



**Summary of report entitled**

**ULTRAVIOLET RADIATION**

**Current knowledge of exposure and health risks**

May 2005

## **Introduction**

Ultraviolet radiation is part of the non-ionizing electromagnetic radiation spectrum emitted by the sun, in the same way as visible radiation (light) and infrared radiation. Although ultraviolet radiation is invisible to the naked eye, the body reacts to it with protective mechanisms: darkening and thickening of the outer layer of the skin. As a result of its penetration into the skin and its mutagenic potential, exposure to ultraviolet radiation, whether natural or artificial, involves some major medium- and long-term health risks, especially for sensitive populations like children. The risks associated with exposure to UVB radiation have long been known, whereas the mutagenic activity of UVA radiation has been known for less than ten years.

The attention of the public authorities was first drawn to the risks associated with exposure to artificial ultraviolet radiation in 1995, and legislation was passed in 1997 (Decree no. 97-617 of 30 May 1997 relating to the sale and provision to the public of certain tanning devices using ultraviolet radiation, and its implementing orders).

Following a study of the mutagenic role of UVA radiation conducted by G. Halliday's team in 2004, Afsse informed the French Ministry of Health of its results in a note dated 19 April 2004, and added an FAQ section to its website in July 2004. The Health and Environment Ministers then requested Afsse (referral of 6 September 2004) to reassess the health risks associated with exposure to ultraviolet radiation of natural origin and with the use of tanning facilities. To reply to the questions posed by the Ministry's referral, Afsse set up a group of experts including representatives of the Academy of Medicine, IARC, members of Inserm research laboratories, and practitioners specializing in the field, as well as representatives of InVS and Afssaps, to which the referral was addressed.

As it is difficult to differentiate between the consequences of exposure to natural and artificial ultraviolet radiation in terms of overall effects, the experts' group decided to base its report on a global analysis of the UV risk. Thus in addition to the objectives stated in the referral, Afsse extended the study to include the possible risks associated with domestic use of "broad-spectrum" light bulbs which emit ultraviolet radiation in addition to the visible spectrum. The experts' group also considered the possible consequences of the use of sunscreens (mainly effective against UVB radiation), which can lead to longer exposure and therefore an increased risk associated with exposure to UVA radiation.

InVS and Afssaps were requested to deal with different aspects of ultraviolet radiation. In parallel to the referral to Afsse, a second working group was set up by InVS to characterize the exposure of the French population, while Afssaps issued a report entitled "Ultraviolet radiation and the use of cosmetic products". The proceedings of the various working groups are presented in a joint report.

## **The physics of ultraviolet radiation**

Ultraviolet radiation is a portion of the non-ionizing part of the electromagnetic spectrum, situated in the wavelength interval between 100 and 400 nm. It is usually divided into three regions: UVA (315-400 nm), UVB (280-315 nm) and UVC (100-280 nm), and can be emitted by natural sources (solar radiation) or artificial sources.

The effective biological ultraviolet radiation (UVReff) at a given wavelength is the value of the energy level of the ultraviolet radiation multiplied by a specific efficiency factor of the biological effect in question at that wavelength. It is expressed as  $W.m^{-2}$  (eff). The biological efficiency of ultraviolet radiation ( $E_{eff}$ ) is used in standard IEC 60335-2-27 2002 to evaluate the emission limits of tanning devices.

The Standard Erythema Dose (SED) measures the erythema UV radiation equivalent to effective exposure of  $100 J.m^{-2}$ . The Minimal Erythema Dose (MED) is the dose that produces barely perceptible erythema (with clearly defined edges) in a given individual on a defined surface.

In 1997, the Erythema Effectiveness Spectrum for human skin became an ISO/IEC standard, which allows the erythema effectiveness of a given UV source to be calculated by convolution with the emission spectrum of that source. The ratio between the solar emission spectrum and the erythema effectiveness spectrum is used to calculate the UV index, a tool designed for communication to the general public. It expresses the erythema power of the sun ( $UV\ index = 40 \times E_{eff} W.m^{-2}$ ).

### **Limit values**

The international scientific bodies responsible for the subject of exposure of workers and the general public (ACGIH and ICNIRP) have established the maximum daily doses that a worker exposed to UV radiation can receive without the risk of acute or long-term effects on the eyes. The maximum daily dose has been fixed at  $30 J.m^{-2} Eff$ , i.e. just under one-third of the SED. This dose takes account of the average cell repair capacity.

There are currently no recommended maximum limits for human skin, as the values established for ophthalmological risk take no account of the thickness of the skin and its thickening as a result of repeated exposure. The maximum limits recommended only constitute advice for indoor workers, and cannot be applied to outdoor workers.

## The biological effects of ultraviolet radiation

<b>Short-term effects of ultraviolet radiation</b>		
<b>Actinic erythema (sunburn)</b>	<ul style="list-style-type: none"> <li>- Its intensity and duration are proportional to the quantity of UV radiation received.</li> <li>- It appears a few hours after exposure to UV radiation, and culminates between 24 and 36 hours, then disappears on the 3rd day, to be replaced by marked pigment darkening</li> <li>- Possibility of fever, headache and vomiting, depending on the size of the damaged areas and the dose received.</li> </ul>	UVB (E=5%) (E <sub>eff</sub> = 80%)  UVA (E=96%) (E <sub>eff</sub> =20%)
<b>Thickening of epidermis</b>	<ul style="list-style-type: none"> <li>- The keratinocytes in the basal layer actively divide around the 3rd day after irradiation.</li> <li>- This provides a degree of photoprotection.</li> <li>- Skin peeling allows a gradual return to normal in 5 weeks in the absence of new irradiations.</li> </ul>	UVB
<b>Immediate pigment darkening</b>	<ul style="list-style-type: none"> <li>- The melanins present in the melanocytes and keratinocytes polymerize; this leads to immediate pigment darkening, which is visible when irradiation ceases.</li> <li>- This is a temporary phenomenon.</li> <li>- This reaction is not developed by melano-compromised people.</li> </ul>	UVA (10 J/cm <sup>2</sup> )
<b>Adaptive pigment darkening (tanning)</b>	<ul style="list-style-type: none"> <li>- Visible on the 3rd day after irradiation, and persists for 3-4 weeks in the case of a single irradiation</li> <li>- In the case of repeated exposures, the pigment darkens increasingly, and this lasts for as long as peeling remains within normal limits.</li> <li>- Exposure to solarium: protection against solar radiation remains fairly low; much lower than that obtained, with an equal tan, from a series of exposures to the sun, as there is little thickening of the skin.</li> </ul>	UVA  UVB
<b>Production of vitamin D by the skin</b>	<ul style="list-style-type: none"> <li>- This is a complement to vitamin D of food origin (80% of needs would be covered by a few minutes' exposure of a small part of the body twice a week).</li> <li>- Vitamin D is needed to fix calcium to the bone matrix.</li> <li>- A real deficiency can be observed in Nordic countries in people with phototypes V and VI, but eating foods rich in vitamin D can compensate for this deficiency. The risk of hypovitaminosis D observed in some populations no longer justifies exposure to artificial UVB radiation.</li> </ul>	UVB
<b>Phototoxicity and photoallergy</b>	<ul style="list-style-type: none"> <li>- The presence in the integument of endogenous substances (porphyria) or exogenous substances (medicines) can trigger phototoxic reactions which present clinically as severe sunburn.</li> <li>- Phototoxic reactions are theoretically restricted to irradiation and substance deposit sites. Photoallergic reactions, often eczematous, extend far beyond the irradiated areas. They require prior contact with the allergen.</li> </ul>	
<b>Keratitis and cataracts</b>	<ul style="list-style-type: none"> <li>- Inflammation of the cornea (keratitis) and temporary blindness (snow blindness) are observed a few hours after exposure. These symptoms are reversible in a few days, but can cause peripheral proliferations (pterygium) in the long term in the event of repetition.</li> <li>- In the long term, the cells constituting the crystalline lens are opacified (cataract) by UVA radiation, leading to a gradual loss of vision.</li> <li>- There is little risk of acute damage to the retina. However, observation of a bright light source can cause retina burning similar to that found in people who watch a solar eclipse without protection.</li> </ul>	UVA  UVB

	- In the long term, UV exposure may be involved in age-related macular degeneration.	
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<b>Genotoxic effects</b>		
<b>Photogenotoxicity</b>	<ul style="list-style-type: none"> <li>- An alteration in the chemical structure of the DNA can cause the appearance of mutations or lead to cell death (apoptosis).</li> <li>- Main types of damage caused by the UVB and UVA components of solar radiation to the DNA: breakage of the nucleotide chain, covalent adducts with proteins, and products of modification of bases.</li> <li>- The nature of the physico-chemical processes involved in the modifications caused by exposure to UV radiation depends on the wavelength of the incident photons.</li> </ul>	UVA UVB
<b>Skin photocarcinogenesis</b>	<ul style="list-style-type: none"> <li>- Mainly comprises basal-cell carcinoma (BCC), featuring slow development and local malignity, and squamous-cell carcinoma (SCC), which is more aggressive.</li> <li>- Main risk factor: intermittent, “burning” solar exposure, especially during childhood, for melanoma and BCC. It is acknowledged that SCC is associated with chronic exposure.</li> <li>- The genetic susceptibility and mechanisms involved in the photocarcinogenesis of melanomas and carcinomas are very different.</li> <li>- The roles of the different wavelengths of the solar spectrum also differ, according to the nature of the cancer.</li> </ul>	UVA (35%) UVB (65%)
<b>Immunosuppressive effects</b>		
<p>The skin’s immune defences protect against external aggression (bacteria, fungi and viruses). These defences are considerably impaired by weak doses of UVB and UVA (below the erythemal dose). This depression is reversible, and its restoration takes around 3 weeks. Following exposure to solar radiation, the skin’s defences are lowered, and skin infections have been observed in tanning centres with poor hygiene.</p>		
<b>Photo-induced skin aging (heliodermatitis)</b>		
<p>Mainly observed in uncovered areas: the face (nose and cheeks), back of the hands and forearms. It varies considerably from one person to another, and even between people of the same age and phototype who undergo the same chronic solar exposure (thus indicating individual genetic susceptibility). The histological modifications concern the epidermis and dermis, but the dermal connective tissue and its cells are the preferential target of solar radiation. UVA radiation, which penetrates deeply into this tissue, plays a large part in forming these lesions.</p>		
<b>Photo-induced skin cancers</b>		
<p>Some 80,000 new cases of skin cancer are diagnosed in France every year. The number is constantly growing, with an annual increase of 7 per cent. Ultraviolet radiation is the major aetiological factor responsible for these cancers, whose aggressiveness depends largely on their histological form. The process of cancerization is the result of damage caused by UV radiation accumulated in the epidermal cells.</p> <p>The mutagenic and carcinogenic effects of UVB radiation in animals and humans have long been known, whereas the oncogenic effects of UVA radiation have only been recognized for a few years. The carcinogenic risk of UV-emitting tanning devices is therefore a topical subject, which can be considered a public health problem.</p>		
<b>Skin carcinomas</b>	<ul style="list-style-type: none"> <li>- basal-cell carcinoma (60%): slow malignant extension, purely local (no metastasis)</li> <li>- squamous-cell carcinoma (30%): occurs on existing lesions (actinic keratosis, leucoplakia of the lips)</li> </ul>	UVA (35%) UVB (65%)
<b>Skin melanomas</b>	<ul style="list-style-type: none"> <li>- Risk factors: solar exposure, genetic (fair skin, failure to tan easily, blond or red hair, etc.), number of moles, family history of melanoma, high solar exposure during childhood</li> </ul>	UVA UVB
<b>Ocular melanoma</b>		
<p>Some publications have suggested a positive correlation between the onset of ocular melanoma and exposure to UV radiation. A recent French publication (relating to workers) seems to confirm this correlation.</p>		

## Health effects of ultraviolet radiation

### *Characteristics of phototypes:*

Phototype	Hair	Complexion	Freckles	Sunburn	Tan
I	Red	Milky	+++	Always ++	0
II	Blond	Pale	++	Always +	Slight tan
III	Light brown	Pale	+ or -	Frequent	Pale tan
IV	Dark brown	Dark	0	Rare	Dark
V	Dark brown	Dark	0	Exceptional	Very dark
VI	Black	Black	0	None	Black

### *Data specific to the French population*

- A specific study was conducted in 1998 on the SU.VI.MAX cohort (however, this cohort cannot be considered really statistically representative of the French population):

Phototype I	0.3%
Phototype II	13%
Phototype III	46.4%
Phototype IV	34.2%
Phototype V	6.1%

- According to a recent case-control study (Bataille et al. 2005, in press):

Phototype I	11.6%
Phototype II	25.7%
Phototype III	30.9%
Phototype IV	31.5%

### *Epidemiological studies – natural ultraviolet radiation*

The population receives 3 to 6 per cent of ambient ultraviolet radiation in temperate countries. Some examples of annual exposure:

Office workers	200 SED (exposure at weekends and holidays) = 3-6% of total ambient UV radiation (temperate countries)
Children under 18 years old	300 - 400 SED
Outdoor workers	400 - 800 SED

### Melanins and photocarcinogenesis

Epidemiological analysis of skin cancer (melanoma, basal-cell carcinoma and squamous-cell carcinoma) shows that predominantly phaeomelanic (red-haired) populations form the majority of skin cancer sufferers (IARC, 1992).

## Skin cancer

The various types of skin cancer, i.e. melanoma and non-melanoma skin cancers (basal-cell and squamous-cell cancers, described as epidermoid carcinomas by French authors), are now the most frequent types of cancer, and their frequency is increasing among all fair-skinned populations, reaching epidemic proportions. In Europe, it is estimated that although the population of the European Union (25 member states) will remain constant between 2000 and 2015, a 22 per cent increase in non-melanoma skin cancer in persons aged over 65, and 50 per cent in those aged over 80, is to be expected (Boyle et al., 2003).

Basal-cell and squamous-cell cancer (often collectively described as non-melanoma skin cancers) are the most frequent types of cancer. Basal-cell carcinoma is around four times more frequent than squamous-cell carcinoma, and both are 18-20 times more frequent than melanoma. However, the incidence estimated by surveying a population is much higher than that recorded in the registers. The total of 80,000 cases of non-melanoma cancer is therefore probably significantly underestimated, as numerous skin tumours, especially basal-cell and squamous-cell carcinoma *in situ*, are destroyed without histological analysis.

### Non-melanoma skin cancer

The epidemiology of non-melanoma skin cancer is far less well known than that of melanoma. In particular, only a little data has been systematically collected from populations.

Epidemiological studies (descriptive studies, cross-sectional studies, case-control studies and cohort studies) of non-melanoma skin cancer are analyzed below.

- Skin cancer mainly affects fair-skinned populations. Non-melanoma skin cancer mainly affects parts of the body chronically exposed to sunlight, such as the head and neck. However, a special feature of the anatomical distribution of basal-cell cancer is that it is almost absent from the back of the hands, and rare on the forearms. This cancer also affects parts of the face which receive relatively little light.
- Since the late 1930s, the incidence and mortality of non-melanoma skin cancer has been inversely related to latitude, i.e. proximity to the equator.
- There is an association with local levels of UV irradiation and studies of immigrants to Australia show that migration from a less sunny to a more sunny country is associated with increased risk.
- There is an association between the risk of non-melanoma skin cancer and outdoor employment.
- Several transverse cross-sectional studies conducted in Europe, Australia and the USA have analyzed a number of sun exposure parameters (job, leisure exposure, sunburn, actinic lesions) in different populations. These studies show that the risk of squamous-cell skin cancer is multiplied by a factor ranging between 1.7 and over 3, depending on the degree of exposure and the exposure parameter.

- A dozen case-control studies and at least three cohort studies in the USA and Australia have shown that there is a cumulative relationship between sun exposure and the risk of squamous-cell cancer, but no correlation between the accumulated dose of sun exposure and the risk of basal-cell cancer. Conversely, the risk increases with recreational exposure during childhood and adolescence, and the more sensitive an individual is to the sun, the higher the risk will be.

### Melanoma

In 2000, an InVS study estimated the number of new cases of cutaneous melanoma which had appeared in France at 7,231: 42 per cent in men and 58 per cent in women. However, the 95 per cent confidence interval is wide: 6,132-8,330 cases, because the estimate is based on registers which only cover part of the French population. Cutaneous melanoma is believed to have been responsible for 1,364 deaths in 2000, 704 of them in men (52 per cent), 47 per cent of whom died before reaching the age of 65. The number of deaths is known with a fairly high degree of precision.

Melanoma is one of the tumours whose incidence is increasing most. In France, between 1978 and 2000, the incidence increased by 5.9 per cent per annum in men, and mortality by 2.9 per cent per annum. In women, the incidence increased in the same period by 4.3 per cent per annum, and mortality by 2.2 per cent per annum. A man born in 1953 is ten times more likely to suffer from cutaneous melanoma than one born in 1913, while the factor is six to one for women. The net risk for a man of dying of cutaneous melanoma is multiplied by 2.7 between these two cohorts, while the risk is multiplied by 2.1 for women. In view of this rate of progress, the incidence of melanoma in 2005 can be estimated at 8000.

The individual risk of melanoma is influenced by host factors (pigmentation characteristics, reaction of skin to sun) and an environmental factor: sun exposure. Sun exposure is now considered to be a leading cause of melanoma. Studies conducted in the 1980s established a correlation between sun exposure and the risk of melanoma, but it is not a simple one. The total accumulated dose of solar radiation is not the only factor involved, and the type of sun exposure, according to age, plays an important role. Moreover, although the ultraviolet component of the solar spectrum seems to contribute to inducing melanoma, the ultraviolet wavelength(s) which contribute to the development of melanoma are not yet definitely known.

The conclusion that solar radiation causes melanoma is based on:

- the positive association between melanoma and residence at low latitudes;
- arguments drawn from studies of migrants, which indicate that the risk of melanoma is associated with exposure to sunlight in the place of residence in early life;
- the anatomical distribution of melanoma, which is more frequent in skin regions regularly or usually exposed to the sun, especially intermittently;
- findings drawn from case-control studies and cohort studies which indicate that melanoma is associated with residence in hot climates, is correlated with solar skin lesions, and is positively associated with intermittent sun exposure and a history of sunburn.

There is currently a fairly broad consensus that melanoma is caused by exposure to solar ultraviolet radiation. Armstrong and Kricger (1993) estimate that 67-97 per cent of melanoma in different populations is attributable to sun exposure. Recent epidemiological studies in the USA and Europe indicate that the development of moles (a lesion indicating the risk of melanoma) in children and the development of melanoma are influenced by short periods of intense UVB exposure (Autier et al., 2003, Fears et al. 2003). However, it is not impossible that exposure to UVA radiation plays a part in the development of melanoma (Armstrong, 2004).

Exposure to ultraviolet radiation may also play a part in the growth and tumoral progression of melanoma. Exposure to ultraviolet radiation causes local and systemic immunosuppression, which may be involved in promoting the growth of melanoma and non-melanoma cancer. An odd phenomenon is the existence of seasonal variations in the incidence of melanoma, with the peak incidence in summer. These variations, which have been known for some 20 years, have been observed in several populations and in both hemispheres, and no clear explanation has yet been given.

Exposure to sunlight, and especially intermittent recreational exposure, is the main known risk factor for melanoma. However, it has been known for some 20 years that sun exposure can also affect the survival of melanoma patients. These findings suggest that sun exposure may increase the melanoma survival rate, but may also be explained by an association between incidence and early detection of melanoma. The mechanism of this effect is not known, but it illustrates the possibility that several pathways exist in the malignant transformation of melanocytes.

### Other cancers

A number of ecological studies have suggested that intense sun exposure is liable to interfere with the incidence or mortality rate of some types of cancer, especially breast, colon, and prostate cancer and lymphomas. These rather surprising results need to be confirmed by new studies which take full account of sun exposure, supported by studies of the mechanisms involved.

### ***Epidemiological studies – artificial UV radiation***

A UV tanning session corresponds to exposure of at least 2 SED. In practice, one session corresponds to approximately 1 MED, i.e. for phototype II = 3 SED, phototype III = 5 SED and phototype IV = 7 SED.

Risk of skin cancer based on number of annual sessions in a 10-year period:

- 10 sessions: risk multiplied by 1.03
- 30 sessions: risk multiplied by 1.10
- 100 sessions: risk multiplied by 1.39
- 300 sessions: risk multiplied by 2.73.

## Melanoma

The risk factors are now well established: pale skin, number of naevi > 50, repeated sunburn (Gallagher et al., 2005).

Epidemiological studies, and especially a meta-analysis and a cohort study (Veierød et al., 2003), have found that the use of tanning devices increases the risk of skin melanoma by a factor of between 1.25 and 1.50. This risk increases with the frequency and duration of use, and is most marked when the exposure takes place in a young adult. It should be noted that a modest but significant increase in risk may lead to a major increase in the number of patients, due to the frequency of use among the population, as the use of artificial tanning is becoming increasingly popular. Exposure to artificial ultraviolet radiation may double the annual doses received in some areas (face, neck, arms, legs, etc.).

## Basal-cell and squamous-cell carcinoma

A number of case studies have linked exposure to artificial UV radiation to skin cancer, but very few case-control studies have explored the relationship between exposure to tanning devices and the risk of basal-cell and squamous-cell skin cancers. The only meaningful results are the findings of a 2002 American study, which showed that the risk that users of artificial tanning devices will develop squamous-cell skin cancer is multiplied by 2.5, and the risk of developing basal-cell skin cancer is multiplied by 1.5 (Karagas et al., 2002). As in the case of melanomas, the risks increase when the first exposure occurred at a younger age. These results suggest that the use of tanning devices is a risk factor for non-melanoma skin cancers.

## *Other effects of UV radiation*

### Effects of UV radiation on skin aging

Little is known about the skin condition of the populations of the industrialized countries, even though, in terms of public health, skin diseases are responsible for major morbidity. Chronic exposure to sunlight, or to other environmental factors such as cigarette smoke, frequently has repercussions on the skin, commonly known as photo-aging, that vary with anatomical location, total exposure time and phototype. The results of a French study published in 2000 (Malvy et al., 2000) suggest that the prevalence of skin photo-aging in the overall adult French population is determined by age, sex, phototype, region of residence and, for women, by menopausal status. Histologically observed actinic elastosis indicates actinic skin aging.

### Photodermatitis

Photodermatitis is a general term for all skin diseases involving photosensitivity, i.e. in which the skin shows abnormal reactions to light and UV radiation. Photobiological exploration can help diagnose the type of photodermatitis, detect the wavelength(s) involved in the disorder, and identify any product or agent involved in the reaction.

## Effects of UV radiation on the eye

In adults, the cornea of the eye absorbs all UVC and most UVB radiation. UVA radiation passes through the cornea and is absorbed by the crystalline lens. Visible light and infrared radiation reach the retina.

The acute risk of ultraviolet radiation and visible light for the eye:

- Acute keratoconjunctivitis: This condition appears following unprotected exposure to sunlight (particularly when the sun's radiation is reflected by snow, sand or cement) or to artificial light such as that of welding arcs, high-pressure discharge lamps and sunbeds. The symptoms of "arc flash" and "snow blindness" are tearing, redness and intense pain in the eyes, difficulty in keeping them open in the presence of light (photophobia) and a feeling of having sand in one's eyes.
- Acute solar retinopathy: Acute solar retinopathy occurs after looking at the sun (e.g. during observation of eclipses) or after prolonged exposure to sunlight without eye protection. Sources of intense artificial light such as welding arcs and some surgical microscopes can also damage the retina.

UV radiation can cause other lesions in some subjects in the long term:

- Cataracts: Epidemiological studies, some of which involved over 100,000 people, give reason to think that cataracts may be directly linked to UV exposure. This research demonstrated, among other things, that areas receiving considerable UV radiation show a high prevalence of cataracts.
- Senile macular degeneration (SMD): This frequent disease of the retina currently affects one of every four people in the 75-85 years age group. It causes partial but virtually incurable blindness by cutting out the centre of the field of vision. Repeated exposure to solar radiation (visible + UV) may lead to SMD. A recent epidemiological study (Tomany et al., 2004) of a cohort of over 6,000 individuals seems to establish a link between SMD and prolonged exposure to the sun (particularly during adolescence) and suggests that the risk is reduced by over 50 per cent if individuals protect their eyes by wearing sunglasses and hats, caps or visors.

## **Behaviour and exposure**

### Exposure to natural UV radiation

#### **Satellite observation**

Since 1985, the SoDa programme ([www.soda-is.com](http://www.soda-is.com)) has been using observations by meteorological satellites to measure the solar radiation received at ground level. The advantage of this system is the complete coverage of France's national territory by its grid, and the ease of measurement it offers. As the archive is currently limited to 21 years, however, it does not allow calculation of variations in UV exposure in relation to climate change.

### **Ground-level observation**

Two stations in France (Lille-Villeneuve d'Ascq and Briançon) are currently equipped with UV spectroradiometers, which are recalibrated regularly and have participated successfully in several European campaigns. These two stations for spectral measurement of solar UV radiation operate as a network with the following purposes: a) to study the natural variability of this radiation and the various parameters that modulate it; b) to detect any long-term trends; c) to provide spectral UV data allowing validation of climatologies based on satellite observation; d) to make this data available to various communities of potential users.

### **Sécurité Solaire data and the MOCAGE model: sequential monitoring of exposure based on meteorological satellites**

This is an application of the MOCAGE (MOdèle de Chimie Atmosphérique de Grande Echelle – Large-Scale Model of Atmospheric Chemistry) project. This model, which is already operational, forecasts UV indexes which are announced to the media by Sécurité Solaire.

Convergence and complementarity of information between this system and other measuring systems has not been studied.

### **Human behaviour with respect to natural UV radiation: review of the French data**

Most of the information available to date comes from studies of the populations of other Western countries (Australia, Canada, Great Britain, the Scandinavian countries), which also provide methodological principles and comparative data. The French data is rather limited.

### **The SU.VI.MAX cohort:**

The SU.VI.MAX cohort is a national cohort of volunteers participating in a controlled trial concerning food supplements, which includes an arm relating to studies of exposure to ultraviolet radiation. This study supplies information about the phototype of the population and analyzes behaviour by classifying individuals on the basis of their sun protection and exposure habits. The limitation of this national cohort in terms of knowledge of UV exposure lies in its demographic representativity, as all volunteers belong to the generations born between 1930 and 1960.

### **Montpellier child study**

A 1993 study, based on a self-administered questionnaire, of 573 children aged 3 to 15 in the Montpellier area, sought information on exposure to the sun during the summer of 1992. Exposure to UV radiation during the summer was considerable, exceeding 6 hours per day in some cases, which for an entire summer amounts to 366 hours of median exposure. This one-off study was not repeated, and no other geographical areas have been covered.

### **Health Examination Centres study**

This was a national study conducted in 2001 on a sample of 33,021 individuals aged

over 30 years old, resident in France, during a randomized multicentric interventional trial for prevention and early diagnosis of skin cancer in health examination centres. This study mainly provided information on how informed the adult population is concerning exposure to the sun. It was not intended to collect information on exposure itself, nor to determine the time budget of those surveyed with respect to UV exposure.

#### Exposure to artificial UV radiation

Information on exposure to artificial UV radiation is highly fragmented in France. In practice, only two studies estimate such exposure: a) the SU.VI.MAX study, which found that 22 per cent of women and 8 per cent of men have used a tanning device, and b) the Health Examination Centres Study, which showed that 2 per cent of subjects frequent tanning booths. The financial data for the industry does not allow analytical examination of this business, which according to manufacturers is growing.

#### Conclusions of studies on human behaviour with respect to UV radiation in French population groups

To date, there are no general studies of the French population, covering all age groups, on human behaviour regarding natural or artificial UV radiation. The studies that have been conducted have served to validate the questionnaires and a methodology. The behaviour of teenagers and young adults, however, is entirely beyond the scope of these studies, although these age groups are a commercial target for tanning booth businesses and are important for campaigns aimed at better informing the public about the risk of UV radiation. Although childhood is the period of life when intense exposure may have a substantial impact on the subsequent risk of cancer, the only study available on this aspect dates from 1993.

#### UV exposure and occupation

There is little documentation on work-related exposure to UV radiation. An evaluation of such exposure by occupation was made as part of an epidemiological study on ocular melanoma. In the absence of usable data from measurements, UV exposure was evaluated on the basis of the judgement of industrial health experts.

#### **Exposure to natural UV radiation (outdoor occupations)**

Outdoor occupations involve exposure to solar UV radiation. The intensity and frequency of such exposure may differ substantially between individuals having the same occupation, depending on local circumstances or the individual's activities. Seamen and fishermen are particularly exposed to this risk, as are mountain guides, ski instructors, swimming instructors, lifeguards, construction workers, etc.

#### **Exposure to artificial UV radiation**

Some occupations can involve exposure to artificially produced UV radiation. The spectrum of artificial UV radiation can be substantially different from that of solar UV radiation. In particular, it can include UVC radiation (arc welding), which is especially harmful.

## **Cosmetic products and UV radiation**

### **Sun protection products**

Current scientific knowledge indicates that sun protection products effectively protect against erythema (sunburn). This protection is necessary, but insufficient. There is no parallel between the acute effects of ultraviolet radiation, especially erythema, and its chronic effects, because their biological mechanisms are different. The disappearance of sunburn due to the use of sun protection products consequently does not guarantee an equivalent reduction in skin aging and the risk of cancer.

The acute toxic effects of sun exposure, especially erythema, are associated with the dose received, and also with the dose rate; the more intense the ultraviolet radiation, the greater the risk of sunburn. Sunscreens reduce the intensity of the radiation that penetrates into the skin, and therefore the dose rate and the risk of sunburn. The chronic toxic effects of sun exposure (skin aging, actinic keratosis and squamous-cell carcinoma) are the consequence of the total cumulative dose of ultraviolet radiation absorbed by the skin. If sun protection products are used to sunbathe for longer, the total dose absorbed by the skin will be very high, and may be even greater if no warning is given by sunburn.

The quantity of ultraviolet radiation that penetrates into the skin, after application to skin protected by a sun protection product, is reduced by a percentage that varies according to the value of the protection factor (PF) (sun protection factor =  $MED_{\text{protected}}/MED_{\text{unprotected}}$ ). For example, a product with a factor of 10 blocks 90 per cent of UVB radiation, but allows 10 per cent to pass through permanently. Thus if the dose received by the skin is equal to the MED, sunburn will appear, and the more intense the solar radiation the more rapidly it appears, despite re-application of the product. For a person with a fair phototype (who sunburns after approximately 20 minutes) using a sun protection product, this corresponds to the onset of erythema after 3 hours' exposure in the South of France in June, or one hour's exposure in the tropics.

Thus the incorrect use of a preventive measure can increase the risk by suppressing warning signs. Information about the correct use of sun protection products should therefore emphasize the fact that these products are designed to protect the skin under normal exposure conditions, but do not allow the time of exposure to be increased under any circumstances.

### **Risks related to the association of UV radiation with cosmetic products other than sunscreens and dietary supplements**

The pathologies classified under the general term "photosensitivity" are associated with abnormal skin reactions to radiation in the UV and visible spectra. These reactions may be caused by either sunlight or artificial light sources, and they present a great variety of clinical symptoms. Photosensitivity conditions may be divided roughly into two groups: genodermatitis, and photosensitive reactions to certain chemical and pharmaceutical

products. In addition, many pathological conditions may be exacerbated and in some cases triggered by UV radiation. Photosensitive reactions due to chemical products, either systemic or topical, represent a problem of growing importance, as new products are constantly arriving on the market. Once these agents penetrate the skin, they may absorb radiation and trigger an abnormal reaction. The reactions induced by UV radiation may be phototoxic, i.e. capable of affecting the entire population if the agent is provided in sufficient quantity, or linked to a biochemical and immunological reaction, which affects only part of the population. However, both types of reaction may be triggered simultaneously by the same molecule in the same individual.

### **International, European and national positions concerning UV-emitting appliances**

Appliances designed specifically for tanning were defined in an international standard prepared by the International Electrotechnical Commission (IEC). This standard came into effect in 1985 and was amended in 1990 and 1995 (IEC standard 60335-2-27). It classifies UV-emitting appliances under four types, depending on the power of the UVA and UVB radiation emitted.

Pursuant to article 5 of Directive 73/23/EEC (the Low-Voltage Directive), the European Commission considers that the legislation governing the safety of UV tanning devices used for cosmetic purposes (harmonized standard EN 60335-2-27: 1997) is insufficient. The Commission consequently requires appliances to be adapted to conform to the harmonized standard, which will prevent changes to the international standards after 1997 (especially the 4th edition, and its amendments 1 and 2) from being taken into account in the drafting of European standards.

A joint public health opinion issued by the radiological protection and health authorities of five Nordic countries (Sweden, Finland, Norway, Iceland and Denmark) in 2005 recommends, in keeping with the positions of international (WHO, ICNIRP, 2003), European (EUROSKIN, 2000) and national bodies (the French Academy of Medicine, the French Dermatological Society, etc.), that increased safety precautions be taken in the use of UV-emitting tanning devices.

As regards legislation, France has passed Decree no. 97-617 dated 30 May 1997 relating to the sale and public availability of certain tanning devices that use ultraviolet radiation. The Decree is supplemented by three executive orders. The important points of Decree no. 97-617 may be summed up as follows:

- The classification of appliances follows that of the 1995 IEC 60335-2-27 standard. Only type 1 and 3 UV appliances are permitted.
- It excludes phototype I subjects and minors from using these appliances.
- It provides for specific training for operators, who must always be present when tanning sessions are in progress (automatic, self-service machines are excluded).
- It provides for mandatory declaration of UV appliances to the Prefect, and an initial inspection of appliances, followed by inspections every two years. The technical regulations that certified inspection bodies are required to follow are set out in a circular.

## **Conclusions**

### Conclusions of Afsse experts' group

Exposure to UV radiation has a beneficial effect on human health, but the dose of UVB radiation necessary and sufficient for vitamin D synthesis is well below 1 MED per week. Exposure to UV radiation also has harmful effects, in both the short and long terms, on the skin, eyes and immune system.

Exposure to UV radiation is carcinogenic for human beings. This effect has long been known for UVB radiation, whereas the mutagenicity of UVA radiation has been demonstrated more recently.

Exposure to solar UV radiation is the main environmental cause of both non-melanoma skin cancer and melanoma. Prevention of skin cancer requires reduction of exposure to the sun. Furthermore, the recent publication of epidemiological studies which indicate a higher survival rate when the skin adjacent to the melanoma presents elastosis lesions, or a reduction in certain tumours (lymphomas) associated with exposure to the sun, do not justify the withdrawal of the recommendation in the European Code against Cancer to avoid excessive exposure to the sun.

It was long believed that UVA radiation presented no danger to health, and could be used as a tanning aid. We know today that this is not true, and that the UV doses received during artificial tanning sessions are added to those received during natural UV exposure, thus increasing the risks. Some epidemiological studies have failed to demonstrate the existence of a major risk. However, the recent publication of a meta-analysis of nine case-control studies and of a very large prospective cohort study allows us to assert today that tanning through exposure to artificial UV radiation increases the overall risk of melanoma by a factor of 1.25, i.e. an increase of one fourth. This risk is further increased by early or frequent exposure (by a factor of 1.6 to 1.7, and in the case of women who engaged in artificial UV tanning from 20 to 29 years of age an increase of 160 per cent). Furthermore in 2002, an American study showed that the risk that users of artificial tanning devices will develop squamous-cell skin cancer is multiplied by 2.5, and the risk of developing basal-cell skin cancer is multiplied by 1.5. Increased use of artificial UV radiation for tanning purposes is therefore a source of concern in terms of public health.

As regards the establishment of limit values on emission and exposure for carcinogenic risks, the proportionality between the erythema effectiveness spectrum and the carcinogenic effectiveness spectrum is fairly good, so it does not seem necessary to introduce multiplication of the action spectra. The erythema effectiveness spectrum may thus be considered as representative of all effects.

The use of sunlamps that only emit UVA radiation in tanning devices is inappropriate from the health standpoint. All suntanning is a response to aggression by UVA and UVB radiation, and the most recent studies have demonstrated that UVA radiation induces mutations and cancer. In addition, it is mainly UVA radiation that causes

photoaging.

There are a number of medical reasons for the prohibition of cosmetic products in tanning booths:

- The application of water/oil or oil/water preparations on the stratum corneum and the epidermis induces increased penetration of UVA and UVB radiation.
- Topical preparations can convey photosensitizing, phototoxic or photoallergenic substances that cause abnormal reactions, increasing the genotoxicity of UV radiation.
- Any use of topical products containing photoprotective agents, such as UVB or UVA filters, changes the radiation received by basal-layer cells in an unpredictable and potentially dangerous manner.

As regards the use of antioxidant preparations or taking oral products intended to protect or restore the natural defensive capacity of the epidermis, the results obtained to date are too fragmented and incomplete to allow us to recommend such practices during exposure to natural or artificial UV radiation.

The experts' group adds its voice to the many warnings and negative judgements concerning tanning by artificial sources issued by a variety of national and international public health bodies (WHO, ICNIRP, EUROSkin, NRPB, France's National Academy of Medicine) and unequivocally advises against the use of UV tanning devices. In addition, the experts' group wishes to retain the classification of UV-emitting appliances used for tanning purposes as set forth in the NF-EN-60335-2-27 standard, 4th edition, 2000.

#### Conclusions of the InVS experts' group

Three complementary sources of data are currently available for measuring the natural (environmental) exposure of the French population to UV radiation.

- The European SoDa programme measures solar radiation at ground level through observations made by meteorological satellites, and estimates the proportions of UVA, UVB and erythemal UV in solar UV radiation for France's entire territory, divided into squares 5 km to a side. It provides a daily, monthly and annual database dating back to 1985.
- Two ground-level solar ultraviolet radiation spectral measuring stations in Lille-Villeneuve d'Ascq and Briançon-Villard St Pancrace are equipped with UV spectroradiometers which record the spectrum of total solar UV irradiance at 30-minute intervals. The scientific purposes of these two measuring stations, which operate as a network, are to study the natural variability of this radiation and the parameters that modulate it, to detect the long-term trends, and to provide spectral UV data allowing validation of climatologies based on satellite observation and for biological, medical and atmospheric chemistry applications.
- Lastly, Météo France and Sécurité Solaire publish projections of the UV index (a general indicator of solar UV radiation) for metropolitan France from May to October.

Considering the impact of intermittent exposure and the role of exposure in childhood, information on human behaviour with regard to UV radiation is very important in the analysis of UV risk. Most of the information available today stems from studies of Western countries' populations (Australia, Canada, the United Kingdom, and Scandinavia). The data on the French population is somewhat limited, and mainly based on three studies:

- The SU.VI.MAX cohort, a national cohort of 12,741 volunteers participating in a controlled trial of dietary supplements. The cohort has provided information on the skin phototypes found in France and the subjects' behaviour with regard to UV exposure: 22 per cent of women and 8 per cent of men reported that they had used artificial UV radiation.
- A 1993 cross-sectional study, based on a self-administered questionnaire, of 573 children aged 3 to 15 in the Montpellier area, which estimated the exposure to UV radiation over the summer.
- A national study, conducted during a randomized trial for prevention and early diagnosis of skin cancer in Health Examination Centres. This cohort of 41,143 adults over 30 years of age provides information on adults' attitudes with regard to exposure to the sun, but was not intended to collect information on exposure itself. In this study, 2 per cent of subjects reported that they use sunbeds, but this figure needs to be measured more accurately.

Individual dosimeters allow direct measurement of the UV dose received, in addition to the data from questionnaires, and have been used to measure the exposure received by children or adults in ordinary daily activities or on holiday. Although certain studies included French subjects, no study to date has measured the long-term exposure of the French population to natural UV radiation.

In conclusion, to date there are no general studies of the French population, covering all age groups, on human behaviour with respect to natural or artificial UV radiation. The behaviour of teenagers and young adults is entirely beyond the scope of these studies, despite the fact that these age groups are a commercial target for tanning businesses and are important to campaigns aimed at better informing the public about UV risk.

Work-related exposure to UV radiation is not well documented on the whole. It has been evaluated by determining indices of exposure to natural and artificial ultraviolet radiation for each occupation. Outdoor occupations involve exposure to solar UV radiation of an intensity and frequency which vary greatly from one occupation to another and between individuals having the same occupation. Seamen, fishermen and mountain guides are particularly exposed occupational categories. Some occupations can involve exposure to artificially produced UV radiation. This artificial UV radiation can be substantially different from solar UV radiation. In particular, it can include UVC radiation (e.g. arc welding), which is particularly harmful.

## **Recommendations**

### **Recommendations by the Afsse experts' group**

## **1. Exposure to the sun**

Ultraviolet radiation plays a vital role in life on earth, yet exposure to solar UV radiation is the primary cause of skin cancer (the incidence of which is rising in a great many countries) and a major cause of cataracts. The health authorities should introduce measures to reduce the risks of exposure to both natural and artificial UV radiation to improve the health of the populations for which they are responsible.

The health authorities can make a significant contribution to reducing exposure to ultraviolet radiation by creating shady areas at bus stops, playgrounds, rest areas and schools, encouraging photoprotective measures in schools and recreation centres, inducing responsible behaviour on the part of businesses providing access to tanning devices or to natural solaria, and providing plentiful information liable to influence the public's knowledge and behaviour via the media.

Within the general population, children should be specifically targeted, as they spend more time outdoors than adults and are more at risk of the carcinogenic effects of UV radiation. The development of good habits in childhood helps substantially in ensuring regular use of suitable photoprotection in adulthood.

### **A preventive approach**

- Increased use of the UV index

Efforts to inform the public can be based on more widespread use of the UV index, a simple indicator of solar intensity. These projections, made by the national meteorological agency, should be extended to areas offering tourist activities, summer resorts in the mountains, public swimming pools, amusement parks, etc. Better knowledge of the UV index and the personal protection methods associated with different levels would certainly influence people's behaviour and make it possible to reach them with simple messages on the prevention of skin cancer.

- Preventing photo-induced skin cancers

As excessive exposure to the sun plays a fundamental role in initiating and promoting skin cancer, so prevention necessarily involves reduced exposure to the sun from the earliest childhood years.

The aim is not to impose sweeping photoprotection measures on the entire population and throughout life, but rather to inform our fellow citizens about the dangers of UV radiation and to advise them as to ways of protecting themselves from it, particularly for individuals in the paler phototypes, people with many naevi and people exposed to intense sunlight.

The medical and paramedical professions are the best placed to deliver messages on primary prevention, many of which are simply commonsense advice: teach people how to assess their own skin's sensitivity to sunlight, remind them that they should avoid the hours when sunlight is most harmful (between noon and 4 p.m. in summertime), make clothing the first line of defence (tightly-woven cotton clothing provides simple,

inexpensive protection), recommend the use of topical photoprotection, with the aim not of increasing the number of hours of exposure but of protecting skin areas that cannot be protected by clothing, limit exposure to artificial UVA radiation, and prohibit minors from using sunbeds.

Protective sunglasses are recommended from an early age during sports and outdoor activities. The material should be suitable for children and ensure sufficient UV filtration.

The foremost target of primary preventive education should be parents, not only because they can control how much their children are exposed, but also because they can serve as an example for adolescents (who are exposed far too much) and give them advice. Photoprotective measures should begin in the earliest years of childhood, as the habits developed in childhood will then have every chance of persisting into adulthood.

- Attract the attention of the resident population and tourists
- The attention of the resident population and tourists should be attracted by billboards carrying photoprotection messages and distribution of information leaflets in busy areas and areas where the risks of overexposure are high (stadiums, training grounds, public swimming pools, parks and gardens, the seaside, etc.).

- Educational strategies

As regards education, a multidisciplinary approach to sun protection should be encouraged at all educational levels. It is important to inform the staff in charge of outdoor activities, educate people who run activities for children, adolescents and adults, and encourage parents to follow the recommendations of the sun protection programme before children go to school or leave for outdoor activities. Information about sun risk prevention should be given in schools.

### **Proper use of sun protection**

The experts' group recommends effective use of sun protection items, but this term must not be taken to mean topical UV filters alone. Sun protection involves a number of measures designed to reduce exposure to ultraviolet radiation:

- Stay in the shade.
- Limit exposure during the hours when the sun is near its zenith (noon-4 p.m.).
- Wear protective clothing.
- Wear a wide-brimmed hat to protect eyes, face and neck.
- Protect your eyes with wrap-around sunglasses complying with the recommendations of the European Commission.
- Use topical sun protection products with a protection factor of 15 or higher on areas not protected by clothing.
- Keep children under one year of age out of the sun.

Draft recommendations concerning the labelling of sun protection products are being

developed by Afssaps. This project is designed to harmonize the methods of evaluation and labelling of sun protection products, simplify technical information, classify products in a limited number of categories to facilitate choice by consumers, and provide information on proper use of sun protection products to consumers.

## **2. Tanning facilities**

The UV radiation received in tanning sessions is added to natural UV radiation, and thus contributes to skin photocarcinogenesis. There is no proof that the use of artificial tanning devices is less dangerous than exposure to the sun; it is therefore recommended that people should not expose themselves to artificial UV sources.

Considering that exposure to UV radiation in general should be limited, the use of UV tanning devices for other than medical purposes cannot be recommended. However, if they are used, the experts' group considers that it is necessary to limit the risks for users by limiting the annual UV doses and providing users with all the information they need to reduce skin damage and all other health risks<sup>1</sup>. In addition, it is important that tanning device operators be sufficiently well acquainted with the risks associated with UV radiation to help users reduce their personal risk and to avoid improper use of the appliances. In view of the importance of this personalized advice and of direct control, the use of automatic appliances is not acceptable under any circumstances.

The experts' group recommends that people aged under 18 and those who are particularly sensitive to ultraviolet radiation (skin phototypes I and II) should be strongly advised not to use artificial tanning devices, and supports the view of the WHO, which recommends that individuals should not use tanning devices if they are phototype I, have numerous naevi and/or freckles, suffered frequent sunburn in childhood, present pre-malignant or malignant skin lesions or sun-damaged skin, have applied cosmetics or take medicines which could increase their sensitivity to ultraviolet radiation.

The health authorities have an important role to play in discouraging exposure to artificial ultraviolet radiation, at least in the locations devoted to physical exercise that are under the authorities' control (swimming pools, gymnasias etc.).

In practical terms, the health authorities could:

- put a stop to advertising claiming that the use of tanning devices carries no risk and may be good for one's health, and stop the promotion of artificial tanning;
- introduce or strengthen legislation in order to ensure that tanning device operators provide accurate and adequate information to their customers;
- more strictly control the age limits at which customers can be admitted (over 18 years);
- conduct occasional inspections to ensure that eye protection is actually used and proper hygiene is maintained;
- provide specific guidance for adolescents on the dangers of artificial tanning (sun protection programme).

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<sup>1</sup> The representative of the French National Academy of Medicine on the experts' group took a different opinion on this point. See Chapter VII.2 and Annex.

Current French legislation provides that irradiance in the UVB band of type UV-1 and UV-3 appliances must not exceed 1.5 per cent of their total UVA + UVB irradiance.

For the sake of clarity and ease of interpretation, this provision could be replaced by a reference to the tropical sun at the zenith.

The effective irradiance of a tanning device should not exceed the irradiance of the tropical sun, and the spectral distribution of its radiation should be fairly close to that of the tropical sun. The irradiance and spectral distribution should meet the specifications for type 3 UV appliances as defined in the European EN 60335-2-27 standard (1997).

The UV index of a type 3 tanning appliance is approximately 12, the equivalent of a tropical sun. If the proposed changes in IEC standard 60335-2-27 were implemented, they would allow a UV index of 24 – a level of exposure not reached naturally anywhere on earth.

Most medical and scientific bodies, learned societies and international organizations recommend avoiding exposure to artificial UV radiation. If some people choose to ignore these recommendations, however, it is advisable to set certain limits: 100 J.m<sup>-2</sup> E<sub>eff</sub> for first exposure to UV appliances, and total annual exposure of three series of ten sessions for melano-competent subjects of phototype III (15 kJ.m<sup>-2</sup>) and phototype IV (21 kJ.m<sup>-2</sup>).

This does not mean that the use of UV devices presents no health risks. The formula used to calculate risk has predicted a significant risk of non-melanoma skin cancer, and some clinical trials have shown a significant increase in the risk of melanoma above ten annual exposure sessions.

### **Regulatory changes**

The working group proposes the following changes to the regulations:

- It is recommended that the exposure time offered by sunbed timers be limited by indexing it to the total power emitted by the appliance, such that the latter cannot deliver more than 8 SED units.
- All melano-compromised subjects should be informed that under no circumstances should they be exposed to artificial UV radiation.
- The prohibition on minors should be strictly enforced.
- Following the recommendation of the WHO, the customer should be required to complete, sign and date an informed consent form before beginning any series of artificial tanning sessions. One copy of the form is for the customer, while the other must be preserved for two years by the tanning salon. This document, which must be presented at the request of inspection officers, as the latter are defined by the regulations, would provide more precise information on the use of tanning devices (see the annexed draft consent form).
- The working group suggests that only type 3 appliances be allowed under French regulations; this will simplify inspections and avoid the dangerous appliances that attempts to deregulate the industry would bring onto the market.
- Advertising and promotion of tanning devices and of the establishments making them available to the public should be prohibited.
- All claims that exposure to artificial UV radiation offers health benefits should be

prohibited.

- The power of UV tanning devices should be limited to that of a tropical sun (UV index 12, or 0.3 W/m<sup>2</sup> eff (weighted by the erythemal effectiveness spectrum). This proposal would align the French position with that of the Scandinavian countries, where over 35 per cent of the population uses UV appliances but people are much less exposed to the sun than in France.

### **3. Other UV sources designed for domestic or industrial use**

Some “broad-spectrum” sources supposed to reproduce the solar spectrum, including its UV components, are currently on sale. These sources are offered for direct lighting use instead of ordinary tubes and lamps, especially for home lighting and the construction of solariums, and in the workplace. The risks which must be taken into account relate in particular to the acute and long-term ophthalmic risks, the risk of photosensitization and the risk of skin cancer.

At the request of the experts’ group, Afsse commissioned the Laboratoire National d’Essais (French National Test Laboratory) to perform irradiance and spectral distribution measurements in various configurations involving “broad-spectrum” lamps and tubes for domestic or similar use. While the first results on a single model of lamps and tubes show that the UV emissions are negligible, in view of the results of tests on other lamp models it may be necessary to establish a regulatory framework on the basis of the Council Directive of 19 February 1973<sup>2</sup>. The regulations relating to the sale and availability to the public of certain tanning devices that use ultraviolet radiation could then be extended to all UV-emitting sources made available to the public.

When selling broad-spectrum lamps, manufacturers and distributors should therefore inform consumers of the risks of prolonged exposure to UV radiation, and clearly explain the proper practices for use of their products. In fact, it seems that most of these products are not used for their initial purpose (e.g. horticulture or industrial use). Statements that this type of lamp may have a beneficial effect on health, or even that they can be used for ordinary day-to-day lighting, should be prohibited. Their use in premises open to the public, and especially to children, or as lighting in workplaces, should consequently be prohibited.

#### InVS recommendations

To improve knowledge of the exposure of the French population to ultraviolet radiation and knowledge of the effects of such exposure on the health, the InVS working group has issued the following six recommendations.

#### **• Recommendation 1: Improving knowledge of environmental exposure to UV radiation**

As regards environmental exposure to ultraviolet radiation, two complementary systems

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<sup>2</sup> Directive relating to electrical material designed for use within certain voltage limits, which requires technical measures to be taken to ensure that dangerous radiation is not produced.

exist, which must be supported and whose consistency should be encouraged: a satellite measuring system and a system based on ground-level measuring stations.

These two systems are wholly complementary: the satellite system is based on measurements and a calculation that provides a grid covering the whole country, while ground-level measurements enable the model to be validated in several atmospheric situations. Coordination of these projects should be encouraged.

Measurement of the exposure to UV radiation throughout the French territory has been conducted, but only partly exploited. This project should be encouraged in order to create an ultraviolet radiation database for the whole country and evaluate and monitor exposure by associating it with a geographical information system. This would produce a digital atlas of the distribution of exposure to UV radiation, and a major source of reliable data for evaluation of the health impact of natural UV radiation. There would also be a regional quantification of the risks to different population categories.

The convergence and complementarity of these projects with the Météo France MOCAGE model should also be systematically studied.

- **Recommendation 2: To improve knowledge of behaviour relating to natural and artificial UV radiation**

It is essential to evaluate practices relating to exposure to natural and artificial UV radiation by all age groups of the population, including children, teenagers and young adults. The current French studies do not cover the whole population, and do not focus on the teenage and young adult age groups, which have the most leisure time and are the commercial target of tanning businesses.

Studies based on existing validated questionnaires should be conducted in several regions of France to take account of the differences in distribution of phototypes, sunshine and behaviour in relation to natural and artificial UV radiation. Intermittent exposure during holidays should be evaluated, including for children. The practice of exposure to artificial UV radiation (sunbeds) should be specifically studied, by describing the financial data for this market (which have never been published), investigating practices, and endeavouring to draw up more accurate profiles of the people who frequent these centres, the history of their exposure to UV radiation, and their motives. Several current cohort studies (adults and children) have been organized to give more information about environmental and nutritional exposure. The addition of a “UV exposure knowledge” arm could be envisaged.

If these studies are repeated, the impact of prevention campaigns could be measured, and their messages adapted if necessary.

- **Recommendation 3: To improve knowledge of advertising messages in relation to exposure to UV radiation**

The social representations that support and encourage exposure to UV radiation of natural and artificial origin should be analyzed. These representations, which are strongly present in advertising messages, either directly or indirectly, are a major part of the reason for exposure to UV radiation. There are also open advertising practices aimed at the general public, networks of beauty treatment professionals, and health

professionals. These messages probably represent the majority of the information messages regarding the UV risk received by the population, and are only moderately counterbalanced by health education messages. Knowledge of these advertising campaigns, analysis of their impact on the behaviour of populations, and the conformity of the messages with legislation should be systematically pursued, as should work on knowledge of the social representations of UV exposure. This project could be included in the terms of reference of the National Health Prevention and Education Institute.

- **Recommendation 4: To improve knowledge of occupational exposure to UV radiation**

Some jobs are particularly exposed to solar or artificial UV radiation. Better characterization of occupational exposure to artificial UV radiation seems necessary. This characterization of exposure could be useful for the conduct of epidemiological studies designed to confirm and improve knowledge of the health risks of such exposure, and would allow the introduction of suitable preventive measures.

- **Recommendation 5: To coordinate actions in the field of knowledge of exposure to UV radiation: proposal for an observatory of human exposure to UV radiation**

The actions required to improve knowledge of the population's exposure to UV radiation are based on a wide variety of skills. Their introduction and development should be designed to cover different fields of UV exposure. This requires a global approach, a concerted strategy between the parties involved, and an operational structure. Such an approach could be coordinated by a body which could be called the "Human UV Radiation Exposure Observatory", and would be responsible for these actions and the production of indicators.

Such an observatory should employ metrologists familiar with the physics of UV radiation, skin cancer epidemiologists and dermatologists. It should guarantee the consistency of actions in the field, and ensure that studies of the UV risk exhaustively cover the various population categories and exposure practices.

It is not essential for this body to have an independent administrative structure: agreements between establishments could govern its operation, and InVS could handle its administrative requirements.

- **Recommendation 6: To improve knowledge of the effects of UV radiation**

Non-melanoma skin cancers (squamous-cell and basal-cell carcinoma) are not subject to epidemiological surveillance in France. Knowledge of the incidence of these cancers does not necessarily require the creation of registers. In view of the moderate severity of these carcinomas, the complexity of the health care network that identifies them and their social consequences (e.g. an inability to obtain bank loans), which suggest under-declaration, the methodology of these studies should be adapted and tested at a feasibility stage. Knowledge of the incidence of lesions indicating strong UV exposure, such as naevi, should also be obtained, primarily through feasibility studies.

The organization and repetition of population studies could enable indicators of the history of past exposure to be obtained at individual level.