

# Protection Against Exposure to Ultraviolet Radiation

## *PREFACE*

This INTERSUN report provides information to people on how to protect themselves from the potentially harmful effects of exposure to ultraviolet (UV) radiation. Following a detailed review of the scientific literature conducted by a WHO Task Group meeting convened under joint sponsorship with the United Nations Environment Programme and the International Commission on Non-Ionizing Radiation Protection, a number of adverse health effects resulting from exposure to UV have been identified that need to be addressed through further research and more particularly through educational programmes for people most exposed to UV.

The purpose of this report is to provide information to the general public and workers on the various health hazards known to be associated with excessive exposure to UV and measures that can be taken to reduce this exposure to acceptable levels.

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The comments received by various specialists in the field are very much appreciated.

## **INTRODUCTION**

Skin cancer and cataracts are important public health concerns. The social cost of these diseases, such as death, disfigurement and blindness, can be overwhelming both in terms of human suffering and the financial burden. Much of this could be avoided by reducing exposure to solar UV.

The sun is the principal source of UV exposure for most people. Exposure to the sun is known to be associated with various skin cancers, accelerated skin aging, cataract (opacity in the lens of the eye) and other eye diseases, and possibly has an adverse effect on a person's ability to resist infectious diseases.

The United Nations Environment Programme has estimated that over 2 million non-melanoma skin cancers and 200,000 malignant melanomas occur globally each year. In the event of a 10% decrease in stratospheric ozone, with current trends and behaviour, an additional 300,000 non-melanoma and 4,500 melanoma skin cancers could be expected world-wide.

Some 12 to 15 million people are blind from cataracts. WHO has estimated that up to 20% of cataracts or 3 million per year could be due to UV exposure. Given that, in the United States alone, it costs the US Government \$US 3.4 billion for 1.2 million cataract operations per year, substantial savings in cost to health care can be made by prevention or delay in the onset of cataracts.

## **WHAT IS UV?**

The sun's emissions include UV, visible light, heat and other radiations. These emissions are characterized by their wavelength, expressed in nanometers ( $1 \text{ nm} = 10^{-9} \text{ m}$ ).

As visible light can be divided into colours which we can see in a rainbow, UV is subdivided and commonly defined as UVA, UVB and UVC. All UVC (very short wavelength UV) is absorbed by the atmosphere and does not reach the earth's surface. UVB is biologically damaging UV, but most of this is absorbed by the atmosphere. Long wavelength UVA is the most intense UV reaching the earth and can penetrate furthest into tissue, but it is not as biologically damaging as UVB.

## **OZONE**

Ozone is a form of molecular oxygen existing predominantly in the upper atmosphere. It is continuously formed by oxygen absorbing the sun's short-wave UVC and then broken down by a number of chemicals, such as chlorine from chlorofluorocarbons (CFCs), and by absorption of UVC and UVB.

Since ozone is an effective absorber of UV, depletion of the stratospheric ozone layer results in people and the environment being exposed to higher intensities of UV, particularly UVB. Recent reports suggest that the protective ozone layer is being depleted at a rate sufficient to leave "holes" over the Antarctic, causing higher UV exposures to residents of New Zealand and the southern parts of Australia. Ozone holes have now been reported over parts of Europe and North America. The consequences for humans and the environment of continuing ozone depletion and the resulting increases in UV exposure have yet to be fully evaluated.

## **FACTORS AFFECTING UV EXPOSURE**

### ***Solar elevation (height of the sun in the sky)***

The intensity of solar UV, and especially UVB, depends on the height of the sun in the sky. This will vary depending on the season of the year, time of day and latitude in which you live. UV intensities are highest during the summer months in the 4-hour period around noon (or 13:00 if daylight saving is in effect).

UVB intensity varies more with the time of the day than does UVA. As a rule of thumb "when your shadow is shorter than your own height" you may receive half or more of the harmful UVB during the 4 hours around solar noon on a clear summer day. In summer at noontime, UVB is two to three times more intense in equatorial areas than in northern Europe. At about 60° latitude the total UVB exposure during the months of January and February can be less than one clear day's exposure around midsummer.

### ***Latitude and altitude***

The UV intensity at the earth's surface is related to the angle at which the UV rays pass through the atmosphere. In the tropics (close to 0° latitude, or near the equator) solar UV is more intense because it has less distance to travel through the atmosphere to the earth's surface.

UV intensities increase with altitude. This is because the amount of atmosphere available to absorb UV is reduced, and so more and shorter wavelength UV is able to reach higher altitude areas. In high altitudes, skiers can be exposed to higher intensities of UV, especially as snow is an excellent reflector.

### ***Atmospheric scattering***

Solar UV is composed of direct and scattered radiation. The sky looks blue because the blue rays from sunlight are highly scattered by the atmosphere. UV is scattered even more than blue light, and this can lead to an increase in a person's exposure.

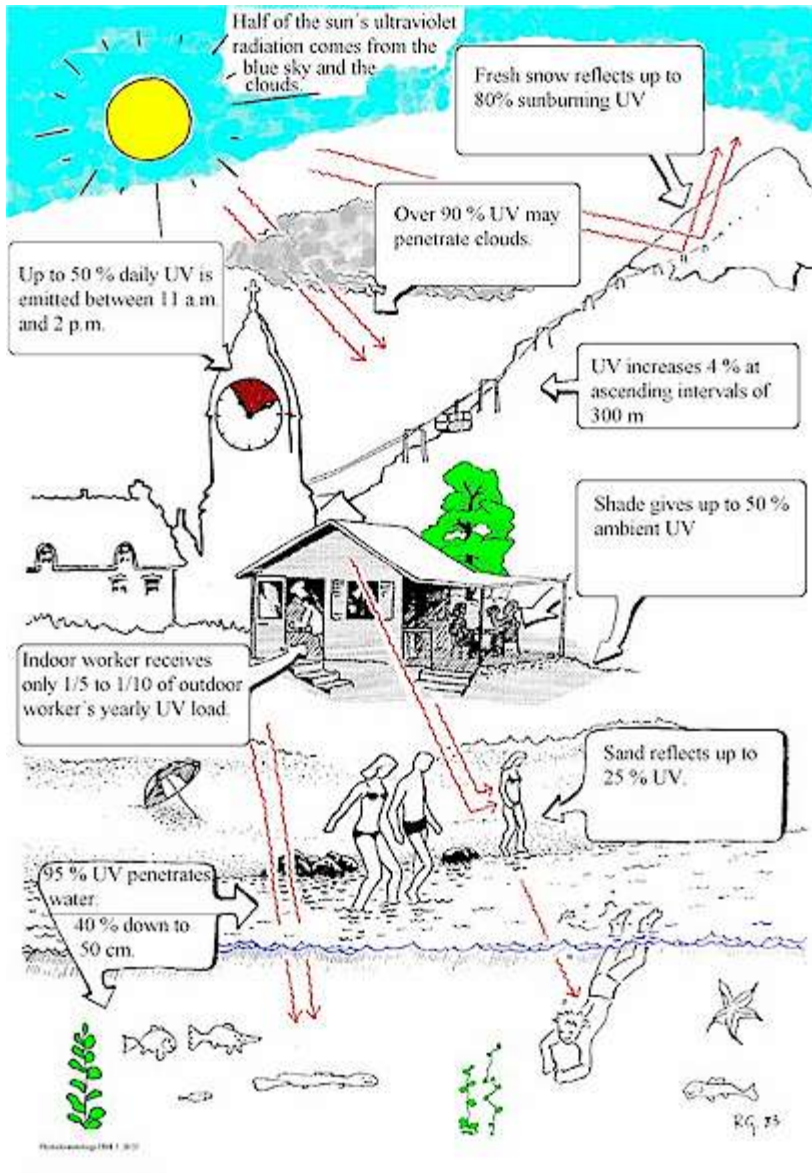
### ***Clouds and haze***

UV intensities are highest under cloudless skies. Clouds generally reduce UV intensity, but light or thin clouds have little effect and under certain conditions may even enhance the UV intensity. Hazy days generally have higher amounts of water vapour; UV scatter in the atmosphere increases and can result in a higher personal UV exposure. Thus, even though haze or cloud cover can cause one to feel cooler, the UV exposure can still be high.

### ***Ground reflection***

The reflective properties of the ground have an influence on UV exposure. Most natural surfaces such as grass, soil and water reflect less than 10% of incident UV. However, fresh snow strongly reflects (80%) UV. During spring in higher altitudes, under clear skies, reflection from snow could increase UV exposure levels to those encountered during summer. Sand also reflects (10-25%) and can significantly increase UV exposure at the beach.

Reflected UV is an important source of exposure to the eye. Acute effects, such as snow-blindness while skiing or photokeratitis at the beach, can result from UV reflected from snow or sand respectively.



Factors affecting UV exposure (Modified from Diffey BL and Larkö O, Clinical climatology. Photodermatology 1984, 1:30-37. With permission.)

## HUMAN EXPOSURE

### Outdoors

For the majority of people the sun is the most important source of exposure. In some cases solar UV exposure will be deliberate (suntanning); in others it will result from outdoor recreational and/or occupational activities. Environmental UV levels constantly change during the day. Personal exposure to UV depends on:

- **Exposure geometry.** Body sites will receive different amounts of UV depending on their orientation with respect to the sun and on reflection from ground surfaces.
- **Exposure duration.** The total daily exposure to UV depends on the intensity of the UV and on the exposure time. For example, the same daily exposure results from either a short time at high level or a long time at low level. Exposure to UV accumulates over the day. However, exposure around noon is equivalent to longer exposure at other times of the day.

- **Personal protection.** Exposure can be reduced considerably by the use of personal protection. Clothing, including hats, can effectively shield otherwise exposed body sites. Where the use of clothing for protection is not practical, the proper use of sunscreen will reduce skin exposure. The use of well designed sunglasses will reduce exposure to the eyes.
- **Behaviour.** Exposure to the sun should be avoided when UV levels are most intense. This occurs in the middle of the day during spring and summer. If you need to be outdoors, cover up with clothing, sunglasses and sunscreen as necessary.

### **Artificial sources**

Exposure may occur from artificial sources of UV used, for example, in industry, for medical treatment or for cosmetic purposes (sunbeds). Important artificial sources of human exposure include:

- **Sunbeds.** These are intended to produce a tan by emitting UVA and some UVB. Regular use of a sunbed may contribute significantly to a person's annual UV skin exposure. The use of eye protection such as goggles or sunglasses should be mandatory. Staff working in tanning salons may also be exposed.
- **Medical exposure.** UV sources are used for a variety of diagnostic and therapeutic medical purposes. Exposures vary considerably according to the type of treatment.
- **Industrial/commercial exposures.** The most significant source of potential exposure is arc welding. The levels of UV around arc welding equipment are very high and the potential for acute injury to the eye and the skin is great. Eye and skin protection is mandatory for this work. Many industrial and commercial processes involve the use of UV-emitting lamps. While the likelihood of harmful exposure is low because of shielding provided with the lamp, in some cases accidental exposure can occur.
- **Lighting.** Fluorescent lamps are common in the workplace and are often used in the home. These lamps emit small amounts of UV and typically contribute only a few percent to a person's annual UV exposure. Tungsten halogen lamps are increasingly used in the home and in the workplace for a variety of lighting and display purposes. Unshielded lamps can emit UV levels sufficient to cause acute injury at short distances. Filters over the lamps can significantly reduce these levels. Blacklights, which emit predominantly UVA, are often used for special effects, for example, in discothèques and also for the authentication of banknotes and documents. These lamps do not cause any significant UV exposure to humans.

## **THE SKIN**

The skin is a large organ with an area of more than 1.5 m<sup>2</sup> in adults. It provides the first stage of protection against chemicals, radiation, and infection and it also prevents the evaporation of fluids from the body. The skin is composed of three very different parts: the epidermis (which includes the outer layer of dead cells called the stratum corneum), the dermis and subcutaneous tissue. The epidermis is the outermost layer of the skin and is continuously renewed.

The epidermis is separated from the dermis by a membrane made of permanently dividing cells (keratinocytes and melanocytes). Melanocytes, synthesize the pigment melanin and transfers this to the neighbouring keratinocytes. A third type of cell, called Langerhans cells, are present immediately under the stratum corneum. Langerhans cells are able to recognize foreign or abnormal substances and play a major role in immunological recognition. Their activity is very sensitive to UV. The dermis, which contains collagen fibres, gives the skin its elasticity and supportive strength. The collagen fibres break down on exposure to high levels of UV, reducing the elasticity of the skin and giving the appearance of premature aging.

### **The skin**

When human skin is exposed to UV it is absorbed, reflected, and scattered. Thus, the actual exposure received by the various layers of the skin will be lower than the incident exposure.

For simplicity, skin sensitivity to UV can be divided into three general groups:

(1) **Lightly pigmented:** UV exposure causes sunburn but little tanning (e.g. Celtic populations). Characteristics of this group include fair or red hair, blue eyes and freckles. People in this group must take extra care in the sun as their skin is poorly protected and easily damaged.

(2) **Intermediately pigmented:** UV exposure results in little sunburn but tanning always occurs (e.g. southern Mediterranean and Asian populations). Characteristics of this group include darker hair and eyes. Although able to tan, people in this group can still burn and sustain significant skin damage from UV.

(3) **Heavily pigmented:** UV exposure rarely causes sunburn (e.g. Aboriginal, African and American Negroid populations). These populations have very good natural protection and are at little risk of skin cancer, but are, like all groups, subject to UV-induced eye damage and possibly reduced ability to combat infections when exposed to excessive UV levels.

### **HEALTH EFFECTS ON THE SKIN**

The skin protects against UV exposure by increasing the amount of pigment (to produce skin darkening) and by increasing cell proliferation to produce thickening of the outer layer (stratum corneum). Health risks associated with exposure to UV include both acute and chronic effects and will vary according to the nature of the exposure. Factors important in assessing such risks include: the levels of UV impinging on the person exposed; the duration and frequency of occurrence of exposures; and the individual sensitivity of the person to UV as determined by their skin characteristics (see skin groups 1-3 above), genetic and other factors.

#### **Short-term effects**

##### ***Sunburn***

In its mildest form, sunburn consists of a reddening of the skin (erythema) that appears a few hours after UV exposure and reaches a maximum intensity between 8 and 24 hours, then fades over a few days.

##### ***Tanning***

When skin is exposed to UV, two distinct types of tanning reactions ensue. Firstly, immediate pigment darkening occurs, where melanin already in the skin darkens on exposure to UV and begins to fade within a few hours after cessation of exposure. Delayed tanning then occurs over about 3 days and can persist for several weeks.

Exposure to UVB also results in an increase in the thickness of the epidermis. Because UVA does not produce thickening of the epidermis, the tan obtained from UV sunbeds, while perhaps cosmetically acceptable in the short term, is less effective in protecting against further exposure to solar UV.

##### ***Photosensitivity***

A small percentage of people have a skin condition that makes them particularly sensitive to the sun's UV rays; this is called photosensitivity. Photosensitivity disease (porphyria) and photo-aggravated disease (e.g. lupus erythematosus) are triggered by minimal UV exposures. In addition, some medications, foods and cosmetics contain ingredients that may cause photosensitivity. This combination of chemicals or drugs with UV causes an adverse effect in the skin such as a rash or exaggerated sunburn.

#### **Long-term effects**

##### ***Effects other than cancer***

The most common long term effects of UV exposure on the skin are:

- Dryness. As the outer layers thicken to protect it from the sun, the skin loses moisture.
- Blemishes. Blotchy discolouration from breakage of small blood vessels can be an early sign of sun damage.
- Aging. UV damages the elastin and collagen fibres in the lower layers of the skin causing loss of the skin's natural elasticity (wrinkles), mainly from UVA exposure. Excessive wrinkling from sun exposure gives the appearance of skin aging.

**Freckles and solar brown spots (lentigines)** are flat pigmented areas (usually no larger than 0.5 cm) normally occurring on the sun-exposed skin of lightly pigmented people (e.g. Caucasians). Their prevalence is higher in those with highly sun-sensitive (group 1) skin. Freckles occur most commonly in children, while the frequency of solar lentigines increases with age and is greatest in those over 60 years of age (estimated at 75% in the USA).

**Melanocytic naevi (moles)** are benign growths of pigmented skin cells, usually beginning in the lower layer of the epidermis and later extending into the dermis. They are common in lightly pigmented or white populations

and rare in black and Asian populations. In white populations they occur mainly on body sites that are maximally or intermittently exposed to the sun and are associated with an increased risk of melanoma.

**Solar keratosis** is a pre-cancerous growth of skin cells. Keratoses are very common on exposed body sites in lightly pigmented, older people living in areas of high levels of sunlight. Their number on the skin is strongly associated with the risk of non-melanocytic skin cancer.

### ***Skin cancer***

Skin cancer is the most common human cancer. About 95% of these are basal and squamous cell carcinomas (commonly referred to as "non-melanoma skin cancers"), the remaining 5% are malignant melanoma. The scientific evidence that sunlight is an important factor in the cause of skin cancers is convincing. While it is not unusual to have some moles or freckles, it is important to watch for any moles that change colour, become bigger, itchy or inflamed, or that weep or bleed. These may be symptoms of melanoma or other skin cancers.

### ***Non-melanoma skin cancer (NMSC)***

NMSCs are not usually fatal but can be very disfiguring if left untreated. A number of facts have emerged from investigations of NMSCs:

- The most common NMSCs are squamous and basal cell carcinomas. About 75% of basal cell carcinomas and more than one-half of all squamous cell carcinomas occur on the head and neck, which are the sites of highest sun exposure. They also occur on the forearms and hands, or on any part of the body commonly exposed to the sun.
- Lightly pigmented people (group 1 skin) are much more likely to develop NMSC than those with higher pigmentation.
- An increased risk of non-melanoma skin cancer has been observed in relation to both freckling and the prevalence of solar lentigines (brown spots) in childhood.
- Hereditary factors associated with a tendency to develop skin cancer are light-coloured eyes, fair complexion, light hair colour, tendency to sunburn and poor ability to tan.
- Surveys of the incidence of skin cancer conducted in various countries yield ample evidence that the risk increases for people living closer to the equator. As a rough guide, the incidence doubles for every 10° decrease in latitude (about every 1000 km from the equator) provided that the population has the same hereditary factors.
- Studies have shown that people over 50 years of age who have worked outdoors for most of their lives are more likely to develop skin cancer than those working indoors.

### ***Melanoma***

Malignant melanoma is the least common but most dangerous type of skin cancer, with about 25% of diagnosed melanomas resulting in death. The number of cases of melanoma is rising at an alarming rate worldwide and at a much higher rate than other skin cancers. Studies have shown:

- While NMSCs occur predominantly on body sites of highest sun exposure (head, neck and hands), melanoma incidence on these sites is similar to that on partially sun-exposed sites, such as the lower legs (women) and the back (men). Thus UV exposure is thought to be only one of the factors that increase a person's risk of developing melanoma.
- Melanoma is much more common in lightly pigmented people than in heavily pigmented people despite the fact that the latter tend to live in sunnier climates. However, hereditary factors such as the number of naevi or moles are more associated with melanoma than pigmentation. An increased risk of melanoma has been observed in relation to freckling in childhood.
- A tendency to sunburn is a risk factor in developing melanoma, as is a history of infrequent, intense exposure resulting in a painful, blistering sunburn, particularly during childhood.
- In general, there is an inverse relationship between melanoma incidence and latitude of residence, although there are some inconsistencies. For example, in Europe the incidence is higher in Scandinavia than in Mediterranean countries. This apparent paradox may be explained by the obvious differences in skin sensitivity and by strong exposures to the sun during vacations in sunnier places.
- People who are born in Europe and migrate to sunnier countries after childhood have a risk of developing melanoma of about one-quarter that of people of European descent born in those countries. However, arrival during childhood results in a comparable risk.

### ***THE EYE***

Light passes through the cornea, pupil and lens onto the retina. It is then converted to nerve impulses which are transmitted to the brain where the sensation of sight takes place. The protective mechanisms of the eye, constriction of the pupil and closure of the eyelids, are activated by bright visible light, not by UV. There are no beneficial ocular effects of exposure to UV.

## The eye

### HEALTH EFFECTS ON THE EYE

#### Effects on the cornea

**Photokeratitis** is the primary acute effect of exposure to intense UV from the sun or welding arcs. This leads to damage to the outer layers of the cornea, causing severe pain and reduced vision, resulting from a corneal haze which develops from the injury and forcing closure of the eyelids. Photokeratitis results from sunlight exposure only in highly reflective environments, such as snow, hence the term "snow-blindness". Photokeratitis is caused by artificial light sources only when there is a substantial UV component, such as from arc welding (where it is frequently referred to as "welders' flash" or "arc eye"). Like sunburn, photokeratitis appears a few hours after exposure and is reversible. Symptoms generally disappear within a day or two.

**Pterygium** is a vascular growth on the surface of the eye and is a common cosmetic blemish with a tendency to become inflamed. When pterygium extends over the centre of the cornea it reduces vision. It is amenable to surgery but tends to recur. Pterygium is likely to be caused, at least in part, by prolonged exposure to UV.

**Climatic droplet keratopathy** is a blinding degeneration of the cornea that occurs in areas of the world characterized by a harsh climate. In these regions climatic droplet keratopathy is a major cause of blindness which is intimately associated with exposure of the eye to UV.

#### Diseases of the retina

Among adults, only small amounts (1% or less) of UV reach the retina because of absorption by the cornea and lens. However, because UV is known to damage tissue, the importance of this small amount as a cause of retinal damage cannot be ignored. It has been suggested that age-related macular degeneration (a loss of central reading vision) is associated with light exposure. This disease is a common cause of untreatable blindness in the developed world.

#### Cancer of the eye

**Malignant melanoma** is the most common malignant cancer of the eyeball and occasionally necessitates its surgical removal. A common location for **basal cell carcinoma** is on the eyelids. There is evidence indicating that these cancers are associated with lifelong exposure to the sun.

#### Effects on the lens

**Cataract** is the leading cause of blindness in the world. It is a loss of transparency of the lens of the eye. Cataract appears to different degrees in most individuals as they age. It is amenable to surgical removal, and with insertion of an intraocular lens or other means of optical correction, vision can be restored. It is widely accepted that lifelong exposure to UV is associated with the formation of certain types of cataract.

### IMMUNE EFFECTS

There is evidence that suggests UV exposure of the skin at environmental levels suppresses some immune responses in humans. Therefore, there is concern that exposure to UV may enhance the risk of infection, decrease the effectiveness of vaccines, and reduce the body's defences against skin cancer. These responses seem to occur in all people regardless of skin colour. One consequence of UV exposure that is widely recognized is recurrent eruptions of herpes simplex virus, particularly on the lip (called "cold sores"). More research is needed to establish these effects.

### PROTECTIVE MEASURES

#### Eye exposure and injury



UV exposure of the eye is determined in part by the anatomy of the skull and by visual responses to bright light. The eye is set into the skull, so when the sun is overhead and UV exposure is most intense, the brow and upper eyelids provide a shield for the cornea. Moreover, people seldom look directly at the sun when it is overhead and very hazardous to view. When the sun is bright and more than 10° above the horizon, people have a tendency to partially close the eyelids or squint, therefore shielding the eyes from direct exposure. People seldom experience a corneal burn when in sunlight except when UV ground reflection exceeds approximately 10%. For example, when a person looks at fresh snow, up to 80% of the UV is reflected towards the eyes. When the sun is overhead, water reflects upward about 2% and sand reflects about 25% of the incident UV.

On an overcast day, UVB is reduced by cloud cover, but the actual UVB dose rate to the eye from atmospheric scattering may be reduced by a factor of only two. The bright, visible light is a cue for people to wear sunglasses and hats, and to squint when exposed to the sun. On lightly cloudy days, the sunlight intensity is lower; the eyes open wider and may receive a greater UVB dose than on a bright sunny day. On heavily clouded days this would not be so.

UV attenuating sunglasses with side shields as well as brimmed hats considerably decrease ocular exposure and should be worn for optimal protection against UV exposure of the eye. Injury to the eye, whether it is acute, such as photokeratitis, or long-term and chronic, seems to occur regardless of skin type or eye colour. Thus people with intermediate or highly pigmented skin should be aware that they are susceptible to UV-induced eye damage, unlike their lower risk of UV-induced skin damage.

### **Education**

In some countries concern about high incidences of skin cancer and eye damage have led to national educational campaigns to encourage people to protect themselves against excessive UV exposure from the sun and in the workplace. Educational programmes directed at both the workforce and the public are intended to create an awareness of the adverse health effects that can result from exposure to UV and to encourage changes in behaviour to reduce this exposure.

Currently, in several different countries around the world, daily environmental UV levels are supplied to the general public in the form of UV indices. Their provision is intended to educate the public on changes in UV levels, to increase awareness of the hazards of UV and to provide information necessary to plan protection. The UV index used in some countries describes the likely UV level at noon on the following day. This index may be widely publicized by radio and television stations.

### **Personal protection**

Everyone should enjoy outdoor activities in the early morning and late afternoon on summer days, but there is good reason to adopt protective measures if a person is exposed to the sun within the 4-hour period around the middle of the day. Shade is a useful method of protection for the skin, but protects the eye only when a person faces the shaded areas. Protection is always necessary for both the skin and eyes when there is sun over snow.

Parents are particularly encouraged to keep UV exposure of their children to minimum levels in order to reduce the risk of UV-induced problems in later life. If the child has freckles, then sun exposure should be kept to the minimum.

The first thing to ask about sun protection is: "Is it necessary?". The table below shows those months of the year when it is sensible for people to take precautions in the sun.

**Months of the year when sun protection is necessary depends on the latitude in which you live.**

Latitude	Months of year when sun protection may be necessary
60°N to 70°N	May to August
50°N to 60°N	April to September
40°N to 50°N	March to October
30°N to 40°N	February to November
30°N to 30°S	All year
30°S to 40°S	August to May
40°S to 50°S	September to April
50°S to 60°S	October to March

The following guidelines will help people who want to protect themselves from overexposure to the sun:

### ***Sun avoidance***

- As a general rule, whenever someone's shadow is shorter than their height, care should be taken: the shorter the shadow the more likely it is that sunburn will occur.
- Solar UV is most damaging in the 3-4 hours around noon when approximately 50% of daily UV is received in summer. In parts of continental Europe, solar noon occurs at 14:00 (daylight saving time) so avoidance of bright sunshine from 12:00 to 16:00 is desirable. If this is not possible, try to seek shade or cover up with clothing, a hat and sunglasses.
- Sunburn can occur on cloudy days as well as clear days, although heavy, overcast skies do offer some protection. It is the UV and not the heat rays of the sun that are harmful, thus you can still burn on a cool, windy day in summer,
- Care should be exercised in and around water and open spaces because of the extensive contribution of UV exposure from the sky (direct and atmospherically scattered UV). Many people are sunburnt when they are swimming, boating or playing on a beach.
- Because of the high level of reflection of UV, eye and skin protection is always needed when in snow.

### ***Clothing and hats***

The best form of protection is to wear loose-fitting, closely woven fabrics that cast a dense shadow when held up to the light. Most types of textiles, both natural and synthetic, provide good protection against UV. It is not difficult to find fabrics that afford sun protection factors (SPF) of 20 or more. It is the density of the weave, not the type of fibre or colour, that primarily determines whether or not the material is a good sunscreen.

Recently the concept of protection factor (PF) for fabrics has been proposed. The PF scheme is analogous to the SPF scheme for sunscreens and a fabric of PF 10 would, in principle, provide a similar level of protection as a sunscreen to SPF 10. This scheme is designed to give the general public information on the amount of UV protection available from fabrics and clothing.

Whether a material is wet or dry is also important in relation to the amount of UV it absorbs. Measurements show that there is less absorption of UV when a fabric is wet.

The sun protection provided by various styles of hat at different positions on the head has been measured using model head-forms and UV-sensitive film badges. The results show that a hat with a brim at least 7 cm wide not only protects the top of the head but also provides shade for the face and neck - sites on which skin cancers commonly occur. A neckerchief (small piece of material about the size of a large handkerchief) on the back of the neck will provide added protection against UV exposure.

### **Sunscreens**

#### ***Sun protection factor (SPF)***

Topical sunscreens act by absorbing, scattering or reflecting UV. The *sun protection factor* (SPF) gives an indication of the effectiveness of the sunscreens. For example, a sunscreen with SPF 4 means that the UV exposure received after spending a given time in the sun is one-quarter that received in the absence of any protection.

#### ***Applying sunscreens***

For those people who want good UV protection, a high factor (SPF of 15 or over), broad-spectrum (blocks UVB and UVA) sunscreen should be used over those parts of the body that are not covered by clothing. An even thickness should be applied liberally to clean, dry skin and allowed to dry for 15 minutes or so before going outside. Sunscreens applied too thinly or too infrequently will not provide adequate protection. A second application 30 minutes later will reduce the risk of severe sunburn on skin areas missed in the first application and will increase the total thickness of the applied sunscreen. Users should follow the directions on the package to ensure best results. Use of a lip balm or cream containing a sunscreen protects some people from recurrent lip eruptions of herpes simplex virus (cold sores) when they go out into the sun for extended periods.

#### ***Are you getting the SPF you expect?***

When sunscreens are tested in the laboratory by manufacturers, an internationally agreed application thickness is used. In practice, studies have shown that people apply much less than this (possibly because of the high cost of each bottle) and so the protection achieved is perhaps only one-half of that indicated by the SPF. Approximately

35 ml of sunscreen must be applied to the total body surface of an adult to achieve the SPF quoted on the pack. It is better to apply too much sunscreen than too little.

### ***Reapply sunscreens frequently when in the sun***

Sunscreens are reasonably waterproof, but not wipe-proof. They should be reapplied every 2 hours or so. Apply sunscreen partly under swimsuits since the material changes position on the skin when you move. A thin strip of sunburn on the upper thighs or other delicate parts can be very uncomfortable.

### ***Are sunscreens effective?***

Correctly used, sunscreens are effective in preventing sunburn. Actual SPF values depend critically on the thickness of the application and on other factors such as absorption into the skin, sweating and contact with water (for example while swimming).

### ***UVB, UVA and broad-spectrum***

Sunscreens traditionally contain ingredients that absorb mainly UVB radiation. This has meant that people can spend long periods in the sun without getting sunburnt but, in doing so, receive high doses of UVA. Current concern about possible long-term effects of UVA, such as photo-aging, has prompted many manufacturers to incorporate chemicals that absorb UVA as well as UVB. Although the majority of sun-care products now on sale offer some protection from UVA, there is currently no industry standard for a declaration of this on the container.

### ***Protective eyewear***

The most effective way to protect the eyes from UV is to completely shield them with safety goggles, spectacles or face-shields that absorb UV. In indoor occupational situations where UV sources are used, goggles and face-shields are well accepted as necessary protection. Similarly, sunglasses should be worn on a sunny day. For sunglasses to be fully protective against UV, the lenses must absorb all UV and side protection should be provided. Clear optical spectacles also afford substantial UV protection, particularly if additional UV absorption is added to the lenses. Adequately designed goggles afford protection against exposure to reflected solar UV from snow.

Transmission of UV through sunglasses varies considerably, yet consumers are provided with little information about the protection afforded by them. Some countries have drafted standards limiting UV transmission through sunglasses, and standardized indices for sunglass protection (similar to that developed for sunscreens) have been proposed. It should be noted that the effectiveness with which sunglasses absorb UV does not depend on the cost or degree of darkness of the lens.

## ***TANNING DEVICES***

Among lightly pigmented people, a suntanned skin is still socially desirable. The use of sunbeds for less than 10 sessions per year is associated with an almost negligible risk of skin cancer. More frequent use can contribute to the overall risk associated with sun exposure. Sunbeds cannot be considered as a safe way to tan - there is no such thing as a safe tan. For further information see "Health issues of ultraviolet A sunbeds used for cosmetic purposes", cited in the Further Reading section.

## ***OCCUPATIONAL PROTECTION***

Occupational exposure to UV should be kept to a minimum. For artificial sources, wherever possible, priority should be given to engineering measures such as shielding and enclosures, and administrative controls, such as limitation of access, to reduce the requirement for personal protection.

The risk from solar UV exposure to outdoor workers such as agricultural workers, labourers, construction workers and fishermen can be minimized by wearing appropriate tightly woven clothing and, most importantly, a brimmed hat to reduce face and neck exposure. Sunscreens can be applied to exposed skin to reduce UV exposure further. Outdoor workers should have access to shade and be provided with all the necessary protective measures mentioned above.

In industry there are many sources capable of causing acute eye injury within a short exposure time. Various types of eye protection are available with various degrees of protection appropriate to their intended use. Those intended for industrial use include welding helmets (additionally providing protection from intense visible and infrared radiation, and face protection), face-shields, goggles and UV-absorbing spectacles. In general, protective

eyewear provided for industrial use should fit snugly on the face, ensuring that there are no gaps through which UV can directly reach the eye, and should be designed and constructed to prevent physical injury.

The appropriateness and selection of protective eyewear are dependent on the:

- intensity and spectral emission characteristics of the UV source,
- behavioural pattern of people near UV sources (distance from the source and time near the source are important factors for reducing UV exposure),
- the attenuation of UV provided by the eyewear, and
- design of the eyewear frame to prevent exposure to direct UV.

In industrial exposure situations the degree of hazard to the eye can be assessed by measurement and comparison with the recommended UV exposure limits. Because these are quite complex people interested in more information on limits are referred to: "IRPA guidelines on exposure limits to ultraviolet radiation". (see Further Reading section.

### ***Medical uses of UV radiation***

Physicians who prescribe UV treatment for their patients must determine whether the benefits outweigh any risk.

### ***ROLE FOR GOVERNMENTS AND OTHER AGENCIES***

National authorities are encouraged to publish the details of their programmes, identify their successes and failures and share the information they gather with WHO and authorities from other countries. International conferences on the evaluation of UV protective measures are also encouraged.

#### ***Governments should:***

##### ***Education***

- Establish education programmes, elements of which might include supplying people such as health care professionals, teachers, and carers of children with UV protection material for distribution to the public. Workshops and congresses for medical and other health care professionals should also be organized.
- Establish education programmes for teachers (primary and secondary).
- Establish education programmes for outdoor workers that include the rationale for protective measures and the procedures needed to reduce exposures, and that emphasize the concept that non-occupational exposure adds to the total burden of UV exposure.
- Encourage the provision of shaded areas in playgrounds (particularly schools), parks, and around public areas, including pools.
- Encourage the use of an internationally acceptable UV index as part of their public awareness and educational programme.
- Recommend against the use of sunlamps and sunbeds for cosmetic purposes.

##### ***Evaluation***

- Establish national statistics on UV-induced skin and eye injuries.
- Support and encourage research on health effects of UV and protective measures.

##### ***Standards***

- Support national programmes and international collaboration efforts for UV monitoring and health planning.
- Encourage and facilitate the development of appropriate standards or information (labelling) programmes that identify drugs and cosmetics, that sensitize people to UV effects, and that give information on the degree of UV protection provided by sunscreens, eyewear, clothing and other protective measures.

***It is further recommended that local authorities and health agencies:***

- Implement local UV health education programmes by distributing brochures and other informative material in locations such as schools, public buildings, banks, shopping centres and health care centres, and holding UV health education "fairs" where health professionals participate in presentations and limited screening programmes.
- Encourage creative activities on UV health education, such as fashion shows using designs and fabrics that protect against UV exposure. Science projects and competitions should also be encouraged.

### **IN THE WORKPLACE**

#### **Employers should:**

- Encourage their workers to be aware of the hazards of excessive exposure to UV and provide adequate equipment for the protection of their employees.
- Provide educational material and workshops on UV hazards and protection.

#### **Employees should:**

- Take seriously the need to be aware of the health effects of excessive exposure to UV and to use the protective measures and devices provided for their work.
- Be aware of the consequences of not availing themselves of the protective measure provided by employers.

### **THE MEDIA**

All mass media (television, radio and print) are primarily interested in conveying a good story that will either raise the ratings of programmes or sell more publications. To ensure continuing interest in the campaign it is necessary to provide progressively information on health risks and prevention programmes in a form and content that will be easily understood. This can be most easily facilitated by encouraging the media to report the UV index with their daily news and weather information, so that people begin to accept it as information they need in addition to the news and weather.

The UV index must be presented in a positive way. For example, the UV index can:

- **save** lives by increasing awareness of skin cancer and how to protect against it
- **protect** good health
- **help** prevent premature aging (appeal to a person's self-esteem).

It is necessary to encourage the media to listen to your message by:

- Holding a press conference at the launch of a campaign, on an appropriate day (e.g. just before the summer) with knowledgeable professionals available for interviews.
- Announcing the content of a press conference that highlights the main points in an attractive manner, followed by carefully thought-out press releases that provide clear messages in simple language.
- Having a human interest story that emphasizes the message. However, ensure that the message you want to communicate is emphasized and not made secondary within the programme or article.
- Having short seminars for journalists to educate them about the problems of excessive UV exposure and the other related messages you want to communicate.

Television, radio and print media, if properly encouraged, can support local and national UV programmes by highlighting health concerns and providing a medium for educating the public on the hazards of UV and the protective measures that can be taken. They can also encourage research by making the results of new health effects or protective devices known to the public

### **FURTHER READING**

International Radiation Protection Association. Guidelines on exposure limits to ultraviolet radiation. Health Physics 56(6): 971-972, 1989.

International Radiation Protection Association. Health issues of ultraviolet A sunbeds used for cosmetic purposes. *Health Physics* 61(2): 285-288, 1991.

Duchêne, AS, Lakey, JRA, Repacholi, MH, eds. IRPA Guidelines on protection against non-ionizing radiation. The collected guidelines of the International Radiation Protection Association/International Non-Ionizing Radiation Committee. New York : Pergamon Press, 1991 (now sold by McGraw-Hill Publishing Company).

*Ultraviolet Radiation*, Environmental Health Criteria 160, World Health Organization, United Nations Environment Programme, International Commission on Non-Ionizing Radiation Protection, WHO, Geneva, 1994.

#### ***FURTHER INFORMATION***

Further information on the health effects of exposure to UV and the protective measures to be taken to minimize adverse health consequences can be obtained from your national or local health authority, or by writing to the Office of Global and Integrated Environmental Health, World Health Organization, Geneva, Switzerland.