LIMITATION OF EXPOSURE TO UV IN COMPARISON WITH IONISING RADIATION: POLICES AND REGULATIONS

Branko F.M. Bosnjakovic *
Radiation Protection Directorate, Ministry of Housing, Planning and Environment
Leidschendam, The Netherlands

INTRODUCTION

Physical characteristics and biological effects of ultraviolet (UV) and ionising radiation display similarities. The present paper endeavours to give an overview of facts and approaches relevant for protection against UV as compared with ionising radiation (1).

EXPOSURES AND RISKS

Exposure to UV radiation may cause erythema of the skin and inflammation of the eye (photokeratitis and photoconjunctivitis). These effects proceed within a few days after the exposure has exceeded a certain threshold value. There are indications that chronic exposure to UV radiation may induce cataract. Exposure of the skin contributes to the ageing of the skin and the risk of the occurrence of skin carcinoma. There is no indication for a threshold below which the skin cancer risk is not affected.
There is little principle difference with respect to ionising radiation, the exposure to which can cause both acute (non-stochastic) and delayed (mainly stochastic) effects. It should be remarked, however, that the dose-effect relationship for photocarcinogenesis in human populations is basically a quadratic function (1A). Therefore no elegant concept like that of the collective dose for ionising radiation exists.

Also, whereas the evidence for beneficial effects of ionising radiation is still under discussion, the positive effects of UV irradiation (vitamin D production, pigmentation) are more clearly defined.

It is of interest to compare the overall risks of exposure to UV and ionising radiation respectively. For simplicity, one can consider in case of UV the carcinogenic effect of skin exposure, which is for more than 90% due to the natural source, the sun. In reference (1B), the corresponding individual risk has been calculated for the Netherlands, on the basis of statistical data on skin cancer and melanoma mortality, to be in the range (0,5 - 2,5) 10^{-5} per year. The range reflects the uncertainty about which fraction of melanoma mortality is due to UV exposure (1C). This situation is not grossly dissimilar from that for ionising radiation, where approximately 80% of exposure is due to natural sources. In a low natural background radiation country like the Netherlands, a corresponding individual risk can be calculated to be $2{,}5 \times 10^{-5}$ per year on the basis of the linear risk factor recommended by ICRP.

BASIC EXPOSURE SITUATIONS

Basic principles of dose limitation recommended by ICRP - justification, As Low As Reasonably Achievable (ALARA) principle, individual dose limits -

* Member, IRPA International Non-Ionising Radiation Committee

are not meant to be applied uniformly in all exposure situations. The individual dose limits for exposure to ionising radiation e.g. do not apply to medical and natural sources of radiation. Besides the three tradional situations - patients' exposure, exposure in the work-place, exposure of the members of the public - additional categories may be needed. They are summarised for UV and ionising radiation in Table I.

Table I

Basic situations of exposure to radiation		Ionising	UV
Patients exposure (intentional)	preventive		+
	diagnostic	+	+
	curative	+	+
Occupational exposure (unintentional)	enchanced natural	+	+
	planned/within limits	+	+
	unplanned/accidental	+	+
Public exposure: (intentional)	cosmetic		+
	enhanced natural		+
(unintentional)	enhanced natural	+	+
	planned/within limits	+	+
	unplanned/accidental	+	+
	large-scale emergencies	+	

Whereas there exists an overall analogy, some differences between UV and ionising radiation are striking. No preventive medical uses of ionising radiation are common whereas they do exist for UV, such as to achieve desensibilisation or vitamin D production. No sudden large-scale accident emergencies are known for UV sources in contrast to ionising radiation, where risk management, planning and preparedness for nuclear accidents form major ingredients of the policy and regulatory processes. On the other hand, slow changes of natural UV levels with potentially serious global deterioration of human and ecological environment may occur if the ozone layer is depleted due to certain forms of pollution.

Finally, intentional exposure for tanning purposes has become a characteristic application of UV radiation in many industrialised countries. This type of exposure is without analogon in the field of ionising radiation.

LIMITATION OF INTENTIONAL EXPOSURE

In North West European countries, a substantial fraction of the population have become regular users of tanning equipment (Sweden 4% (1D), the Netherlands 7% (1E)).

The effects of UV radiation are wavelength dependent. Using a spectral effectiveness function or action spectrum the radiant exposure (in J/m^2), or irradiance (in W/m^2) can be weighted per wavelength with a factor appropriate for the biological effect considered. Integration over the whole UV spectrum produces an effective radiant exposure, or effective irradiance.

Action spectra for skin erythema and for pigmentation, respectively, can be defined as a function of the skin type. They are similar but not identical. Representatives from two international organisations, IEC (International Electrotechnical Commission) and CIE (Commission Internationale d'Eclairage), have agreed at Amsterdam in 1987 to recommend and use the simplified action spectrum proposed by McKinlay and

Diffey (1F). So far, no such general agreement has been arrived at as far as the pigmentation is concerned. Also there is no agreement on an action spectrum on carcinogenesis although there are strong indications that the latter is well represented by the erythema action spectrum.

Since 1980 several countries (USA, Canada, Sweden, UK, FRG, Australia, the Netherlands) have promulgated regulations or recommendations concerning the exposure to tanning equipment, as summarised in (4). The general aim is to prevent acute, undesirable effects (and in some cases to limit the risk of chronic effects) without undue curtailment of the desired cosmetic effect. In most countries, the requirements concern a limitation of the irradiance (in W/m^2); a limitation of the initial and/or total radiant exposure (in J/m^2) during an irradiation course; the existence of devices such as a timer and an emergency switch; the use of eye protection; the information to be provided to the public, especially concerning the hypersensitive individual, the effects of drugs, cosmetics etc.

From the foregoing, it is clear that the total annual radiant exposure is not limited. It may be interesting to mention that the skin cancer incidence in the Dutch population has been calculated to increase by a few percent due to the estimated exposure from tanning equipment.

LIMITATION OF UNINTENTIONAL EXPOSURE

Unintentional exposure from artificial UV sources can occur both in the work-place (research laboratories, curing of ink and lacquers) and for the members of the public (illumination, amusement industry). American Conference of Governmental Industrial Hygienists (ACGIH) was the first body to formulate corresponding threshold limit values (2). The underlying principles and limiting values have been further developed by the IRPA International Non-Ionising Radiation Committee (INIRC) (3) and by the Health Council of the Netherlands (4). Both latter documents require the ALARA principle to be applied. The purpose of the IRPA/INIRC guidelines is to provide limits of exposure to UV and represent conditions under which it is expected that nearly all individuals may be repeatedly exposed without adverse effects. The Dutch Health Council states more explicitely that the exposure limits recommendations are based on two principles:

- harmful effects for which there is a threshold must be avoided
- the risk of chronic effects for which there is no threshold dose, is to be restricted to a reasonable value.

The exposure limits apply to exposure during a normal working day, and are adequate to protect lightly pigmented individuals, both in the working and general population. They do not apply to lasers; exposure duration less than 0,1 microseconds; some rare, highly photosensitive individuals; individuals concomitantly exposed to photosensitising agents; and to aphakic individuals (persons with a lens removed).

The exposure limit has a minimum value of 30 J/m^2 at 270 nm. In the wavelength region up to 310 nm, it is based upon combined effects on the skin and the eye, and is equal in all three documents. At higher wavelengths the exposure limit of the Health Council of the Netherlands has been derived from the erythema action spectrum. In the 310-400 nm region ACGIH and INIRC/IRPA propose to limit the irradiance to 10 W/m^2 for exposure durations longer than 1000 s. For shorter exposures the radiant exposure is limited to 10 kJ/m^2. These recommendations are related to the possible induction of the cataract. The Dutch Health Council concluded, however, that an exposure limit related to the cataract is only necessary in case of chronic exposures and recommends a value of 1 W/m^2.

It has been estimated (4) that a radiant exposure equal to the proposed exposure limit corresponds, for average exposure conditions, to skin cancer risk increase of 25% for an average indoor worker. The skin cancer risk of an outdoor worker is a factor 5 larger than that of an indoor worker. The risk of skin cancer induction in case of chronic exposure to UV radiation approximating the exposure limit appears to be much less than the extra risk caused by working outdoors.

CONCLUSIONS

Both UV and ionising radiation may cause acute and late effects. The average mortality risk due to overall exposure is similar in both cases. Several basic situations of exposure are comparable; but UV exposure is characterised by (a) intentional use for cosmetic purposes, and (b)lack of sudden large-scale emergencies. The limitation of unintentional exposure to UV and ionising radiation follows similar principles of protection. It would be desirable to deepen further the degree of uniformity and harmonisation in protection against these two types of radiation.

References

(1) This paper is mainly based on the following contributions from the proceedings of a seminar on "Human exposure to UV radiation: risks and regulations", held in Amsterdam, 23-35 March 1987, and published in Excerpta Medica, International Congress Series 744.

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