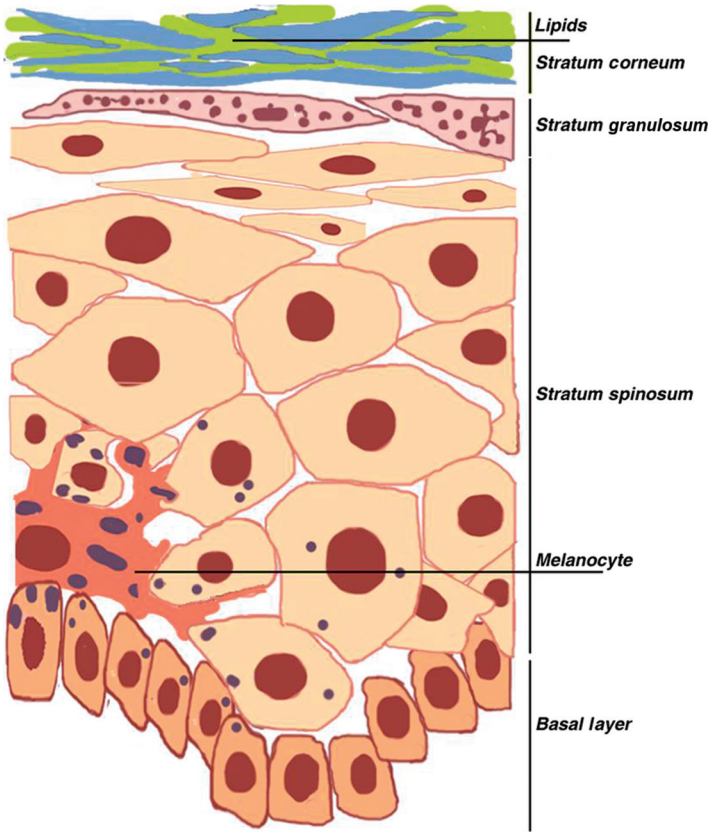

FIGURE 1
Infant epidermal structure.

TABLE 1 Differences in Infant and Adult Epidermal Structure[132]

	Infants	Adults
SC thickness, μm	7.3 ± 1.1	10.5 ± 2.1
Epidermal thickness, μm	29.7 ± 3.4	36.2 ± 5.2
Corneocyte size, μm^2	949.9 ± 19.1	1077.6 ± 26.9
Granular cell size, μm^2	443.6 ± 6.2	475.9 ± 8.3
Lipid/protein ratio	0.37 ± 0.012[a]	0.91 ± 0.027[a]
Melanin apparent concentration, au	1.4 ± 0.017	1.7 ± 0.014

All data are represented as average ± SD ($P < .05$). au indicates arbitrary units.
[a] Johnson & Johnson, unpublished data, 2009.

atively lower melanin concentration in infant versus toddler skin ($P < .01$) and in infant and toddler versus adult skin ($P < .0005$).[51]

Despite efforts to quantify UVR exposure in infants,[52–56] methodologic limitations, including measurement techniques unsuited to very young subjects and limited histologic investigations, have precluded pinpointing when UVR-induced effects become detectable.[51] Conducting longitudinal clinical trials in human infants raises additional challenges involving compliance and retention of subjects, as well as difficulties controlling for confounding variables and ensuring reliability of self-reported behaviors. A recent small longitudinal study used noninvasive diffuse reflectance spectroscopy to quantify cutaneous responses of infant skin to solar UVR exposure. Seasonal changes in pigmentation were found in 20 light-complexioned infants who had been well protected by sunscreen for traditional recreational activities but not for incidental exposure (such as inside a car, in the shade, or on a cloudy day) (Table 2). The infants were studied during their first summer (6–12 months of age; $n = 10$; average age at onset: 9 months) or second summer (ages 16–24 months; $n = 10$, average age at onset: 20 months) of life. Infants in both groups showed a significantly greater increase in pigmentation on the forearm (sun-exposed) versus the inner aspect of the upper arm (sun-protected) at the end of the summer. The baseline and final melanin concentrations of infants during their second summer were higher at all time points than during their first, which reflects the increase with advancing age of constitutive pigmentation (unrelated to UVR exposure and calculated as the difference in ap-

TABLE 2 Increases in Facultative Pigmentation After Summers in Infants and Toddlers

Age Group	*n*	Apparent Concentration of Melanin, au				Facultative Pigmentation, au	
		May 2006		September 2006		May 2006, Dorsal Minus Upper Inner	September 2006, Dorsal Minus Upper Inner
		Upper Inner Arm	Dorsal Arm	Upper Inner Arm	Dorsal Arm		
6–12 mo (infants)	10	1.39 ± 0.110[a]	1.40 ± 0.171[a]	1.59 ± 0.066[a,b]	1.87 ± 0.230[a,b]	0.007 ± 0.096[a]	0.279 ± 0.211[b]
16–24 mo (toddlers)	10	1.50 ± 0.096	1.68 ± 0.151	1.72 ± 0.152[b]	2.13 ± 0.269[b]	0.177 ± 0.101	0.414 ± 0.154[b]

au indicates arbitrary units.
[a] For each time point within each skin site, $P < .05$ versus toddlers.
[b] For each age group within each skin site, $P < .05$ versus May 2006.
Adapted from Mack MC, Tierney NK, Ruvolo E, Stamatas GN, Martin K, Kollias N. *J Invest Dermatol*. 2010;130(9):2335–2338.

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parent melanin concentration between the 2 sites). There was only partial reversal of pigmentation during colder months with decreased sun exposure. Development of facultative pigmentation in these infants, even when mothers applied sunscreen for recreational activities, suggests that incidental exposure, not recreational exposure alone, promotes UVR-related skin changes.[57] Besides highlighting the need for further research into the kinetics of infant melanogenesis, these findings suggest that UVR-induced skin changes and associated photodamage may begin as early as the first summer of life, before infant skin has accommodated to the environment and before natural photoprotection is fully developed.[44,58,59]

Results of epidemiologic studies have suggested that young children may be especially vulnerable to specific types of sun-related damage. Early and intense intermittent UVR exposure seems linked to truncal melanomas, whereas chronic UVR exposure is more frequently linked to head and neck melanomas.[60–62] Timing of exposure also seems to affect the risk and nature of genetic damage. A recent population-based case series of 214 patients with primary invasive melanoma associated high exposure to ambient UVR at the ages of 0 to 20 years with *BRAF* mutations and a mean age of diagnosis of 47.3 years. In contrast, high UVR exposure at ages 50 and 60 years was associated with *NRAS* mutations and a mean age of diagnosis of 62.1 years.[63] Another small study recently found that nevi acquired on sun-exposed skin during childhood and adolescence were genetically distinct from congenital nevi.[64] Although these findings reflect broad population trends and require more extensive investigation, the association of specific somatic mutations with early-life UV exposure reinforces the importance of early sun protection.

Increasing recognition of the skin's role as an immunologic, and physical, barrier raises additional concerns regarding specific vulnerability in early life. The epidermis not only provides a physical barrier against the ingress of organisms but also can generate protective soluble and cellular factors as part of the innate immune response. Exposure to UVR modulates the skin immune response and, ultimately, induces immunosuppression.[22,65] UVB-related immunosuppression, in particular, directly damages DNA and promotes skin cancer.[66–68] Whether infants and toddlers are unusually susceptible in this regard remains uncertain, but results of animal studies have suggested the need for further investigation. For example, single high-dose exposure to UVB caused a melanoma-like cancer in neonatal, but not adult, transgenic mouse models with overexpression of hepatocyte growth factor.[69] Several newer studies that used transgenic mice revealed that both single high-dose and chronic exposure to solar-simulated radiation in the neonatal period can reduce the number of epidermal Langerhans cells and potentially compromise skin immune-system development.[69–72] Future studies of UVB-related immunosuppression in human infants and toddlers, as well as improved understanding of the concept of innate immunity in infants, should help determine if an immature immune system makes infants unusually susceptible to UVR-related immunosuppression.

SUN PROTECTION FOR INFANTS AND CHILDREN

Current Sun Protection Practices

Despite growing understanding of infant skin's unique vulnerability and needs, sun protection practices for infants and children remain suboptimal. Sunburn incidence among American children remains substantial, ranging from 29% to 83% for the summer season and between 7% and 13% for a single summer weekend.[5,73–76] Parental attitudes that children look "healthier with a tan" and adolescent perceptions that tanning enhances attractiveness may contribute to unnecessary sun exposure.[77] Sunburn incidence in children and adolescents is associated with increasing age, fair skin, time outdoors, sporadic sunscreen use, and inadequate protective clothing, as well as increased use of tanning beds by teenagers.[5]

Sun Protection Recommendations

Many US public health organizations (the Centers for Disease Control and Prevention, the US Environmental Protection Agency, and the National Council on Skin Cancer Prevention) and professional organizations (the American Academy of Dermatology, the American Cancer Society, the Skin Cancer Foundation, and the AAP) actively promote public awareness about comprehensive sun protection. Comprehensive sun protection includes avoiding peak sun exposure, wearing protective clothing, and using sunscreen.[78] Sun avoidance is the first-line strategy for infants under 6 months, given the ease of controlling exposure at this age, and, in addition, dressing infants in brimmed hats and lightweight but tightly woven clothing, which is less susceptible to UVR penetration.[79–83] Concerns about a relatively high body surface/mass ratio, possible differences in absorption, metabolism, and excretion of sunscreen products, and lack of testing to prove safety of topical sunscreens for newborns may contribute to this recommendation. Although these measures are likely sufficient at this immobile age, the AAP has suggested that sunscreens can be applied to small areas of skin uncovered by clothing and hats if an infant cannot

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avoid the sun or is particularly susceptible to UVR.[84] The AAP also recommends that pediatricians incorporate sun protection counseling into practice.[13,84] Pediatricians have several opportunities to counsel about sun protection, including at least 6 visits in the first year of life and 4 in the second year. However, many do not use these opportunities to their full advantage. Surveys have revealed that pediatricians often address sun protection, but only a minority of them counsel most patients in every age group.[85–87] More than 90% of respondents in a national survey of 1616 randomly selected AAP members agreed that skin cancer is a significant public health problem and that preventing episodic high exposures to sun during childhood can reduce risks of adult melanoma. However, given limited counseling time, most of them ranked sun protection as a lower priority than other preventive care topics such as seat belt use, nutrition, immunization, and smoking prevention.[13] Use of sunscreen decreases precipitously between the ages of 9 and 15 years. Teaching children how to use sunscreen correctly and encouraging its continued use throughout life is an important pediatrician-to-parent-to-child "skill."

SUNSCREENS AS PHOTOPROTECTION

Notwithstanding recommendations for comprehensive protection, sunscreens remain the primary means of sun protection for many children and adults, even when parents are specifically educated about comprehensive protection.[73,77,88–91] In addition, sunscreens are still the only form of sun protection conclusively shown to prevent any form of skin cancer.[9,92] Randomized trials have revealed that, at least among adults, daily sunscreen use reduces risk of squamous but not basal cell carcinoma[9,93] and retards progression of solar (actinic) keratoses, precursors of squamous cell carcinoma.[94–96] Although previous studies have not proven that sunscreens prevent melanoma,[97,98] and the question of whether their use fosters a false sense of security about safety has been raised, Green et al[99] recently provided strong evidence that sunscreens protect against melanoma. In addition, the results of several studies have linked sunscreen use to higher UVR exposure,[23,56,97] and using higher SPF sunscreens may extend recreational sun exposure and, therefore, promote nevi and melanoma.[88,98,100] Nevertheless, recent reviews failed to show evidence of any link between sunscreen use and melanoma risk.[98,101,102] Indeed, randomized controlled trials that involved white schoolchildren have shown that casual use of sunscreen (eg, when exposed for ≥30 minutes) in childhood may prevent new nevi, which correlate with increased melanoma susceptibility.[103,104]

How Sunscreens Work

Sunscreens are formulated to attenuate UVA and UVB radiation before it reaches the deeper epidermis and dermis. The first modern sunscreens, simple alcoholic solutions of para-aminobenzoic acid (PABA) and benzophenones, appeared in the 1960s. Early sunscreens offered only modest protection against UVB and none against UVA, and they washed off easily with water or sweat. Waterproofing systems based on polymeric resins in emulsion products emerged in the early 1980s and are now graded as "water-resistant" (photoprotective after two 20-minute exposures to water) or "very water-resistant" (effective after 4 exposures).

Active sunscreen ingredients are often organic (chemical absorbers), inorganic (physical blockers), or a combination of these chemicals.[27] Organic agents directly absorb UVB and, increasingly more efficiently, UVA; these agents transform UV light as fluorescence or dissipate it by internal conversion mechanisms and release it as harmless energy.[105] Preparations of inorganic agents (zinc oxide and titanium dioxide) are formulated as cosmetically acceptable micronized particles that both absorb and scatter radiation, although they protect more modestly than the best organic filters. Zinc oxide provides more comprehensive UVA protection, whereas titanium dioxide offers better UVB protection. Sunscreens that use only inorganic filters have been shown to penetrate no farther than the outermost 2 SC layers (as measured in adult human skin), thereby reducing potential irritation or sensitization.[106–108] All organic sunscreen filters, in contrast, penetrate skin after topical application to some extent, although the US Food and Drug Administration (FDA) considers organic filters in the US monograph safe for topical use at permitted concentrations, because their systemic absorption is too low to cause estrogenic effects.[109–112]

The efficacy of a sunscreen against sunburning (caused largely by UVB) is represented by its SPF, a measure calculated after applying sunscreen (2 mg/cm^2 of skin) before sun exposure. The SPF reflects the ratio of UVR dose received before burning of protected versus unprotected skin after exposure.[113] Proper application of an SPF-15 product, for example, allows a person to receive a 15-times-higher UVR dose than those without protection. The choice of sunscreens with an SPF of ≥15 depends on susceptibility to sunburn. However, if adequate sunscreen is applied and reapplied appropriately, the protection against UVB light afforded by an SPF of 30 (~97%) is not much less than that by an SPF of 50 (98%) (Fig 2[114]). In fact, in a 2007 proposed amendment to update the la-

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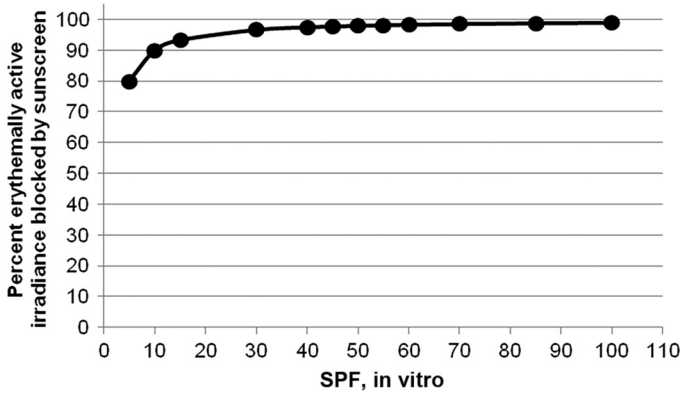

FIGURE 2
In vitro SPF values are calculated as the ratio of the amount of applied erythemally active irradiance to the amount of transmitted erythemally active irradiance. Incremental increases in the amount of UVR blocked decrease with increasing SPF. Sun protection is marginally increased above an SPF of 30. However, the FDA standard for SPF testing is based on an application of 2 mg/cm^2, whereas most people apply only 0.5 to 1.0 mg/cm^2, which lowers the effectiveness of the sunscreen. (Adapted from Stanfield J, Osterwalder U, Herzog B. *Photochem Photobiol Sci.* 2010;9[4]:489–494.)

beling of sunscreens, the FDA suggested a maximum SPF rating of ≥50. Most people, however, apply considerably less sunscreen than recommended (2 mg/cm^2 of skin for adults), so that sunscreen of a given SPF may not be as protective as predicted. In addition, many users, including caregivers who spread sunscreen on their children, leave portions of skin exposed to burn, such as through use of sprays that do not cover evenly or by avoiding skin along the hairline or near clothing.[115–118]

The FDA recently added a 4-star UVA protection rating system that includes both in vitro and in vivo testing (Table 3). The ultraviolet A protection factor (UVA-PF) ratio, which largely measures UVA2 (340–400 nm) represents the UVA dose required to induce persistent pigment darkening with and without sunscreen protection.[119] The in vitro testing determines protection against UVA1 (320–340 nm) as the UVA1/total UV ratio on the basis of penetration through a quartz plate before and after sunscreen application. If in vitro and in vivo testing results differ, the lower value determines the rating. Avobenzone (butyl methoxydibenzoylmethane [BMDM]), the first broad-spectrum UVA absorber, was approved in 1996.[120] Avobenzone is photounstable, especially if improperly formulated, and cannot be combined with either titanium dioxide or zinc oxide. As a result, avobenzone combined with oxybenzone and oxybenzone with titanium dioxide and zinc oxide have been the primary "broad-spectrum" protective agents.[120] Ecamsule (Mexoryl SX [La Roche-Posay, La Roche-Posay, France]), which protects in the 290- to 400-nm range (peak protection at 345 nm), was approved in 2006 by the FDA and is now marketed in combination with avobenzone and octocrylene.

TABLE 3 UVA Protection Rating System

	Rating	In Vitro (UVA1/UV)	In Vivo (UVA-PF)
★★★★	Highest	>0.95	≥12
★★★	High	0.70–0.95	8–12
★★	Medium	0.40–0.69	4–8
★	Low	0.20–0.39	2–4
—	None	<0.20	<2

UVA-PF indicates UVA protection factor.
Data source: *Fed Regist.* 2007:347–352; 49071–49122.

Sunscreens for Infants and Toddlers

No sunscreen is ideal in terms of efficacy, safety, and practicality. Many properties (including solar protection, physical stability, photostability, skin penetration, microbial resistance, and wash resistance) are considered in formulating sunscreens, and one property must often be sacrificed for another. Sunscreens that stain clothing or are hard to spread, greasy, or opaque may not be used in sufficient amounts, if at all, regardless of potential to screen UVR.[120]

Finding effective, safe, and practical sunscreens for infants and toddlers is even more complicated. Besides providing adequate UVR shielding, sunscreens for infants must be nonirritating to the skin and eyes and have aesthetic qualities that encourage effective application by caregivers. Photostability and ease of application apply universally, but product transparency and water resistance may be less important for infants. For example, a mother may use an invisible sunscreen for her own skin but prefer an opaque sunscreen that leaves a temporary film on her infant's skin to ensure complete coverage.

Approximately 19% of adults experience an adverse reaction, usually of short duration, to sunscreen products; most common is irritant dermatitis, but occasionally allergic contact dermatitis, contact urticaria, photosensitivity, and acne have been described.[121,122] The frequency of reactions to sunscreens in infants and children has not been assessed, although anecdotal cases and series of photosensitivity and allergic contact dermatitis have been reported.[123–126] The immature epidermal barrier and prev-

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alence of atopic dermatitis in infants reinforce the need for sunscreens with minimal irritation or sensitization potential. Sunscreen products that do not irritate eyes are also important, because infants often rub topical products into or near their eyes. Not only is infant tear secretion still developing, but involuntary blinking that protects the eyes also continues maturing throughout the first year, which increases vulnerability.[127,128] Sunscreens with only inorganic filters seem to be mildest to the eye, both in in vitro assessments
(eg, transepithelial permeability tests, widely used to assess the compatibility of a surfactant system with tissue[130]) and in clinical assessments of perceived sting, observable eyelid inflammation, corneal abnormalities, lacrimation, and conjunctival irritation.[129,130]

Few sunscreens currently marketed for infants and toddlers satisfy all these needs. Oil-based emulsions of inorganic filters seem particularly promising in minimizing the sensitization, irritation, and skin-penetration potential of the filters, fragrances, photostabilizers, preservatives, and dozens of other chemicals that typically comprise sunscreens.[130] However, such emulsions have traditionally been associated with more greasiness, which reduces compliance, and higher acidity, which can cause skin irritation. Novel structures that incorporate inorganic filters into oil-based formulas are easy to apply uniformly and seem to have been well tolerated in clinical tests for sensitization, irritation, phototoxicity, and photoallergy in adults[115] but have yet to be tested in infants.[131]

CONCLUSIONS/FUTURE RESEARCH

Results of recent research have suggested that skin possesses unique properties and vulnerability in infants and toddlers, which leads to an increased risk of xerosis, atopic dermatitis, and UVR damage. Pediatricians must remember the special vulnerabilities of infants and toddlers when counseling parents about sun protection measures. These measures include avoiding midday sun, wearing protective clothing and hats, seeking shade, using UVA/UVB protective sunglasses, and applying sunscreen. The ultimate goal of sun protection is to protect all parts of the skin exposed to the sun by using a variety of techniques, including sunscreen in infants older than 6 months.

Establishing firm standards of care for infant and toddler sun protection on the basis of a developing understanding of their needs will require additional epidemiologic data about sun exposure and sunburn in early life. These data include the specific nature of sunburn in infants and actual caregiver practices, stratified according to setting and ethnicity. Definitively establishing that sun avoidance in the first 6 months and vigorous sun protection thereafter during infancy prevents melanogenesis-related DNA damage and standardizing results for barrier function according to different SC thickness throughout the body are logical next steps as well. More noninvasive studies to elucidate the time course of pigmentation in sun-exposed areas compared with the development of the skin barrier and immunity will be critical for making decisions about sunscreen use. Ensuring that oral vitamin D_3 administration obviates the need for UVR-induced vitamin D_3 production in skin will also be essential. In addition, any sunscreen recommended for infants and toddlers must be evaluated thoroughly in children in this age group for broad-spectrum protection, safety, skin absorption, and reactivity. Separate assessments, including clinical studies, must also be conducted to ensure tolerance for products recommended for infants with atopic dermatitis. Studies to better assess the need for sun protection in infants and toddlers with darker skin types (eg, is a lower SPF value sufficient?) should also be performed. Finally, consideration might be given to designing sunscreens in bases that provide added benefit, such as emollition, vitamin D_3 supplementation, and promotion of barrier development.

ACKNOWLEDGMENTS

We acknowledge the contributions and ongoing research of Johnson & Johnson and, in particular, the assistance of Nikolas Kollias, PhD. In addition, we thank Terra Ziporyn, PhD, for providing editorial assistance in the preparation of this article.

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EARLY MEMORIES: *What is your earliest memory? How old were you at the time? If you are like most, your first memory is of an event that occurred after the age of three or four years. Why we cannot remember our early childhood experiences has always puzzled scientists. As reported in* The Wall Street Journal *(Health: May 31, 2011), some have suggested that childhood memory is linked to language skills. The youngest children have yet to develop the language skills necessary to store and retrieve memories. Others believe that the concept of self plays a role. Young children have yet to develop a firm idea of self so they cannot create autobiographical memories. Culture plays a role as well. In a study published in 2009 comparing Canadian and Chinese children, Canadian children were able to recall earlier events and these events tended to be about their own experiences. Chinese children remembered family activities. This may reflect how adults interact with children. The Canadian parents may have told the story many times savoring the individuality of the child, while the Chinese parents may value the group experience more. It appears, however, that children can remember very early childhood events, even those occurring before the age of two but these memories are fragile and easily lost. According to the article, researchers asked 140 children between the ages of four and 13 to describe their earliest memories and then repeated the experiment two years later. On average, 50 children aged four to six could recall events from age two. However, two years later, only 10 percent of that 50 could recall the same event. In contrast, one-third of children aged 10 to 13 at the time of the first interview could recall the same first memory. The findings imply that by age 10 or so, the early memories that we have are solid and much more likely to be permanent. The long term implications are not known, but the data suggest that if parents want a young child to remember a significant event that occurred early in life, he or she should discuss the event in question often, asking the child his or her views of the event, and help the child relate the event to other experiences.*

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