AMERICAN ACADEMY OF PEDIATRICS

Committee on Environmental Health

Ultraviolet Light: A Hazard to Children

ABBREVIATIONS. UVR, ultraviolet radiation; NMSC, nonmelanoma skin cancer; XP, xeroderma pigmentosum; SPF, sun protection factor.

BACKGROUND

Sunlight is subdivided into visible light, ranging from 400 nm (violet) to 700 nm (red); longer infrared, "above red" or >700 nm, also called heat; and shorter ultraviolet radiation (UVR), "below violet" or <400 nm. UVR is further subdivided into UV-A (320–400 nm), also called black (invisible) light; UV-B (290–320 nm), which is more skin-penetrating; and UV-C (<290 nm). UV-B constitutes <0.5% of sunlight reaching the earth's surface, but is responsible for most of the acute and chronic sun-related damage to normal skin.[1] Most UVR is absorbed by stratospheric ozone.

UV-B has greater intensity in summer than in winter, at midday than in morning or late afternoon, in places closer to the equator, and at high altitudes. Sand, snow, concrete, and water can reflect up to 85% of sunlight, thus intensifying exposure.[1]

EFFECTS ON THE SKIN

Erythema and Sunburn

Exposure to solar radiation causes vasodilatation and increases the volume of blood in the dermis, resulting in erythema. The minimal erythemal dose depends on factors such as skin type and thickness, the amount of melanin in the epidermis and its capacity to produce melanin after sun exposure, and the intensity of the radiation. Six sun-reactive skin types have been developed (Table 1).

Tanning

Tanning occurs as a protective response to sun exposure. Immediate tanning (or immediate pigment darkening) is a transient grayish-brown skin discoloration induced by UV-A and certain visible wavelengths. The effect begins during exposure, maximizes at the end of the exposure, and persists depending on the duration and intensity of exposure. It does not involve the production of new melanin. Delayed tanning occurs 48 to 72 hours after exposure to UVR, peaks at 7 to 10 days and can persist for several weeks to months. Delayed tanning is the result of increased production of new melanin.[2]

Nonmelanoma Skin Cancer (NMSC)

Cumulative sunlight exposure over a prolonged period is important in the development of NMSC (basal cell and squamous cell carcinoma). More than 90% of NMSCs can be attributed to exposure to UV-B.[3] Nonmelanoma skin cancer is the most common malignant neoplasm of the US adult population (approximately 1 million cases per year). It rarely is fatal unless left untreated. In general, NMSC occurs in maximally sun-exposed areas of fair-skinned persons and is uncommon in blacks. Nonmelanoma skin cancer is rare in children in the absence of predisposing conditions.

Cutaneous Malignant Melanoma

Exposure to large amounts of sunlight that is episodic and relatively infrequent is important in the pathogenesis of cutaneous malignant melanoma (referred to hereafter as melanoma). Although much less common than NMSC, melanoma is a serious public health issue. The incidence rates of melanoma in the United States have risen more rapidly than any other cancer except for lung cancer in women. The lifetime risk of melanoma was 1 in 1500 in 1930; 1 in 250 in 1980; 1 in 120 in 1987; and, in 1996, was projected to reach 1 in 75 by 2000. In 1996, estimates were that melanoma would develop in >38 000 Americans, making this the seventh most frequent cancer,[4] and that 7300 deaths from melanoma would occur.[5] Although survival rates are high if melanoma is detected in its early stages, melanoma that has metastasized has a grave prognosis. Thus, efforts have been directed toward prevention and early detection.

The exact cause for the increase in melanoma is unknown. It most likely represents a combination of effects, including stratospheric ozone depletion, resulting in more intense UVR reaching the earth's surface, and changes in dress favoring more skin exposure. Other factors, yet to be determined, are most likely involved.

Sunlight is implicated in the cause of most, but not all, cases of melanoma.[6] The evidence implicating sunlight includes:

1. Xeroderma pigmentosum (XP). Melanoma is seen frequently in people with XP and related disor-

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

TABLE 1. Classification of Sun-reactive Skin Types[2]*

Skin Type	History of Sunburning or Tanning
I	Always burns easily, never tans
II	Always burns easily, tans minimally
III	Burns moderately, tans gradually and uniformly (light brown)
IV	Burns minimally, always tans well (moderate brown)
V	Rarely burns, tans profusely (dark brown)
VI	Never burns, deeply pigmented (black)

* Based on 45 to 60 minutes of sun exposure after winter or no sun exposure.

ders in which there is a genetically determined defect in the repair of DNA damaged by UVR and a high risk of NMSC.[7]

2. Latitude. There is an inverse relationship between latitude and the incidence and mortality rates of melanoma in whites, with higher rates seen closer to the equator (where there is a greater amount of sunlight).[8]
3. Race and pigmentation. Melanoma occurs predominantly in whites with an incidence approximately 10 times greater for white men and women than for blacks. The mortality rate among whites is 5 times greater than that for blacks. There is, in general, an inverse correlation between the incidence of melanoma and the skin pigmentation of people in various countries in the world. Melanin decreases the transmission of UVR. This may protect melanocytes from sunlight-induced changes that lead to their malignant transformation.[8]
4. Childhood exposure. Episodic high exposures sufficient to cause sunburn, particularly in childhood and adolescence, increase the risk of melanoma.[9–11] In a study conducted within the Nurses' Health Study, blistering sunburns at 15 to 20 years of age (but not after 30 years) were significantly associated with increased risk (relative risk, 2.2 for >5 sunburns vs none).[12] Migration studies indicated that high exposure to sunlight during childhood was related to a higher risk of developing melanoma in adulthood.[13]

   Approximately 80% of lifetime sun exposure occurs before the age of 18 years.[14] In childhood and adolescence, melanocytes may be more sensitive to the sun, resulting in alteration of their DNA, possibly leading to the formation of unstable moles that may become malignant. Sunlight exposure and blistering sunburns during youth may be more intense than later in life because of child and adolescent behavior patterns. Passing through critical stages of carcinogenesis early in life may increase the chance of completing the remaining stages. One of these stages may involve the formation of nevi, particularly dysplastic nevi.
5. Nevi. Acute sun exposure is implicated in the development of nevi (moles) in children. The number of nevi increases with increasing age[15]; nevi occur with more frequency on sun-exposed areas; the number of nevi on exposed areas increases with the total cumulative sun exposure during childhood and adolescence[16,17]; children with light skin who tend to burn rather than tan have more nevi at all ages,[15] and children who have more severe sunburns have more nevi.[15] There is a relationship between the number and type of melanocytic nevi and the development of melanoma. Dysplastic melanocytic nevi, which may represent a reaction to solar injury, are considered precursor lesions that increase risk.[18] The presence of congenital nevi >1.5 cm in diameter also increases risk.[16] The familial dysplastic nevus syndrome has the following features: 1) a distinctive appearance of abnormal melanocytic nevi; 2) unique histologic features of the nevi; 3) an autosomal dominant pattern of inheritance; and 4) hypermutability of fibroblasts and lymphoblasts.[18] Fibroblasts and lymphoblasts from patients with this syndrome are abnormally sensitive to UV damage, and persons with this syndrome are at markedly higher risk for developing melanoma.

Exposure to sun beds and sunlamps, which produce primarily UV-A, has been associated with increased risk of melanoma in some studies.[19,20] In Sweden, people <30 years who used sun beds or sunlamps >10 times a year had an almost eightfold increased risk for developing melanoma.[19]

Phototoxicity and Photoallergy

Chemical photosensitivity refers to an adverse cutaneous reaction that results when certain chemicals or drugs are applied topically or taken systemically at the same time that a person is exposed to UVR or visible radiation. *Phototoxicity* is a form of chemical photosensitivity that does not depend on an immunologic response because the reaction can occur on first exposure to an agent. Most phototoxic agents are activated in the range of 320 to 400 nm. *Photoallergy* is an acquired altered reactivity of the skin that is dependent on antigen-antibody or cell-mediated hypersensitivity.[2]

People who take medications or use topical agents known to be sensitizing should avoid all sun exposure, if possible, and avoid all UV-A from artificial sources. The consequences of exposure can be uncomfortable, serious, or life-threatening.[2] Sensitizing medications include sulfonamides, tretinoin, tetracyclines, and thiazides.

Skin Aging

Chronic exposure to UVR without sunscreens typically results in excessive wrinkles and skin thickening and thinning. The cumulative effects of such sun exposure weaken the skin's elasticity, resulting in sagging cheeks, deeper facial wrinkles, and skin discoloration later in life.[21]

EFFECTS ON THE EYE

In adults, >99% of UVR is absorbed by the anterior structures of the eye. UVR can contribute to the development of age-related cataract, pterygium, photodermatitis, and cancer of the skin around the eye. It also may contribute to age-related macular degeneration.[22] The formation of cataracts seems to be positively correlated with decreasing latitude and

increasing UV-B and total sunlight exposure.[2] Melanoma of the uveal tract, the most common primary intraocular malignant neoplasm in adults, is associated with a tendency to sunburn and with intense exposure to UVR.[23]

Infants and children <10 years may be at increased risk for retinal injury because the transmissibility of the lens to damaging visible blue and UV light is greatest during this period.[24]

Malfunctioning high-intensity mercury vapor lamps, in which the outer glass envelope of a mercury vapor bulb is broken while the mercury lamp is still functional, have been sources of high doses of UVR. Exposure has resulted in conjunctivitis, keratitis, and blepharospasm.[25,26]

EFFECTS ON THE IMMUNE SYSTEM

In mice, contact hypersensitivity and delayed-type hypersensitivity can be suppressed by exposure to UVR; immune suppression is thought to have an important role in the growth of skin cancer, in progression of certain infections, and in vaccine response. In humans, exposure to UVR doses achieved at midday in the summer sun has been shown to cause suppression of contact hypersensitivity similar to that demonstrated in mice.[27]

A 1995 workshop sponsored by the Environmental Protection Agency and the World Health Organization identified research needs in this area. Priorities were to study the effects of UVR on the effectiveness of immunizations against measles, hepatitis, and bacille Calmette-Guérin. Research needs were further identified in defining the effects of UVR on other immune functions, such as serum cytokine responses and epidermal mixed-lymphocyte reactions, the effects of different wavelengths, and the role of UVR in allergy, asthma, and autoimmune disease.[27]

PREVENTION

Although other risk factors (eg, precursor lesions, age, race, previous melanoma, and family history) are more closely associated with melanoma than sunburns, solar radiation is the only risk factor that is avoidable. Because the evidence linking melanoma to sunburn during childhood and adolescence is strong, effective sun protection needs to begin early in life. It has been estimated that sun avoidance could reduce the number of lifetime NMSC by almost 80%.[14]

Pediatricians have an important role in education beginning in infancy and later when developmental stages result in new patterns of sun exposure (eg, when the child begins to walk, before starting school, and before entering adolescence).[28] Preteens and teenagers may need special reinforcement as they are often susceptible to societal notions of beauty and health. In 1 survey, only one third of teenagers reported regular use of sunscreens, despite reports by most that they spend substantial amounts of time in the sun.[29] Counseling for teenagers should include warnings about using sun beds and sunlamps.

All parents and children should receive advice about sun protection. Although not all children sunburn easily, people of all skin types can experience skin cancer, skin aging, and sun-related damage to the eyes and immune system. Children who should be especially targeted include those with XP (who must be shielded from all sources of UVR), those showing evidence of excessive sun exposure (eg, freckles), and those at high risk of melanoma for other reasons (such as those with familial dysplastic nevus syndrome, with excessive numbers of nevi, or with 2 or more family members with melanoma).[28]

No evidence exists that rigorous sun protection through use of protective clothing and sunscreens interferes with serum levels of vitamin D.[30]

Avoiding Exposure

Infants <6 months should be kept out of direct sunlight. Because they are not mobile and cannot remove themselves from uncomfortable light and heat, they should be moved under a tree, umbrella, or the stroller canopy, although on reflective surfaces an umbrella or canopy may reduce UVR exposure by only 50%. Many infants have impaired functional sweating. Exposure to the heat of the sun may increase the risk of heatstroke. Sunburn may occur readily because an infant's skin has less melanin than at any other time in life.[31,32]

The issue of whether sunscreen is safe for infants under the age of 6 months remains controversial. Concerns have been raised that human skin under 6 months may have different absorptive characteristics; biologic systems that metabolize and excrete drugs may not be fully developed in children <6 months.[33] Despite these concerns, the Australian Cancer Society, supported by the Australasian College of Dermatologists, concluded that there is no evidence to suggest that using sunscreen on small areas of a baby's skin is associated with any long-term effects. They recommend that sunscreen be used when physical protection, such as clothing, hats, and shade, is not adequate.[34] Based on the available evidence, it is reasonable to tell parents what is known about the safety of sunscreens in infants <6 months of age and to emphasize the importance of avoiding high-risk exposure. In situations where the infant's skin is not protected adequately by clothing, it may be reasonable to apply sunscreen to small areas, such as the face and the back of the hands.

Children's activities can be selected to avoid or minimize sun exposure between 10 AM and 4 PM. Parents should be particularly careful when the child is near sand, snow, or concrete. The risk of sunburn during certain activities, such as water sports, is high. Clouds are not sufficiently protective against UVR. UVR on cloudy days may be reduced by only 20% to 40%.[35]

Clothes

Clothes offer the simplest and often most practical means of sun protection. The factors that determine the protection provided by a fabric are its material, structure, color, and thickness; the most important factor affecting the UV-B transmission is the structure, or weave, of the material.[9,36] Parents should consider dressing their children in lightweight long pants and long-sleeved shirts even in the summer if

burning is possible. Clothes should have a tight weave, one that lets in little light when held up to a lamp or window. Cotton clothing is cool and protective. Wet clothing is not an effective optical filter.[37,38] Hats with bills can be cooler and more comfortable than a bare head in the summer. When a cap with a bill is used, it should be faced forward to shade the face.

Sunscreens

There are no data from clinical trials to demonstrate the efficacy of sunscreens for the prevention of skin cancer. The American College of Preventive Medicine and others have questioned the use of sunscreens for the prevention of skin cancer.[39] The American Cancer Society and the American Academy of Dermatology continue to recommend sunscreen[40] as part of a program of sun avoidance.

Sunscreens reduce the intensity of UVR affecting the epidermis. Opaque sunscreens, including zinc oxide and titanium dioxide, do not selectively absorb UVR, but reflect and scatter all light. They are useful for patients with photosensitivity and other disorders who require protection from full-spectrum UVR, but they are cosmetically unacceptable to many.[1] Chemical UV absorbent agents are the most commonly used. They are usually colorless and therefore cosmetically acceptable. "Normal UV-B absorbers" have maximal UV-B absorption but permit transmission of all radiation above 320 nm. "Broad-spectrum absorbers," absorb UV-A and UV-B. Early sunscreen preparations incorporated one type of chemical agent, whereas more recent formulations aim to provide a higher degree of protection through a combination of UV absorbers. Para-aminobenzoic acid (PABA) and its esters, the most widely used sunscreen chemical, absorb predominantly within the UV-B range. They are appropriate for preventing sunburn but minimally effective for photosensitivity disorders. Other chemical sunscreens containing benzophenones or anthranilates protect against UV-A radiation.[1] The effectiveness of sunscreen preparations has been tested.[41]

The sun protection factor (SPF) is a grading system used to quantify the degree in the reduction of erythema provided by using a given sunscreen. The SPF is the ratio of the dose of UVR required to produce minimal pinkness, assessed 24 hours after exposure to sunscreen-covered skin, to the dose of UVR required to produce the same effect on unprotected skin. The higher the SPF, the greater the protection; a person who would normally experience an effect in 10 minutes can be protected up to about 150 minutes (10 × 15) with an SPF-15 sunscreen.[21] Sunscreens with an SPF of 15 or more theoretically filter >92% of the UVR responsible for erythema; sunscreens with an SPF of 30 filter out about 97% of UVR. In actual use, the SPF is often much lower than expected because the amount used is less than half the recommended amount.[1] An SPF of 15 should be adequate in most cases. A sunscreen-containing lip protection product can be helpful.

Sunscreen should be used when the child might sunburn. Although there are no data showing that sunscreens prevent melanoma, there is no benefit in burning, and it should be avoided. It is also likely that prevention of tanning might prevent or delay aging of the skin related to sun exposure, keratoses, and NMSC.

Window Glass

Window glass blocks virtually all UV-B and at least half of all UV-A energy.

The UV Index

The UV index, developed by the National Weather Service, predicts the intensity of UV light. It is based on the sun's position, cloud movements, altitude, ozone data, and other factors. It is conservatively calculated based on effects on skin types that burn easily. Higher numbers predict more intense UV light during midday of the next day (Table 2). The index, available in 58 cities, is printed in the weather section of many daily newspapers.[42,43]

Protection for the Eyes

Wearing a hat with a brim can reduce UV-B exposure to the eyes by 50%. Sunglasses should be worn whenever the child may be in the sun long enough to get a sunburn or tan. Sunglasses should be chosen to block 99% to 100% of the full UV spectrum. The label should indicate sufficient UV blocking capacity such as, "Blocks 99% of ultraviolet rays," "UV absorption up to 400 nm," "special purpose," or "meets ANSI (American National Standards Institute) UV requirements." Because there is no uniform labeling, parents should be wary of nonspecific labels such as "blocks harmful UV." Even infants should wear sunglasses. Larger lenses, well fitted and close to the surface of the eye, provide the best protection.[24]

Changes in Knowledge and Attitudes

Australia, which has the world's highest incidence of melanoma, has mounted a 16-year sun-safety campaign directed toward children and teenagers. Fashion norms have been changing; a study of the midsummer editions of 6 Australian fashion magazines between 1982 and 1991 showed an increasing proportion of light tans over the years and more models wearing hats.[44] Melanoma mortality, which had been rising steadily, peaked in 1985 and overall has reached a plateau; the mortality rate of women has decreased.[45] Some encouraging although more mod-

TABLE 2. Exposure Levels Predicted by the UV Index[43]*

Index Value	Exposure Level	Time in Sun Needed for Burn
0 to 2	Minimal	1 h
3 to 4	Low	30–60 min
5 to 6	Moderate	20–30 min
7 to 9	High	13–20 min
10 to 15	Very high	<13 min

* These UV effects are on unprotected skin type II, which usually burns easily and tans minimally.

est trends have been noted in the depiction of models in American fashion magazines.[46] Public health campaigns promoting sun protection have been mounted in the United States. This includes the SunWise School Program sponsored by the Environmental Protection Agency, which targets elementary school children.

RECOMMENDATIONS

1. Pediatricians should incorporate sun protection advice into their health supervision practices. This includes recommendations that parents consult the UV index in cities where the index is available.
2. Pediatricians will rarely see patients with NMSC or melanoma. Patients at high risk should be identified and treated in collaboration with a dermatologist. These include children with XP and related disorders and those with a large number of nevi and a family history of melanoma.
3. The government should mount campaigns, similar to those successfully used in Australia, to raise awareness about the dangers of sun exposure. These campaigns should be directed to children, adolescents, and their parents.
4. Pediatricians should consider encouraging schools to adopt sun-protective policies, such as shaded playgrounds, outdoor time before 10 AM, and allowing "uniform" hats.
5. Schools should incorporate education about the dangers of sun exposure into their curricula. Topics might include protection of the ozone layer.

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