Photoprotection encompasses all methods to prevent UV radiation (UVR) damage to the skin, including sunscreens, clothing, seeking shade, and duration and time of the day spent outdoors under UVR. As scientific research validates short- and long-term detrimental effects of UVR, physicians and the public must become increasingly aware of these problems to avoid them. Photoaging is defined. Choice of sunscreens, their Food and Drug Administration labeling, and future sunscreen products are reviewed. Hazards of UVR on the skin include acute sunburn, photocarcinogenesis, immunologic supression, and photoaging. Distinguishing between UV-A and UV-B damage to the skin is discussed. Education of physicians and their patients is crucial to reduce future photodamage to our population, especially with a reduction of the ozone layer and with patients having more free time. The complete skin examination is emphasized as a method to detect photodamaged skin and give patients insight to provide themselves with future photoprotection. A summary of advice for patients is provided for physicians to give to their patients.

The incidence and prevalence of skin cancer is increasing worldwide. Although our patients are becoming increasingly aware of the harmful effects of short- and long-term sun exposure, the misguided concept of an “attractive, healthy suntan” persists. Articles in the lay press attempt to educate, but much of the public is still confused or misinformed. Well-conducted health promotion campaigns can cause attitudinal shifts toward more healthful behavior. Physicians are increasingly asked for their advice on how to look younger, avoid the appearance of “old looking” skin, and reduce the risk of skin cancers. This article reviews the latest developments in the field of photoprotection so that we can better educate and inform our patients.

Photoaging (previously called dermatoheliosis) refers to the changes in the skin caused by chronic exposure to UV radiation (UVR)—UV-A and UV-B. These include formation of flat brown spots on the skin (solar lentigines or the misnomer “liver spots”), fine and deep wrinkling, blackheads and under-the-surface whiteheads or comedones, small superficial prominent blood vessels (telangiectasias), a yellow, sallow color of the skin, loss of elasticity of the skin, and a parchment like appearance of the skin with dryness and, often, itchiness. Severity of photoaging depends on the duration and intensity of sun exposure and the natural melanin protection of the person. In addition, excessive UV radiation exposure results in the premalignant solar (actinic) keratoses and skin cancers, basal cell carcinomas, squamous cell carcinomas, and malignant melanomas. Photoaging should be contrasted to intrinsic aging of the skin, which occurs solely with time in all areas of the body.

Sunscreens are chemical or physical agents which, when applied to the skin, afford some protection against UVR. Sunscreens are classified as chemical photoabsorbers that absorb UVR or as physical blockers that reflect UVR away from the skin.
skin surface.\textsuperscript{4} However, these physical blockers are chemicals that absorb UVR. Sunscreens also can be classified as organic and inorganic agents. The inorganic or physical sunscreens, primarily zinc oxide and titanium dioxide, are different from the organic sunscreens, which include most sun protection products now in use.\textsuperscript{22,23} Newer inorganic micromized reflecting powders are less visible than earlier formulations, do not cause photosensitization, but provide broad-spectrum protection against UVR.

Ultraviolet radiation is a segment of the broad radiation that emanates from the sun toward the earth. Most of the radiation of the sun, including the shorter wavelength UV-C and much of the UV-B, is blocked by our atmosphere, primarily the ozone layer. Ultraviolet radiation is divided into UV-C, from 220 to 290 nm; UV-B, from 290 to 320 nm; and UV-A and II, from 320 to 400 nm. Beyond 400 nm, visible light occurs. Visible light and infrared radiation also can damage skin.\textsuperscript{24}

Minimum erythema dose (MED) represents the minimum amount of UVR (determined with a solar stimulator or natural sunlight) that causes visible erythema or redness. Thus, the MED may vary from only 10 minutes outdoors for a fair-skinned redhead to an hour or longer for a darkly pigmented person. The "time to burn" varies with geographical location and season.

Sun Protective Factor (SPF) is a measurement of photoprotection using a solar stimulator. The definition of SPF is as follows:

\[
\text{MED in Sunscreen-Protected Skin} \quad \text{SPF} = \frac{\text{MED in Non-Sunscreen-Protected Skin}}{2}.
\]

HISTORY OF PHOTOPROTECTION

After World War II, when people had more free time, a suntan was a status symbol and a thing of beauty. Coco Channel helped glamorize the suntan in the 1940s. Advertisements for suntanning products in the 1950s and 1960s emphasized the evenness and depth of tan. Little thought was given to the long-term detrimental effects of UVR. In the 1970s, the relation between acute sunburns and chronic exposure to sunlight led to the development of the first widely used sunscreen, p-aminobenzoic acid (PABA). Its disadvantages were that as an alcohol solution it stung the eyes and face and it washed off too easily with water. By 1978, the Food and Drug Administration (FDA) Proposed Monograph on Sunscreens included a maximum SPF of 15 for ultraprotective sunscreen products.\textsuperscript{25} The PABA derivatives were the most commonly used ingredients in these products. Many thought SPF of 4 or 8 were adequate for most persons, and SPF 15 sunscreens made up less than half of the sunscreen market.

In the 1980s, the skin-damaging effects of UV-A were more intensely investigated, and the meteoric rise of skin cancers, especially melanoma (500% since 1935) caused widespread interest and concern. Sunscreen manufacturers were perfecting techniques using smaller percentages of active ingredients to give higher SPF, and more products used combinations of ingredients for protection against a wider range of UVR, achieving SPF up to 50. The concept of "pale is beautiful" was encouraged.\textsuperscript{26}

In May 1993, the FDA issued a Tentative Final Monograph on sunscreens that more closely defined labeling and definitions of water-resistant and very water-resistant (compared with "waterproof") and included as "drugs" any cosmetic, such as lip balm, moisturizer, or makeup, that incorporated a sunscreen and claimed an SPF of 4 or greater.\textsuperscript{27} The proposal would also mandate the following "sun alert" on all sunscreen drug products: "The sun causes skin damage. Regular use of sunscreens may reduce the chance of skin aging, some types of skin cancer, and other harmful effects due to the sun."

Two controversial issues related to the Tentative Final Monograph are the suggested cap on SPF at 30, and the avoidance of additional guidelines on UV-A protection.\textsuperscript{28} Although knowledge of the health effect of UV-A rays on the skin has become increasingly more understood, many UV-A claims are outside the coverage of the Tentative Final Monograph.

The damaging effects of the more penetrating UV-A wavelengths (320 to 400 nm) are not addressed in the monograph. Not having one universally accepted assay for UV-A protection\textsuperscript{29} is given as a reason UV-A was excluded from the monograph. A recent National Institutes of Health statement said that incorporation of UV-A protection "is of ultimate concern." Existing sunscreens, while protecting against UV-B, might allow increased exposure for UV-A onto the skin if it flooded patients into prolonged outdoor exposure,\textsuperscript{30} because they could remain outdoors longer without getting a sunburn from UV-B but still get damage from prolonged UV-A exposure. This concept is disputed.\textsuperscript{31,32}

HAZARDS OF UVR ON HUMAN SKIN

The four major areas of concern with UV on human skin are acute changes of sunburn and discomfort, photocarcinogenesis, with chronic changes of premalignant and malignant skin growths; immunologic suppression; and photoaging. Exposure to the sun is a risk factor that can be modified if people are made aware of these dangers.\textsuperscript{33}

Excessive acute UVR damage on human skin results in erythema that may progress to vesicle and bulla formation ("acute sunburn"). This also may result in permanent pigmented alternations, including postinflammatory hyperpigmentation and hypopigmentation. Severe, acute childhood sunburns are associated with an increased incidence of malignant neoplasms of the skin in adulthood, especially of children with skin type I.\textsuperscript{34-42} Two such episodes before age 18 years can double the incidence of nonmelanoma skin cancers.\textsuperscript{43} More than two severe sunburns in childhood or adolescence may confer a 10-fold elevated risk of squamous cell carcinoma. The childhood sunburn may also be a marker of fair skin in addition to a risk factor. Childrens skin
may be more sensitive to UVR, causing initiation of cancer that manifests itself in adulthood as skin cancer. Persons immigrating to Australia when older than 10 years had fewer skin cancers than similarly aged adults born and raised there, implying that increased UVR exposure during early childhood increases the risk for skin malignant neoplasms as an adult. Regular use of SPF 15 sunscreen during the first 18 years of life could reduce lifetime incidence of nonmelanoma skin cancer by 78%.

Chronic UVR exposure for many years, especially in those most susceptible (those with fair skin, light hair [a person with red hair has the highest risk]), blue eyes, and freckling), results in formation of premalignant, red, scaly actinic or solar keratoses, Bowen's disease, and the two most common types of skin cancer—basal cell carcinoma and squamous cell carcinoma. There is an alarming increased incidence of nonmelanoma skin cancers now affecting 900,000 to 1.2 million Americans a year, causing billions of dollars worth of missed work and medical care, tremendous morbidity, and an estimated 2500 deaths. Although all causes of melanoma are yet unclear genetic factors and solar exposure play an important role in its formation, and more than 32,000 new cases of melanoma with 7000 deaths are predicted for 1995.

Sun exposure status is highly correlated with immune status. Recent advances in immunologic research show that UVR suppresses contact dermatitis, sensitization to chemicals recognized as "foreign," and causes immunologic rejection of implanted malignant neoplasms (photoimmunosuppression). Delayed-type hypersensitivity and Langerhans' cells' function is reduced in UV-exposed skin. It is unnecessary to have visible erythema to have these changes. As little daily exposure as 0.75 MED can cause this suppressive activity in humans. Fortunately, sunscreens are effective in preventing this immunosuppression.

Photoaging is an important topic and concern for most Americans, as the population continues to grow older in better general health. With the increase in life expectancy, our patients want to look as good as they feel. The search for the "Fountain of Youth" is stronger than ever. The multibillion-dollar cosmetics and toiletries industry attests to this quest, as do popular lay magazines with their articles about reducing wrinkles and looking younger.

UV-B VS UV-A

The predominant cause of sunburn is UV-B, 290 to 320 nm. It is also the major villain in the formation of skin cancers and photoaging. Pharmaceutical companies that offered sunscreens focused first on protection against UV-B. Research in the past decade has indicated that UV-A, 320 to 400 nm, also contributes to causing sunburn, skin cancer, and photoaging. Although UV-B is more damaging and penetrates deeper into the dermis, UV-A is present in as much as 1000 times the concentration, and it does not vary in intensity with time of day and altitude nearly as much as UV-B. In addition, UV-A enhances the acute and chronic effects of UV-B. A person getting 20 minutes of sunlight at noon may get only a mild sunburn, caused mostly by the UV-B exposure. If the same person is also outdoors at 4 to 5 PM, the UV-A will enhance the mild sunburn from earlier UV-B exposure to cause a more severe sunburn. In experiments with hairless mice, the addition of UV-A to UV-B augments and speeds the induction of skin cancer. Thus, UV-A has become recognized as a second villain whose destructive effects must be thwarted by effective clothing and a new breed of broad-spectrum sunscreens.

CURRENT AND FUTURE SUNSCREENS

The US population is becoming aware of the hazards of sun exposure and is reacting to it by changing lifestyles and environment. For the past several years, at least three of the top-selling 10 sunscreen products carried SPF of 45. The concept of broad-spectrum protection in sunscreen products has become a reality. Sunscreens are being incorporated for daily use into moisturizers and lip balms and even eye makeup. Some children are being covered in more protective clothing and not being allowed to get burned at the beach or swimming pool. Yet, despite our knowledge and warnings, public-service advertisements, peer leader modeling, and television shows are not being used by millions of people who should be using them. Why is there such poor compliance with sunscreen use?

Most current sunscreens use organic chemicals as their major active ingredients. Of the list of 21 given initial FDA approval, only about eight are currently actively used. These products include PABA esters, benzophenones, and cinnamates. Each family has a different absorption spectrum, and they are used in combination to give broader protection. Introduced in 1990, the patented ingredient Parsol 1789 (Givaudan-Roure Corporation, Vernier, Switzerland) absorbs the longer UV-A range and has been recently incorporated into products to provide extra protection against UV-A. Yet many patients refuse to wear sunscreens regularly. Some dislike the stinging of the eyes as the screen sweats off from exercise or swimming. Some fear loss of vitamin D. Others have an allergic, photoallergic, or phototoxic reaction to the ingredients. This may result in an ironic worsening of a rash by a product used to cure it. Some have a hard-to-detect sensitivity to the product or just do not like the feel or appearance of it on their skin.

Sunscreen products with higher SPF and more active ingredients do not cause an increased risk of skin irritation or contact sensitivity. The quality and quantity of the fragrances, preservatives, emulsifiers, film formers, thickening agents, solvents, and other ingredients they contain are more likely causes for the irritation.

No specific indicator exists for patients to determine which sunscreens provide adequate protection against UV-A and UV-B other than reading the label for UV-A and UV-B protection. As a general rule,
Sun Protection—Advice for Patients

Sun protection involves knowing what might happen if you have too much sun, and what you can do to prevent skin damage.

The Risks
Skin cancer (may cause death if left untreated)
Skin cancer removal (may cause scars)
Premature aging of the skin (wrinkling)
Red scaly precancerous spots
Brown "liver" spots
Blackheads
Broken blood vessels
Sunburn

What You Can Do
1. Avoid direct sun exposure especially between 10 AM and 2 PM.
2. Always use a sunscreen, preferably one that is waterproof (and reapplies hourly when the subject is in water) and that has a SPF (sun protection factor) of 30 or higher. The higher the SPF, the greater the protection it gives. Choose sunscreens that block both UV-A and UV-B. Facial make-ups should contain a sunscreen of at least SPF 15.

Remember: Most sun exposure happens while walking to and from our car and as other incidental exposure and not just on special occasions, eg, while at the beach, while on a picnic, or while attending a Bar-B-Q.
3. Wear sun-protective clothing made with tightly woven fabrics. Hat brims should be at least 3-in wide.
4. Avoid sun tanning parlors that only cause damage to the skin whether UV-A or UV-B bulbs are used. Any suntan means skin damage! Repeated damage results in wrinkles and skin cancer—NOT BEAUTY!
5. You may use self-tanning products, but the "tan" will not give any protection from the sun. The product may or may not contain sunscreen. Be sure to check the label.
6. Check your skin and your loved ones' skin regularly. Any growth that is irregular in shape, color, or size should report to your doctor.

Remember: By avoiding sun damage and catching any skin problems early, you are helping yourself!
For more information on all types of cancer you can call the National Cancer Institute at 1-800-4-CANCER.

the higher the SPF, the more the product will protect against UV-A and UV-B. Yet sunscreen testing is not an exact science. The FDA Tentative Final Monograph does not address UV-A protection, but may be amended in the future to provide more information on UV-A claims. Laboratory data suggests that sunscreens may reduce photocarcinogenesis. Documented studies show the clinical value of regular sunscreen use in reducing the incidence of actinic keratoses and, subsequently, skin cancers.

Increasing use and improved performance, along with public demand and more sophisticated technology, have increased interest and use of the inorganic sunscreens zinc oxide and titanium dioxide. When micronized, these ingredients act as UV absorbers and not as reflectors. These semitransparent, nonreflecting agents attenuate UVR effectively as absorbers, paralleling the action of the organic sunscreens. While they have a broad spectrum of coverage, their absorbance cuts off sharply at about 370 nm. When formulated into cosmetically acceptable water-resistant products with longer shelf life, these products will provide additional choices of protection for our patients. Sunscreen formulations have improved because they have better vehicles, increased combinations of compatible ingredients that overlap and enhance photoprotection, and more reproducible testing methods. New products also may help protect against infrared rays, which account for 40% of the solar radiation that reaches the skin and which can potentiate UV-B damage. Ultraviolet monitoring has become less expensive and more widespread. Promotion of the daily UV index on radio and television will heighten public awareness of the dangers of UVR.

ADVICE FOR OUR PATIENTS

Sunscreens

No ideal sunscreen completely protects us from UVR, but sunscreen use must play a key role in photoprotection. Unfortunately, many lay publications incorrectly promote the concept that sunscreens above an SPF of 15 offer little more protection than do SPF 15 sunscreens. This is incorrect. I urge my patients to use a sunscreen of SPF of 30 or higher. The benefits of these sunscreens include increased protection against UV-A and UV-B. An SPF of 15 blocks 93% of the UVR damage; an SPF of 30 blocks 97%. These higher SPF sunscreens also provide greater protection when less sunscreen is on the skin from sweating, wearing off, washing off, or using insufficient amount of sunscreen per surface area. In other words, an SPF 45 sunscreen applied too thinly may afford protection of only SPF 15, but an SPF 15 sunscreen applied too thinly could only give protection of an SPF 4.

Environmental Exposures

We must educate our patients to the hazards of environmental sun exposure, sunlamps and sunbeds, and especially the incidental exposure we all get in routine activities such as gardening and walking to and from the car and to the store. The more intense UVR of midday should be avoided by taking siestas or seeking shade or shelter. The role of shade, including trees and umbrellas, should not be overlooked, because it is a practical method of reducing exposure when outdoors. Since window glass blocks UV-B but not UV-A, tinting that blocks UV-A should be encouraged as long as it does not interfere with visibility when used in cars.
Clothing

The use of clothing, especially sun-protective clothing formulated to be comfortable but with a SPF of 30 and higher is important. The nature and density of the weave is more important than the type of textile. Holding the material up in front of a lightbulb or the sun to determine the amount of light transmission is a simple method to assess photoprotection potential for most garments. Dampness (after sweating or swimming) may reduce the sun-protective qualities of clothing. Hat brims should be wider than 7.5 cm. Protection of the eyes and sensitive skin around the eyes with goggles that block UV-B and UV-A should be encouraged for all outdoor activities.

Synthetic Sun Tan

Patients insisting on a suntanned appearance should be informed about sunless or self-tanning products containing dihydroxyacetone. Patients should be warned that a synthetic tan does not provide photoprotection, and that even if these products are incorporated with an effective sunscreen, the persistence of "tan" gives no photoprotection.

Complete Skin Examination

A complete, total-body skin examination should be given to all new patients and repeated during routine examinations. Diagrams are helpful to detect changes in size, shape, and color of skin growths. Photographs are a valuable addition to records. Diagnosis and treatment of even one photorelated skin lesion, such as a solar keratosis or skin cancer, encourages the patient to use photoprotective measures in the future.

Patients phenotypically sensitive to the sun (those who do not get tan, burn easily, and have fair skin or red hair) need to heed this advice the most. These persons are generally of English, Celtic, and Scandinavian origin. However, even the sun-resistant skin of persons of southern European extraction (Portuguese, Spanish, Italian, and Greek) is susceptible to malignant neoplasms of the skin with time as the capacity to repair UVR damage is overwhelmed. Recent research indicated that the pre malignant actinic keratoses, precursors of squamous cell carcinoma, may disappear or decrease in number if UVR exposure is reduced by continuous use of higher SPF sunscreens.

The sun has provided UVR to the surface of the earth for billions of years. Our own species may be increasing the dosage because of reduced ozone protection, but we still have the ability to control our activities and environment for our better health. As physicians, we must influence the attitudes, knowledge, and behavior of our patients in their endeavors to achieve better and prolonged good health.

Although early detection and treatment of malignant neoplasms of the skin are important, emphasis should be on the primary prevention of skin cancers, and all physicians can help achieve this goal. Patient handouts giving advice and instructions can be part of every new patient visit and can be reoffered yearly (see box).

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