WHO/SDE/OEH/02.2

GLOBAL SOLAR UV INDEX

A Practical Guide

A joint recommendation of:

World Health Organization

World Meteorological Organization

United Nations Environment Programme

UNEP

International Commission on Non-Ionizing Radiation Protection

WHO Library Cataloguing-in-Publication Data

Global Solar UV Index: A Practical Guide.

A joint recommendation of the World Health Organization, World Meteorological Organization, United Nations Environment Programme, and the International Commission on Non-Ionizing Radiation Protection

1. Ultraviolet rays – adverse effects 2. Sunlight – adverse effects 3. Radiation monitoring – instrumentation 4. Radiation monitoring – standards 5. Reference values 6. Health education 7. Environmental exposure – prevention and control 8. Manuals

ISBN 92 4 159007 6 (NLM classification: QT 162.U4)

Graphic icons designed by Pauls Sloss
Printed in Switzerland
Available at http://www.who.int/uv/

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Preface

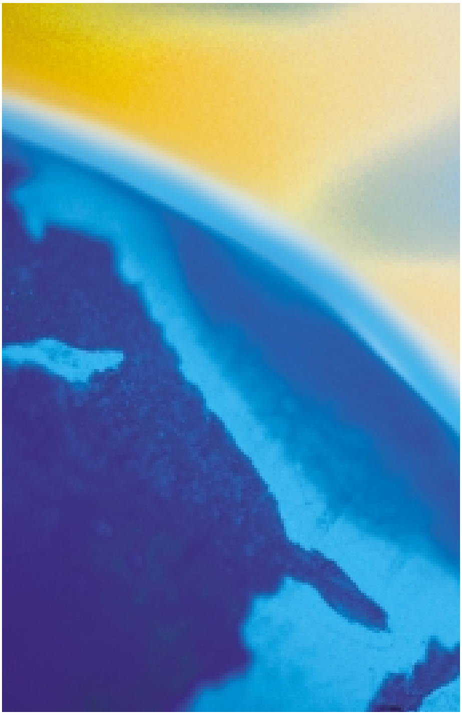
A marked increase in the incidence of skin cancers has been observed in fair-skinned populations worldwide since the early 1970s. This is strongly associated with personal habits in relation to sun exposure and its ultraviolet (UV) component, and the societal view that a tan is desirable and healthy. Educational programmes are urgently needed to raise awareness of the damaging effects of UV radiation, and to encourage changes in lifestyle that will arrest the trend towards more and more skin cancers.

The Global Solar UV Index (UVI) described in this document is a simple measure of the UV radiation level at the Earth's surface and an indicator of the potential for skin damage. It serves as an important vehicle to raise public awareness and to alert people about the need to adopt protective measures when exposed to UV radiation. The UVI was developed through an international effort by the World Health Organization (WHO) in collaboration with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) (see Annex F for list of contributors). Since its initial publication in 1995, several international meetings of experts (Les Diablerets, 1994[1]; Baltimore, 1996[2]; Les Diablerets, 1997[3]; Munich, 2000[4]) have been convened with the aim to harmonize the reporting of the UVI and to improve its use as an educational tool to promote sun protection.

This practical guide, prepared by Eva Rehfuess, is based on the consensus reached at the Munich meeting, and is intended to be used by national and local authorities and non-governmental organizations active in the area of skin cancer prevention, as well as meteorological offices and media outlets involved with UVI reporting. This publication can serve as an entry point for the development and implementation of an integrated public health approach to sun protection and skin cancer prevention.

1 *Report of the WMO meeting of experts on UVB measurements, data quality and standardization of UV indices, Les Diablerets, Switzerland, 22–25 July 1994.* Geneva, World Meteorological Organization, 1995 (Global Atmosphere Watch, No. 95).
2 *Educating the public about the hazards of ultraviolet radiation. Summary report. International workshop, Baltimore, 26–28 August 1996.* Aberdeen Proving Ground MD, U.S. Army Center for Health Promotion and Preventive Medicine, 2001.
3 *Report of the WMO–WHO meeting of experts on standardization of UV indices and their dissemination to the public, Les Diablerets, Switzerland, 21–24 July 1997.* Geneva, World Meteorological Organization, 1997 (Global Atmosphere Watch, No. 127).
4 *UV index in practical use. Proceedings of an international workshop.* Munich, Federal Office for Radiation Protection, Institute of Radiation Hygiene, in press.

Introduction



Everyone is exposed to UV radiation from the sun and many artificial sources used in industry, commerce and recreation. Emissions from the sun include light, heat and UV radiation.

The UV region covers the wavelength range 100–400 nm and is divided into three bands:

UVA (315–400 nm)

UVB (280–315 nm)

UVC (100–280 nm)

As sunlight passes through the atmosphere, all UVC and approximately 90% of UVB radiation are absorbed by ozone, water vapour, oxygen and carbon dioxide. UVA radiation is less affected by the atmosphere.

Therefore, the UV radiation reaching the Earth's surface is largely composed of UVA with a small UVB component.

UV RADIATION LEVELS ARE INFLUENCED BY:

SUN ELEVATION

The higher the sun in the sky, the higher the UV radiation level. Thus UV radiation levels vary with time of day and time of year. Outside the tropics, the highest levels occur when the sun is at its maximum elevation, at around midday (solar noon) during the summer months.

LATITUDE

The closer to equatorial regions, the higher the UV radiation levels.

CLOUD COVER

UV radiation levels are highest under cloudless skies but even with cloud cover, UV radiation levels can be high. Scattering can have the same effect as the reflectance by different surfaces and thus increase total UV radiation levels.

ALTITUDE

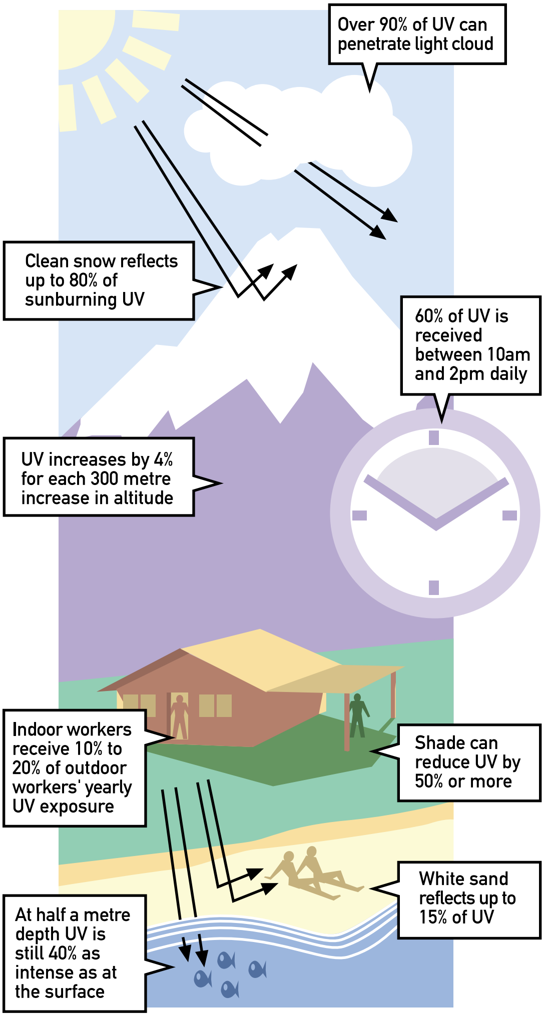
At higher altitudes, a thinner atmosphere absorbs less UV radiation. With every 1000 metres increase in altitude, UV radiation levels increase by 10% to 12%.

OZONE

Ozone absorbs some of the UV radiation that would otherwise reach the Earth's surface. Ozone levels vary over the year and even across the day.

GROUND REFLECTION

UV radiation is reflected or scattered to varying extents by different surfaces, e.g. fresh snow can reflect as much as 80% of UV radiation, dry beach sand about 15% and sea foam about 25%.



Small amounts of UV radiation are beneficial for people and essential in the production of vitamin D. UV radiation is also used to treat several diseases, including rickets, psoriasis and eczema. This takes place under medical supervision and the benefits of treatment versus the risks of UV radiation exposure are a matter of clinical judgement.

Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Sunburn and tanning are the best known acute effects of excessive UV radiation exposure; in the long term, UV radiation-induced degenerative changes in cells, fibrous tissue and blood vessels lead to premature skin ageing. UV radiation can also cause inflammatory reactions of the eye, such as photokeratitis.

Chronic effects include two major public health problems: skin cancers and cataracts. Between two and three million non-melanoma skin cancers and approximately 132000 melanoma skin cancers occur globally each year. While non-melanoma skin cancers can be surgically removed and are rarely lethal, malignant melanoma substantially contributes to mortality rates in fair-skinned populations. Some 12 to 15 million people are blind from cataracts. According to WHO estimates, up to 20% of these cases of blindness may be caused or enhanced by sun exposure, especially in India, Pakistan and other countries of the "cataract belt" close to the equator. Furthermore, a growing body of evidence suggests that environmental levels of UV radiation may enhance the risk of infectious diseases and limit the efficacy of vaccinations. Please see Annex A for a detailed description of the health effects of exposure to UV radiation.

People's behaviour in the sun is considered to be a major cause for the rise in skin cancer rates in recent decades. An increase in popular outdoor activities and changed sunbathing habits often result in excessive exposure to UV radiation. Many people consider intensive sunbathing to be normal; unfortunately, even children, adolescents and their parents perceive a suntan as a symbol of attractiveness and good health.

Sun protection programmes are urgently needed to raise awareness of the health hazards of UV radiation, and to achieve changes in lifestyle that will arrest the trend towards more and more skin cancers. Beyond the health benefits, effective education programmes can strengthen national economies by reducing the financial burden to health care systems caused by skin cancer and cataract treatments. Billions are spent worldwide to treat these diseases, many of which could have been prevented or delayed. The Global Solar UV Index should be an important element of an integrated and long-term public health approach to sun protection.

The Global Solar UV Index

AN EDUCATIONAL TOOL

WHAT IS THE GLOBAL SOLAR UV INDEX?

The Global Solar UV Index (UVI) describes the level of solar UV radiation at the Earth's surface. The values of the index range from zero upward – the higher the index value, the greater the potential for damage to the skin and eye, and the less time it takes for harm to occur.

WHY DO WE NEED THE UVI?

A marked increase in the incidence of skin cancer in fair-skinned populations worldwide is strongly associated with excessive UV radiation exposure from the sun; it may also be associated with the use of artificial UV radiation sources such as sunbeds. Current evidence indicates that personal habits in relation to sun exposure constitute the most important individual risk factor for UV radiation damage. The UVI is an important vehicle to raise public awareness of the risks of excessive exposure to UV radiation, and to alert people about the need to adopt protective measures. Encouraging people to reduce their sun exposure can decrease harmful health effects and significantly reduce health care costs.

HOW SHOULD THE UVI BE USED?

This educational tool should be used as an integral component of a programme to inform the public about UV radiation health risks and sun protection, and to change people's attitudes and behaviour with respect to UV radiation exposure. The UVI should especially aim at vulnerable and highly-exposed groups within the population, e.g. children and tourists, and should inform people about the range of UV radiation-induced health effects including sunburn, skin cancer and skin ageing, and effects on the eye and immune system. Educational messages should emphasize that the risk of adverse health effects from UV radiation exposure is cumulative, and that exposure in everyday life may be as important as exposure during vacations in sunny climates.

HOW IS THE UVI PRESENTED?

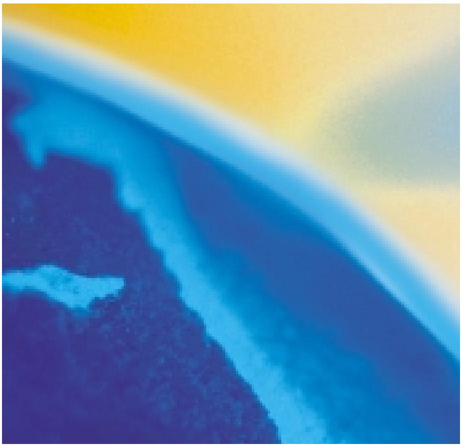
UV radiation levels and therefore the values of the index vary throughout the day. In reporting the UVI, most emphasis is placed on the maximum UV radiation level on a given day. This occurs during the four-hour period around solar noon. Depending on geographical location and whether daylight saving time is applied, solar noon takes place between local noon and 2 p.m. The media usually present a forecast of the maximum UV radiation level for the following day.

WHERE IS THE UVI REPORTED?

In many countries the UVI is reported along with the weather forecast in newspapers, on TV and on the radio; however, this is usually done only during the summer months. Annex B lists a series of Internet links that provide the UVI for a range of countries and in many different languages.

WHAT IS THE IMPORTANCE OF A HARMONIZED UVI?

Many countries use the UVI to promote sun protection. Surveys suggest that a large percentage of the public is aware of the existence of the UVI but does not understand its meaning or usefulness. These problems are related to the lack of standardized messages associated with the UVI. The UVI is clearly defined as an educational tool, and its use must be based on effective communication with the public and the media. Uniformity of UVI presentation, and uniformity of sun protection messages associated with different UVI values, will facilitate the delivery of a simple and relevant message, and will help to familiarize people with this important concept.



Reporting the UV Index

THE BASIC SCHEME

REPORTING UVI VALUES

The UVI is a measure of the intensity of UV radiation on the Earth's surface that is relevant to effects on the human skin.

- UVI reports should present at least the daily maximum value. When forecasting or reporting daily maxima, a 30-minute time average value should be used. Where continuous observations are available, a 5–10 minute average is useful to display short-term changes.
- The UVI should be presented as a single value rounded to the nearest whole number.
- However, when cloud cover is variable, the UVI should be presented as a range of values. UVI forecasts should include effects of cloud on UV radiation transmission through the atmosphere. Programmes not incorporating cloud effects in their forecasts should refer to them as a "clear sky" or "cloud free" UVI.

UVI values are grouped into exposure categories (*Table 1*). The national meteorology office or media service may choose to report the exposure category, the UVI value or range of values, or both.

EXPOSURE CATEGORY	UVI RANGE
LOW	< 2
MODERATE	3 TO 5
HIGH	6 TO 7
VERY HIGH	8 TO 10
EXTREME	11+

Table 1: UV radiation exposure categories

REPORTING BURN TIMES IS NOT RECOMMENDED.

Burn times have been used in many countries as this simple concept can be directly translated into action. However, people tend to interpret burn times to mean that there is a safe level of unprotected sun exposure. Hence, relating UVI values to "time to burn" or "safe tanning time" sends out the wrong message to the public. The UVI should not imply that extending exposures is acceptable. Although the priority goal of primary skin cancer prevention is to avoid sunburn, cumulative UV radiation exposure plays a major role in developing skin cancer and promotes damage to the eyes and immune system.

A SIMPLE AND RELEVANT MESSAGE

Acceptance by the general public of the UVI as useful daily information is the ultimate goal. In order to achieve this, the messages must be simple and easily understood. Reporting the UVI with relevance to the recipient will allow people to put recommendations into practice and accept the UVI as a guide to healthy, sun-protective behaviour.

Figure 1: Enjoy the sun but enjoy it safely

From a public health point of view, it is especially important to protect the most vulnerable population groups. Based on the finding that more than 90% of non-melanoma skin cancers occur in skin types I and II *(Table 2)*, the basic protective messages associated with the UVI should focus on fair-skinned people who tend to burn. Children, who are particularly sensitive to UV radiation, require special protection.

Even though the incidence of skin cancer is lower in dark-skinned people, they are nevertheless susceptible to the damaging effects of UV radiation, especially to the effects on the eye and immune system. Additional messages at the national or local level will allow the particular needs of other population sub-groups to be addressed.

These should take into account differences in climate and culture, the perception of UV radiation risks in the population, and the stage of sun protection education.

SKIN TYPE CLASSIFICATION		BURNS IN THE SUN	TANS AFTER HAVING BEEN IN THE SUN
I. II.	Melano-compromised	Always Usually	Seldom Sometimes
III. IV.	Melano-competent	Sometimes Seldom	Usually Always
V. VI.	Melano-protected	Naturally brown skin Naturally black skin	

Table 2: Classification of skin types (adapted from TB Fitzpatrick and JL Bolognia, 1995[1])

1 *Fitzpatrick TB, et al, reported in TB Fitzpatrick and JL Bolognia, Human melanin pigmentation: Role in pathogenesis of cutaneous melanoma. In: Zeise L, Chedekel MR, Fitzpatrick TB (eds.) Melanin: Its role in human photoprotection. Overland Park, KS, Valdenmar Publishing Company, 1995:177-82.*

THE BASIC SUN PROTECTION MESSAGES

- ***Limit exposure during midday hours.***
- ***Seek shade.***
- ***Wear protective clothing.***
- ***Wear a broad-brimmed hat to protect the eyes, face and neck.***
- ***Protect the eyes with wrap-around-design sunglasses or sunglasses with side panels.***
- ***Use and reapply broad-spectrum sunscreen of sun protection factor (SPF)15+ liberally***
- ***Avoid tanning beds.***
- ***Protect babies and young children: this is particularly important.***

Shade, clothing and hats provide the best protection – apply sunscreen to parts of the body that remain exposed, like the face and hands. Sunscreen should never be used to prolong the duration of sun exposure.

Two different concepts of sun protection have been proposed: a binary response with a defined threshold UVI value beyond which sun protection is recommended, or a graded response with increasing UVI values that would involve the successive use of different sun-protective measures. There is little scientific basis to support the latter: if sun protection is required, this should include all protective means, i.e. clothing, sunglasses, shade and sunscreen *(Figure 1)*. Nevertheless, a graded approach is relevant in the sense that more sun protection is needed at higher UV radiation levels.

Even for very sensitive fair-skinned people, the risk of short-term and long-term UV radiation damage below a UVI of 3 is limited, and under normal circumstances no protective measures are needed. Above the threshold value of 3, protection is necessary, and this message should be reinforced at UVI values of 8 and above.

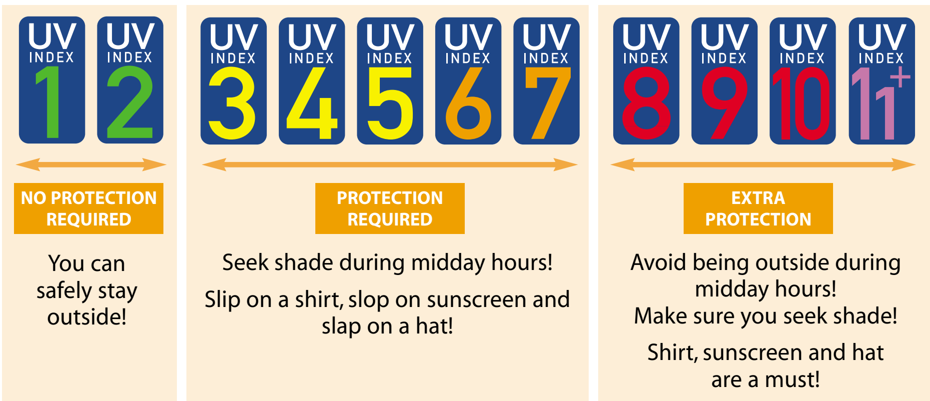


Figure 2: Recommended sun protection scheme with simple "sound bite" messages

GRAPHIC PRESENTATION OF THE UVI

A standard graphic presentation of the UVI promotes consistency in UVI reporting on news and weather bulletins, and serves to improve people's understanding of the UVI concept. Ready-made materials for UVI reporting facilitate successful media uptake, and more than one option is given to allow different media to cope with technical limitations. The graphics package (see Annex D) can be downloaded from the website of WHO's Global UV Project Intersun http://www.who.int/uv/ and includes the UVI logo, icons for UVI reporting, sun protection icons, and colour codes for different values of the UVI.

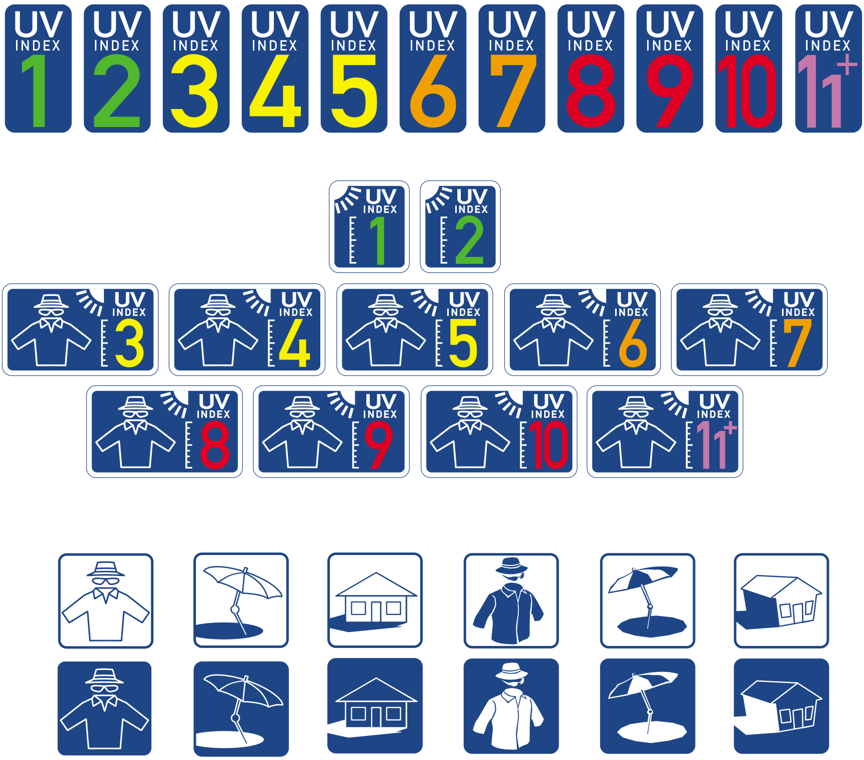


Figure 3: Examples of UVI graphics

Sun Protection Messages

CREATING VARIETY

ADDITIONAL SUNSMART MESSAGES

The basic scheme for UVI reporting and sun protection can be varied and expanded through the use of additional messages at the national or local level. Messages on suntanning, sun protection and people's inability to perceive UV radiation underlie the basic message and can be used in all settings.

Environment-based, activity-based or risk group-based messages can be geared specifically to local weather conditions, or the particular environmental or societal situation of a given country. Annex E lists examples of such additional sun protection messages adapted from Australia, Canada and France.

Figure 4: Children require special protection

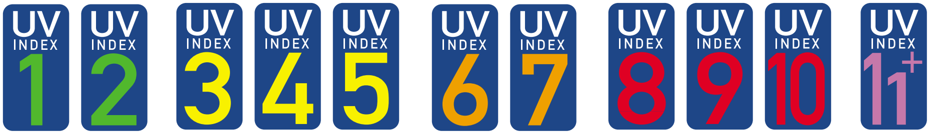
Targeted groups must include children and young people *(Figure 4)*, since frequent UV radiation exposure and a history of sunburn during childhood and adolescence is an important risk factor for skin cancer, especially for potentially lethal malignant melanoma. Additional messages can also be used to correct common misconceptions about UV radiation and its effects on human health *(Table 3)*.

FALSE	TRUE
A suntan is healthy.	A tan results from your body defending itself against further damage from UV radiation.
A tan protects you from the sun.	A dark tan on white skin offers only limited protection equivalent to an SPF of about 4.
You can't get sunburnt on a cloudy day.	Up to 80% of solar UV radiation can penetrate light cloud cover. Haze in the atmosphere can even increase UV radiation exposure.
You can't get sunburnt while in the water.	Water offers only minimal protection from UV radiation, and reflections from water can enhance your UV radiation exposure.
UV radiation during the winter is not dangerous.	UV radiation is generally lower during the winter months, but snow reflection can double your overall exposure, especially at high altitude. Pay particular attention in early spring when temperatures are low but the sun's rays are unexpectedly strong.
Sunscreens protect me so I can sunbathe much longer.	Sunscreens should not be used to increase sun exposure time but to increase protection during unavoidable exposure. The protection they afford depends critically on their correct application.
If you take regular breaks during sunbathing you won't get sunburnt.	UV radiation exposure is cumulative during the day.
If you don't feel the hot rays of the sun you won't get sunburnt.	Sunburn is caused by UV radiation which cannot be felt. The heating effect is caused by the sun's infrared radiation and not by UV radiation.

Table 3: UV radiation danger: Facts and fiction

USING COLOUR TO INCREASE VARIABILITY

Specific colours should be used for presenting the solar UVI. These do not have a scientific basis but are a means of making the presentation of the UVI more appealing. The colour coding facilitates variation between geographic areas of high and low UV radiation levels, and a basic colour is defined for each category *(Table 4; see also Annex D)*.



Low (1,2)	Moderate (3,4,5)	High (6,7)	Very high (8,9,10)	Extreme (11+)
Green PMS 375	Yellow PMS 102	Orange PMS 151	Red PMS 032	Purple PMS 265

Table 4: Presenting the UVI: International colour codes[1]

The colour within categories can be graded to allow for variation at the national level where values often remain within one category throughout the summer months (see Annex D).

Not all media will be able to integrate the variation in colour into their presentation. Television media generally use standardized maps and changing the colours may not be feasible due to technical limitations. Similarly, black and white print media will not be able to use the recommended colour scheme.

EMPHASIZING DANGEROUS HOURS

In countries where UV radiation levels are high and where knowledge about UV radiation and sun protection in the population is widespread, a further concept may be applied to increase variability. This was introduced in Australia in 2000.

The approach focuses on the hours of the day during which the UVI is above a given threshold value *(Figure 5)*. While on one day the UVI may reach a value of above 3 for no more than 30 minutes, on another day it may remain above 3 for several hours. The advice to the public emphasizes the need to adopt sun-protective practices during these hours.

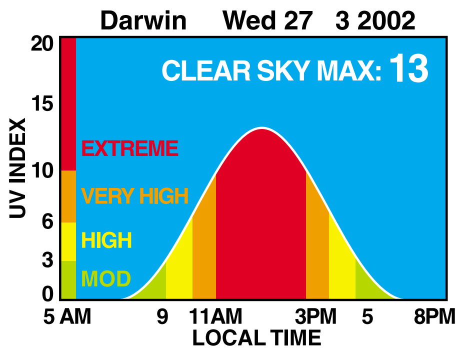


Figure 5: A graphic representing dangerous hours (Bureau of Meteorology, Australia)[2]

1 *The eps graphic files, which are downloadable from the website of WHO's Global UV Project Intersun http://www.who.int/uv/, will reproduce satisfactorily in most cases, allowing the worldwide reproduction of a standardized colour scheme. Pantone Matching System (PMS) colour references may be used for minor colour correction.*

2 *The colour scheme currently used by the Bureau of Meteorology, Australia does not comply with the international colour codes promoted in this publication.*

Educational Concepts and Their Practical Implementation

Increased sun exposure has been identified as the main reason for the increase in skin cancer rates since the early 1970s, and only changes in lifestyle can stop this ongoing trend. Public education aims to improve people's knowledge about the health risks of excessive sun exposure, and to achieve a change in attitudes and behaviour. Reducing the occurrence of sunburn and cumulative UV radiation exposure over a lifetime will eventually cause skin cancer rates to decline.

It is important that information be presented in a positive manner that enables people to enjoy the sun safely but at the same time makes them aware of the need to avoid overexposure. The UVI should form an integral element of programmes to educate the public about the health hazards of excessive UV radiation exposure. The sections below address key elements of effective education campaigns.

MAIN TARGET AUDIENCES AND SUN PROTECTION SETTINGS

A majority of a person's lifetime exposure occurs before age 18, and sun avoidance during childhood has a greater impact on health risk reduction than sun protection during adulthood. Therefore, children and adolescents should be the primary target for education about the sun and how to avoid damage to health. An effective campaign can have an enormous impact on public health: a change in people's behaviour towards effective sun protection could eliminate more than 70% of skin cancers in Australia.

Schools are essential for getting the message across to young people. Teachers and their associations should be encouraged to take up the cause and include UV radiation awareness and protection projects in the educational system. Furthermore, all outdoor recreational sites – beaches, sports centres and swimming pools, zoos and parks – provide a good setting for information about UV radiation levels and sun protection.

As a large percentage of many people's lifetime exposure to UV radiation is received during vacations, tourists represent an important audience for UVI reporting and sun protection advice.

BUILDING NETWORKS AND ALLIANCES

In order to change people's sun exposure habits and the current societal view that associates a tan with good health, long-term strategies are required. The cooperation of different sectors is necessary to implement far-reaching educational strategies and create a supportive environment for the integration of sun protection into the culture of a country. For this reason, campaigns in many countries are organized as a collaborative effort between different medical and scientific associations, government and specialized private institutions, and charitable societies.

Further partners in disseminating the message may include the tourism industry such as airlines, hotel chains and cruise liners, national weather bureaux and companies producing sun protection items such as sunscreen and sunglasses.

THE ROLE OF NATIONAL GOVERNMENTS

EDUCATION

- Encourage the use of the UVI as part of public awareness programmes.
- Supply health care professionals, teachers and carers of children with educational material for distribution to the public.
- Organize workshops for medical doctors and other health professionals.
- Establish education programmes for teachers.
- Establish education programmes for outdoor workers.
- Encourage and support the provision of shaded areas in schools, playgrounds and parks, and in public places such as bus stops and swimming pools.
- Recommend against the use of sunlamps and sunbeds for cosmetic purposes.
- Inform the community of drugs and cosmetics that sensitize the skin to the effects of UV radiation.
- Enlist weather broadcasters, health reporters and the media to provide the UVI service to the public.

EVALUATION

- Establish national statistics on UV radiation-induced skin and eye diseases.
- Encourage research on UV radiation related health effects and protective measures.
- Support national programmes and international collaboration efforts on UV radiation monitoring and health education.
- Conduct research that monitors behavioural, knowledge and attitudinal trends related to sun protection.

STANDARDS

- Facilitate the development of standards related to sun protection products such as sunscreens, clothing, sunbeds and sunglasses to ensure clear and safe guidelines for manufacturers and consumers.
- Encourage the provision of information on the degree of UV radiation protection provided by sunscreens, eyewear, clothing and other protective measures.

ENSURING MEDIA SUPPORT

The media should be encouraged to report the UVI with their daily weather information, so that people begin to accept this as an important piece of information in addition to the news and weather report. The TV, radio and print media provide an essential medium for informing the public about the hazards of UV radiation and the need to adopt protective measures. They can support local and national programmes by highlighting health concerns, and can even promote research by making the results of new health effects or protective devices known to the public. To ensure continuing interest in the awareness campaign, it will be necessary to progressively develop short, clear messages that are tailored to the particular medium.

THE ROLE OF LOCAL AUTHORITIES AND HEALTH AGENCIES

- Encourage behaviour change through sign prompts and educational activities in community and recreation facilities and services. These could include programmes in schools and kindergartens, the distribution of brochures in public buildings, banks, shopping centres and health care centres, and sun protection fairs where health professionals participate in presentations and skin cancer screening.
- Promote creative activities on sun protection, e.g. fashion shows using UV radiation-protective designs and fabrics, science projects, and competitions.
- Modify the physical environment and promote the consideration of shade in urban planning and in the modification of public places.

USEFUL STRATEGIES INCLUDE:

- Holding a press conference at the launch of a campaign, e.g. in late-spring, where appropriate health professionals are available for interviews.
- Organizing short seminars for journalists to educate them about the problems of excessive UV radiation exposure and to disseminate the key sun protection messages.
- Using the announcements for press conferences to highlight key issues, followed by press releases that provide clear and simple messages.
- Using human interest stories to get the message across.

The promotion of the UVI needs to be conducted in a positive and attractive way. The key words are "save", "protect" and "help".

THE UVI CAN:

✓ save lives
✓ protect good health
✓ help preserve youthful complexion

EVALUATING THE EFFECTIVENESS OF A UVI CAMPAIGN

A sun awareness programme that uses the UVI as an educational tool aims to improve people's knowledge, and change attitudes and behaviour with respect to sun exposure and sun protection. A well-designed evaluation survey should assess:

- whether members of the general public understand the meaning of the UVI and the message it carries;
- whether the campaign has changed people's knowledge, attitudes and behaviour with respect to sun exposure.

Health Effects of UV Radiation Exposure

ANNEX A

Human exposure to solar radiation may result in acute and chronic health effects on the skin, eye and immune system. It is a popular misconception that only fair-skinned people need to be concerned about overexposure to the sun. Darker skin has more protective melanin pigment, and the incidence of skin cancer is lower in dark-skinned people. Nevertheless, skin cancers do occur with this group and unfortunately they are often detected at a later, more dangerous stage. The risk of UV radiation-related health effects on the eye and immune system is independent of skin type. A comprehensive summary and review of UV radiation-related health effects can be found in the WHO Environmental Health Criteria Monograph *Ultraviolet Radiation*[1] *and in the Proceedings of an International Workshop on Ultraviolet Radiation*[2].

SKIN

SUNBURN, SUNTAN AND SKIN AGEING

The best known acute effect of excessive UV radiation exposure is erythema, the familiar skin reddening termed sunburn. In addition, most people will tan from the UV radiation stimulation of melanin production, which occurs within a few days of exposure. A further, less obvious adaptive effect is the thickening of the outermost layers of the skin that attenuates UV radiation penetration to the deeper layers of the skin. Both changes are a sign of damage to the skin. Depending on their skin type, individuals vary greatly in their skin's initial threshold for erythema and their ability to adapt to UV exposure. Chronic exposure to UV radiation also causes a number of degenerative changes in the cells, fibrous tissue and blood vessels of the skin. These include freckles, nevi and lentigines, which are pigmented areas on the skin, and diffuse brown pigmentation. UV radiation accelerates skin ageing, and the gradual loss of the skin's elasticity results in wrinkles and dry, coarse skin.

NON-MELANOMA SKIN CANCERS

Non-melanoma skin cancers (NMSC) comprise basal cell carcinoma and squamous cell carcinoma. These are rarely lethal but surgical treatment is painful and often disfiguring. The temporal trends of NMSC incidence are difficult to determine, because reliable registration of these cancers has not been achieved. However, specific studies carried out in Australia, Canada and the United States, indicate that between the 1960s and the 1980s the prevalence of NMSC increased by a factor of more than two. The risk of NMSC has been examined with respect to personal exposure, and the

1 *Ultraviolet radiation. An authoritative scientific review of environmental and health effects of UV, with reference to global ozone layer depletion.* Geneva, World Health Organization, 1994 (Environmental Health Criteria Monograph, No. 160).

2 Proceedings of an international workshop on ultraviolet radiation exposure, measurement and protection, St Catherine's College, Oxford, 1999. *Radiation Protection Dosimetry,* 2000, 91:1-3.

NMSC is most frequent on parts of the body that are commonly exposed to the sun such as ears, face, neck and forearms. This implies that long-term, repeated UV radiation exposure is a major causal factor.

Within some countries there is a clear relationship between increasing incidence of NMSC with decreasing latitude, i.e. higher UV radiation levels.

Figure 6: Basal cell carcinoma

Figure 7: Squamous cell carcinoma

MALIGNANT MELANOMA

Malignant melanoma (MM), although far less prevalent than NMSC, is the major cause of death from skin cancer and is more likely to be reported and accurately diagnosed than NMSC. Since the early 1970s, MM incidence has increased significantly, e.g. by an average 4% every year in the United States. A large number of studies indicate that the risk of malignant melanoma correlates with genetic and personal characteristics, and a person's UV radiation exposure behaviour. The following is a summary of the main human risk factors:

- A large number of atypical nevi (moles) is the strongest risk factor for MM in fair-skinned populations.
- MM is more common among people with a pale complexion, blue eyes, and red or fair hair. Experimental studies have demonstrated a lower threshold erythema and more prolonged skin reddening in melanoma patients than in controls.
- High, intermittent exposure to solar UV radiation appears to be a significant risk factor for the development of MM.
- The incidence of MM in white populations generally increases with decreasing latitude, with the highest recorded incidence occurring in Australia, where the annual rates are 10 and over 20 times the rates in Europe for women and men respectively.
- Several epidemiological studies support a positive association with history of sunburn, particularly sunburn at an early age.
- The role of cumulative sun exposure in the development of MM is equivocal. However, MM risk is higher in people with a history of NMSC and of solar keratoses, both of which are indicators of cumulative UV radiation exposure.

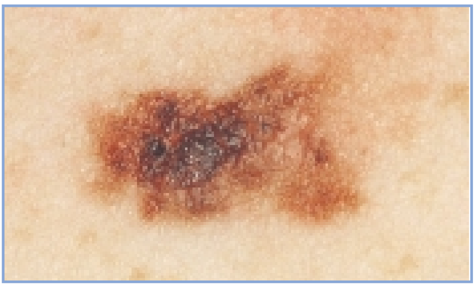


Figure 8: Maligant melanoma

EYE

The eye is recessed within its orbit and shielded by the brow ridge, the eyebrows and the eyelashes. Bright light activates the constriction of the pupil and the squinting reflex to minimize the penetration of the sun's rays into the eye. However, the effectiveness of these natural defences in protecting against the dangers of UV radiation is limited under extreme conditions such as sunbed use or strong ground reflection from sand, water and snow.

Acute effects of UV radiation exposure include photokeratitis and photoconjunctivitis. These inflammatory reactions are comparable to a sunburn of the very sensitive skin-like tissues of the eyeball and eyelids, and usually appear within a few hours of exposure. Both can be very painful, but are reversible and do not result in any long-term damage to the eye or vision. Extreme forms of photokeratitis are "arc-eye" and "snow blindness".

Cataracts are the leading cause of blindness in the world. Proteins in the eye's lens unravel, tangle and accumulate pigments that cloud the lens and eventually lead to blindness. Even though cataracts appear to different degrees in most individuals as they age, sun exposure, in particular exposure to UVB, appears to be a major risk factor for cataract development.

IMMUNE SYSTEM

The immune system is the body's defence mechanism against infections and cancers, and is normally very effective at recognizing and responding to an invading micro-organism or the onset of a tumour. Although the data remain preliminary, there is increasing evidence for a systematic immunosuppressive effect of both acute and low-dose UV radiation exposure.

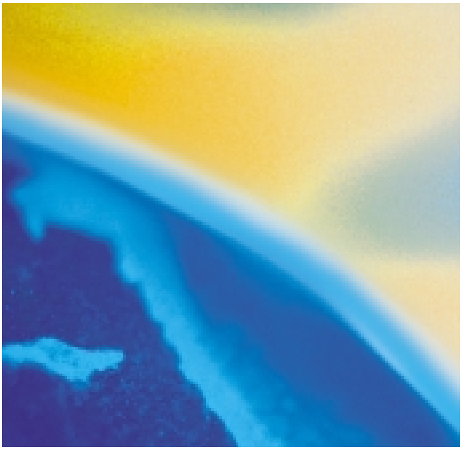
Animal experiments have demonstrated that UV radiation can modify the course and severity of skin tumours. Also, people treated with immunosuppressive drugs have a greater incidence of squamous cell carcinoma than the normal population. Consequently, beyond its role in the initiation of skin cancer, sun exposure may reduce the body's defences that normally limit the progressive development of skin tumours.

Several studies have demonstrated that exposure to environmental levels of UV radiation alters the activity and distribution of some of the cells responsible for triggering immune responses in humans. Consequently, sun exposure may enhance the risk of infection with viral, bacterial, parasitic or fungal infections, which has been demonstrated in a variety of animal models. Furthermore, especially in countries of the developing world, high UV radiation levels may reduce the effectiveness of vaccines. Since many vaccine-preventable diseases are extremely infectious, any factor that results in even a small decrease in vaccine efficacy can have a major impact on public health.

OZONE DEPLETION AND UV-RELATED HEALTH EFFECTS

Depletion of the ozone layer is likely to aggravate existing health effects caused by exposure to UV radiation, as stratospheric ozone is a particularly effective UV radiation absorber. As the ozone layer gets thinner, the protective filter provided by the atmosphere is progressively reduced. Consequently, human beings and the environment are exposed to higher UV radiation levels, and especially higher UVB levels that have the greatest impact on human health, animals, marine organisms and plant life.

Computational models predict that a 10% decrease in stratospheric ozone could cause an additional 300 000 non-melanoma and 4500 melanoma skin cancers and between 1.6 and 1.75 million more cases of cataracts worldwide every year.



Internet Links: Organizations Reporting the UV Index

ANNEX B

WORLD
World Ozone and Ultraviolet Radiation Data Centre
http://www.msc-smc.ec.gc.ca/woudc/

WORLD
Institute of Medical Physics and Biostatistics, University of Veterinary Medicine Vienna
http://i115srv.vu-wien.ac.at/uv/uv_online_alt.htm#uvimaps

EUROPE
Scientific UV Data Management (SUVDAMA)
http://www.ozone.fmi.fi/SUVDAMA/

MEDITERRANEAN BASIN
(French/English/Spanish/Italian)
Environmental Forecast and Information Service
http://www.enviport.com/index_en.html

ARGENTINA
(Spanish)
Regional Centre of Satellite Data
http://www.conae.gov.ar/iuv/iuv.html

National Meteorological Service
http://www.meteofa.mil.ar/

AUSTRALIA
Bureau of Meteorology
http://www.bom.gov.au/info/about_uvb.shtml

AUSTRIA
Institute for Medical Physics, University of Innsbruck
http://www.uibk.ac.at/projects/uv-index/aktuell/mon_kart_eng.html

CANADA
(English/French)
Meteorological Service of Canada
http://www.msc-smc.ec.gc.ca/uvindex/

CZECH REPUBLIC
(Czech/English)
Czech Hydrometeorological Institute
http://www.chmi.cz/meteo/ozon/o3uvb.html

FINLAND
(Finnish)
Finnish Meteorological Institute
http://www.ozone.fmi.fi/

FRANCE
(French)
Securité Solaire
http://www.securite-solaire.org

GERMANY
(German)
Federal Office for Radiation Protection
http://www.bfs.de/uvi/index.htm

German Weather Services
http://www.uv-index.de/

GREECE
(Greek)
Laboratory of Atmospheric Physics
http://lap.physics.auth.gr/uvindex/

HONG KONG SPECIAL ADMINISTRATIVE REGION OF CHINA
Hong Kong Observatory
http://www.info.gov.hk/hko/wxinfo/uvindex/english/uvindex_e.htm

ISRAEL
(Hebrew/English)
Israel Weather Forecast
http://www2.iol.co.il/weather/Edefault.asp

ITALY
(Italian/English)
Labratory for Meteorology and Environmental Modelling
http://www.lamma.rete.toscana.it/previ/ita/stazlam.htm

JAPAN
(English)
Shiseido UV Ray Information
http://www.shiseido.co.jp/e/e9708uvi/html/index.htm

LUXEMBOURG
(French)
Meteorological Station of the Lycée Classique de Diekirch
http://meteo.lcd.lu/

MEXICO
(Spanish/English)
Mexico City Air Quality Report
http://sima.com.mx/sima/df/_zseeng.html

NEW ZEALAND
Lauder National Institute of Water and Atmospheric Research (NIWA)
http://katipo.niwa.cri.nz/lauder/homepg07.htm

NORWAY
(Norwegian/English)
Norwegian Radiation Protection Authority
http://uvnett.nrpa.no/

POLAND
(Polish)
Institute of Meteorology and Water Management
http://www.imgw.pl/

PORTUGAL
(Portuguese/English)
Meteorological Institute
http://www.meteo.pt/uv/uvindex.htm

SLOVENIA
(Slovenian)
Environmental Agency of Slovenia
http://www.rzs-hm.si/zanimivosti/UV.html

SPAIN
(Spanish)
National Meteorological Institute
http://www.inm.es/wwz/fijo/estaciones.html

SWEDEN
(Swedish/English)
Swedish Radiation Protection Institute
http://www.smhi.se/weather/uvindex/sv/uvprog.htm

SWITZERLAND
(German/French)
Federal Office of Public Health
http://www.uv-index.ch

TURKEY
(Turkish)
Scientific and Technical Research Council of Turkey
http://www.tubitak.gov.tr/

UNITED KINGDOM
The Meteorological Office
http://www.met-office.gov.uk/sec3/gsuvi.html

UNITED STATES OF AMERICA
The Weather Channel
http://www.weather.com/activities/health/skin

National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency (EPA) Climate Prediction Center
http://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/index.html

ANNEX C

The Global Solar UVI is formulated using the International Commission on Illumination (CIE) reference action spectrum for UV-induced erythema on the human skin (ISO 17166:1999/CIE S 007/E-1998). It is a measure of the UV radiation that is relevant to and defined for a horizontal surface. The UVI is a unitless quantity defined by the formula:

$$I_{UV} = k_{er} \cdot \int_{250\ \text{nm}}^{400\ \text{nm}} E_{\lambda} \cdot s_{er}(\lambda)\,d\lambda$$

where E_{λ} is the solar spectral irradiance expressed in $W/(m^2.nm)$ at wavelength λ and $d\lambda$ is the wavelength interval used in the summation. $s_{er}(\lambda)$ is the erythema reference action spectrum, and k_{er} is a constant equal to 40 m^2/W.

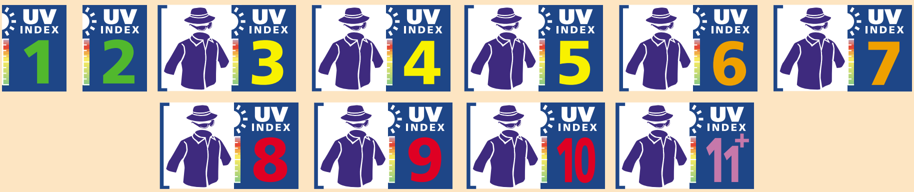
The determination of the UVI can be through measurements or model calculations. Two measurement approaches can be taken: the first is to use a spectroradiometer and to calculate the UVI using the above formula. The second is to use a broadband detector that has been calibrated and programmed to give the UVI directly. Prediction of the solar UVI is achieved with a radiative transfer model that requires the input of total ozone and the aerosol optical properties. A regression model is used to predict the total ozone using the input from ground-based ozone spectroradiometers or from satellites. A good cloud parameterisation is also required unless only clear sky values are reported.

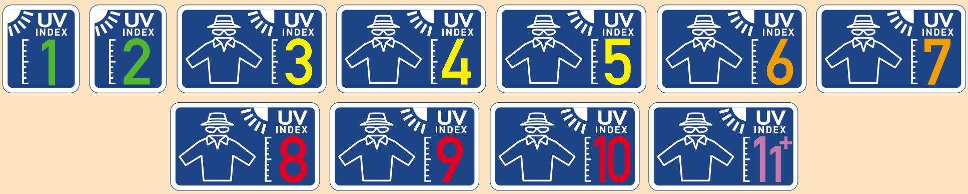
Graphic Presentation of the UV Index

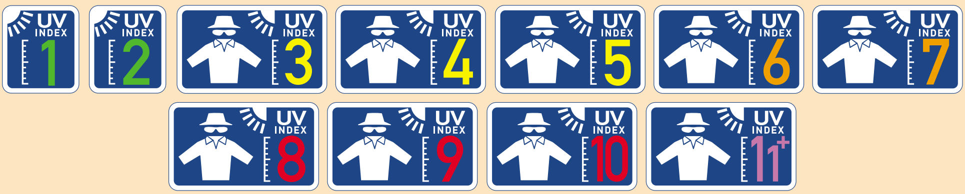
ANNEX D

UVI	Web Colour Table (HEX)
1	#4eb400
2	#a0ce00
3	#f7e400
4	#f8b600
5	#f88700
6	#f85900
7	#e82c0e
8	#d8001d
9	#ff0099
10	#b54cff
11 +	#998cff

UV INDEX	Recommended protection
< 2	
3 – 7	
8 +	







Additional Sun Protection Messages

ANNEX E

SUNTANNING MESSAGES

- Tanning does not stop much UV radiation! Even when your skin is tanned, limit your exposure during midday hours, and continue to protect yourself.
- Don't UV OD. Sunburn is literally an indication that your skin has overdosed on UV radiation so Slip! Slop! Slap! and Save Your Skin.

SUN PROTECTION MESSAGES

- Wear sunglasses, a wide-brimmed hat and protective clothing, and frequently apply sunscreen of SPF 15+ to protect yourself.
- Applying sunscreen is not a means to prolong your stay in the sun but to reduce the health risk of your exposure.
- Taking certain medications as well as using perfumes and deodorants can sensitize your skin, causing serious burns in the sun. Ask your pharmacist for advice.
- Sun exposure increases skin cancer risk, accelerates skin ageing and causes damage to the eyes. Protect yourself!
- Shade is one of the best defences against the sun's radiation. Try to find some shade during midday hours when the sun's UV rays are at their peak.

PERCEPTION OF UV RADIATION

- Cloudy weather doesn't mean you can't get burnt. It's the UV radiation in the sun's rays that burns you and causes skin cancer, and UV radiation can penetrate through cloud.
- Remember the sun does not need to feel hot to damage your skin and eyes. The damage is done by UV radiation, which is not seen or felt – so don't be fooled by mild temperatures.

ACTIVITY-BASED MESSAGES

- If you're out to watch or participate in (name of event), don't forget your sunscreen, hat and long-sleeved shirt. That should be all you need to make sure all you go home with are great memories of today's events – and not a nasty dose of sunburn.
- This is a great time to head to the ski slopes. High altitudes and fresh snow can double your UV radiation exposure, so wear sunglasses and sunscreen!
- Going on a sunny vacation? Make sure to pack your wide-brimmed hat, sunglasses and sunscreen.
- School break means fun in the sun for the lucky ones. If you're one of them, remember to pack a hat, sunscreen and sunglasses.

- Springtime, gardening time. While tending your flower beds, don't forget to protect your skin.

ENVIRONMENT-BASED MESSAGES

- Identify risky situations. If your shadow is short or if you are exposed for a long time – protect yourself!
- Watch out! A lot of UV radiation can pass through clouds.
- In the mountains, UV radiation levels increase by approximately 10% with every 1000 metres in altitude. Snow reflection can double the quantity of UV radiation you are exposed to.
- Fresh snow can double your UV radiation exposure, so wear sunglasses and sunscreen!

MESSAGES FOR CHILDREN AS A SPECIAL RISK GROUP

- Extended sun exposure during childhood increases the risk of skin cancer later in life and can cause serious damage to the eye.
- All children below age 15 have sensitive skin and eyes – protect them and set a good example for them!
- Children below one year of age must never stay in direct sun.
- The sun is getting stronger and children are exposed to its damaging rays during lunch and recess. Encourage your children to use sun protection and to take a break in the shade.
- Most of our lifetime UV radiation exposure occurs before age 18. Protect your children … their skin will be healthier and look younger throughout their lives.
- Parents – protect your children from the sun. Teach them about avoiding sun exposure and the proper steps for sun protection.

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