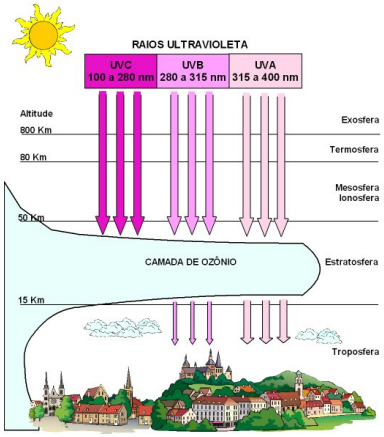
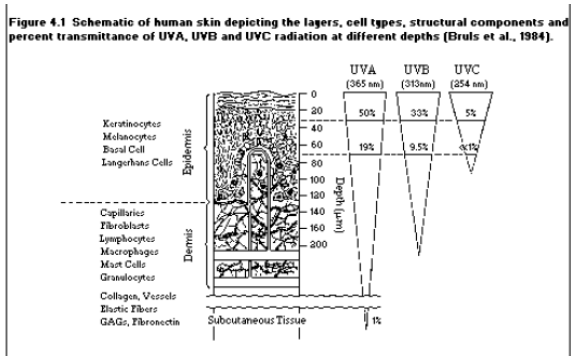
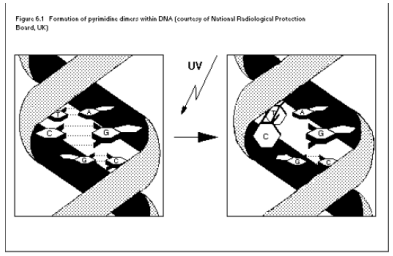


UV

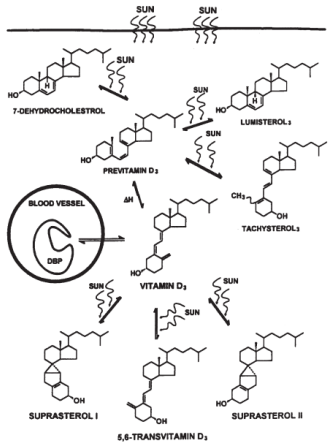


UV

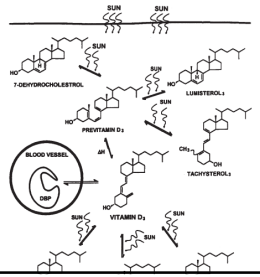


Efeitos Biológicos da RUV

- Agudos (Imediatos)
  - Eritema de pele
  - Foto conjuntivite
  - Opacificação temporária do cristalino
- Tardios (longo prazo)
  - Envelhecimento da pele
  - Indução de câncer de pele (não-melanoma e melanoma)
  - Catarata
- Bronzeamento
- Fotoproteção
- Produção de vitamina D
- Fototerapia
- Imunomodulação(??)



Holick et al (*20*) estimate that exposure of the whole body in a bathing suit to 1 (individual) MED is equivalent to ingesting 10,000 IU of vitamin D. Thus exposure of 6-10% of the body surface to 1 MED is equivalent to ingesting 600-1000 IU. The current recommended daily intake of vitamin D for children is 400 IU and for adults is 200 IU (*21, 22*), although recent research suggests that this should be increased to 600 IU (with some suggesting daily intake of up to 4000IU) in the absence of sunlight exposure. Based on these data, daily exposure of 6-10% of the body surface (one arm, one lower leg, or face and hands) to 1 MED should be sufficient to maintain vitamin D sufficiency (>50nmo/l). It should be noted however that recent research suggests that the lower level of vitamin D sufficiency should be raised to at least 80nmo/l (*23*).



- MED – dose eritematosa mínima (1 MED – avermelhamento mínimo, pele sensível, 24h)
  - Depende da pessoa, da parte do corpo
- SED – dose eritematosa padrão –
  - 1 SED = 100 J/m^2

Table A2. Examples of minimal erythemal doses.

Central wavelength nm	Bandwidth (FWHM[a]) nm	Median MED J cm^{-2}	95% range J cm^{-2}
300	5	0.027	0.015–0.051
320	10	1.9	1.0–3.4
330	15	5.6	3.1–10
350	30	19	11–35
370	30	27	16–47
400	30	62	38–102

[a] Full-width at half-maximum.

Table A3. Dose response values.

Exposure level	Effect	Reference
0.1 MED	*p*53 and *p*21 activated	Ponten 1995
0.3 MED	Sunburn cells just detectable	Cesarini 1996
0.3 MED	Immunosuppressive effect in melanocompromised individuals	Kelly 1998
0.5 MED	Modification and depletion of Langerhans cells	Cooper 1992
1.0 MED	20 sunburn cells/cm^2	Cesarini 1996
1.0 MED	Immunosuppressive effect in melanocompetent individuals	Kelly 1998
2 MED	150 sunburn cells/cm^2	Cesarini 1996
3 MED	400–500 sunburn cells/cm^2	Cesarini 1996
6–10 MED	Blistering	Everett 1965

$$\mathrm{ery}(\lambda) = 1.0 \qquad 250\,\mathrm{nm} < \lambda \leq 298\,\mathrm{nm}$$
$$\mathrm{ery}(\lambda) = 10^{0.094\,(298-\lambda)} \qquad 298\,\mathrm{nm} < \lambda \leq 328\,\mathrm{nm}$$
$$\mathrm{ery}(\lambda) = 10^{0.015\,(140-\lambda)} \qquad 328\,\mathrm{nm} < \lambda \leq 400\,\mathrm{nm}$$

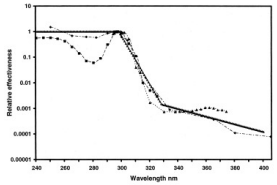


Fig. A1. Erythemal action spectra. The CIE (1998) reference action spectrum for erythema in human skin (solid line), an erythema action spectrum (Anders et al. 1995) determined using dye lasers (triangles), and the CIE (1935) action spectrum (squares) are shown with the action spectrum of human skin adapted from Parrish et al. (1982) for 8 h after irradiation (diamonds). If measured at 24 h, the MED differs below 300 nm.

ICNIRP, 2004

Exposure of the eyes

Ultraviolet radiant exposure in the spectral region 180 to 400 nm incident upon the unprotected eye(s) should not exceed 30 J/m² effective spectrally weighted using the spectral weighting factors contained in Table 1, and the total (unweighted) ultraviolet radiant exposure in the spectral region 315 to 400 nm should not exceed 10k J/m².

RECOMENDAÇÕES – ICNIRP / WHO / OIT

$$E_{eff} = \Sigma\ E_\lambda \cdot S(\lambda) \cdot \Delta\lambda$$

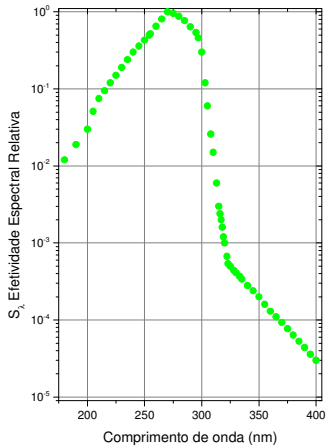
Exposure of the skin

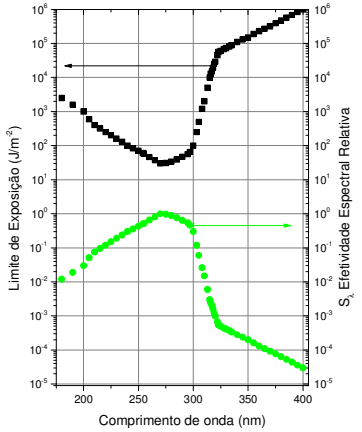
For the most sensitive, non-pathologic, skin phototypes (known as "melano-compromised"), ultraviolet radiant exposure in the spectral region 180 to 400 nm upon the unprotected skin should not exceed 30 J/m² effective spectrally weighted using the spectral weighting factors contained in Table 1. This limit should be considered a desirable goal for skin exposure to minimize the long-term risk, but it must be recognized that this limit is difficult to achieve in sunlight and judgment must be used in its practical application. It has a very substantial safety factor for dark skin phototypes (known as "melano-competent") and more generally for individuals who have been conditioned by previous, repeated exposures (known as "melano-adapted," i.e., tanned).

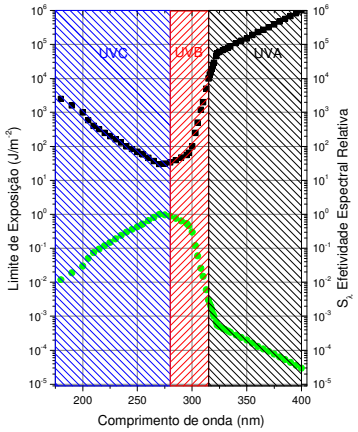
Table 1. UV exposure limits and spectral weighting function.

λ[a] (nm)	EL[d] (J m^{-2})	EL[d] (mJ cm^{-2})	$S(\lambda)$[b]	λ[a] (nm)	EL[d] (J m^{-2})	EL[d] (mJ cm^{-2})	$S(\lambda)$[b]
180	2,500	250	0.012	310	2,000	200	0.015
190	1,600	160	0.019	313[c]	5,000	500	0.006
200	1,000	100	0.030	315	1.0×10^4	1.0×10^3	0.003
205	590	59	0.051	316	1.3×10^4	1.3×10^3	0.0024
210	400	40	0.075	317	1.5×10^4	1.5×10^3	0.0020
215	320	32	0.095	318	1.9×10^4	1.9×10^3	0.0016
220	250	25	0.120	319	2.5×10^4	2.5×10^3	0.0012
225	200	20	0.150	320	2.9×10^4	2.9×10^3	0.0010
230	160	16	0.190	322	4.5×10^4	4.5×10^3	0.00067
235	130	13	0.240	323	5.6×10^4	5.6×10^3	0.00054
240	100	10	0.300	325	6.0×10^4	6.0×10^3	0.00050
245	83	8.3	0.360	328	6.8×10^4	6.8×10^3	0.00044
250	70	7	0.430	330	7.3×10^4	7.3×10^3	0.00041
254[c]	60	6	0.500	333	8.1×10^4	8.1×10^3	0.00037
255	58	5.8	0.520	335	8.8×10^4	8.8×10^3	0.00034
260	46	4.6	0.650	340	1.1×10^5	1.1×10^4	0.00028
265	37	3.7	0.810	345	1.3×10^5	1.3×10^4	0.00024
270	30	3.0	1.000	350	1.5×10^5	1.5×10^4	0.00020
275	31	3.1	0.960	355	1.9×10^5	1.9×10^4	0.00016
280[c]	34	3.4	0.880	360	2.3×10^5	2.3×10^4	0.00013
285	39	3.9	0.770	365[c]	2.7×10^5	2.7×10^4	0.00011
290	47	4.7	0.640	370	3.2×10^5	3.2×10^4	0.000093
295	56	5.6	0.540	375	3.9×10^5	3.9×10^4	0.000077
297[c]	65	6.5	0.460	380	4.7×10^5	4.7×10^4	0.000064
300	100	10	0.300	385	5.7×10^5	5.7×10^4	0.000053
303[c]	250	25	0.120	390	6.8×10^5	6.8×10^4	0.000044
305	500	50	0.060	395	8.3×10^5	8.3×10^4	0.000036
308	1,200	120	0.026	400	1.0×10^6	1.0×10^5	0.000030

[a] Wavelengths chosen are representative; other values should be interpolated (see Eqns. 2a–c).
[b] Relative spectral effectiveness.
[c] Emission lines of a mercury discharge spectrum.
[d] EL for a monochromatic source, but also limited by a dose-rate of 10 kW m^{-2} (1 W cm^{-2}) for durations greater than 1 s as well in order to preclude thermal effects.

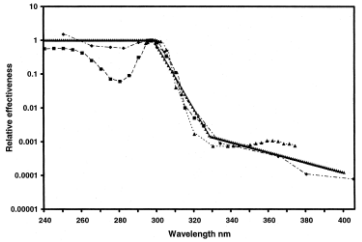






ÍNDICE UV – para público, educação

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



Onde:
E_λ é a irradiância solar espectral, expressa em $W\cdot/(m^2\cdot nm^1)$,
para o comprimento de onda λ;
dλ é o intervalo de comprimento de onda usado na integração
S_{er} (λ) é o espectro de ação de referência para eritema;
k_{er} é uma constante igual a 40 m^2/W.

Radiometria: Grandezas e Unidades para o Feixe

- P = **Potência Radiante** (ou **Fluxo Radiante** ϕ)
- **(W)** = energia radiante emitida por unidade de tempo **Q** = **Energia Radiante (J)** = energia do campo eletromagnético (emitida pela fonte)

$Q = P \times t$ $\quad Q = \Sigma N \times (h\nu)$

- **E = Irradiância (W/cm²)** = é a potência radiante que atinge uma área unitária

$E = P / área$

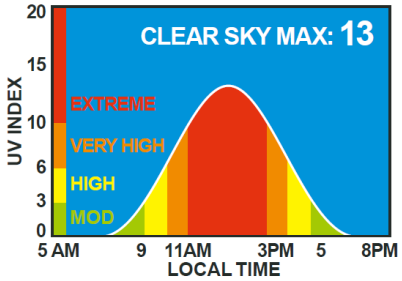


Figure 5: A graphic representing dangerous hours (Bureau of Meteorology, Australia)[2]

Espectro eletromagnético

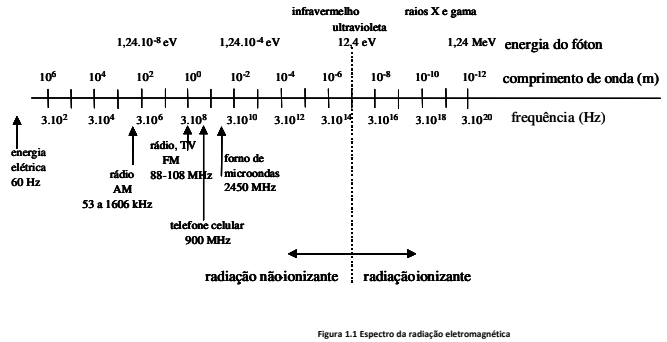


Figura 1.1 Espectro da radiação eletromagnética

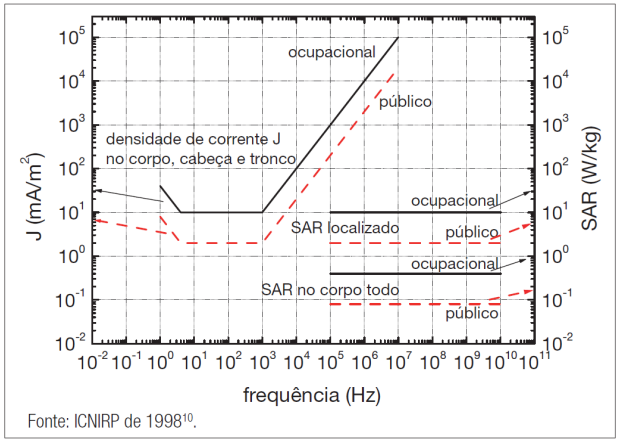
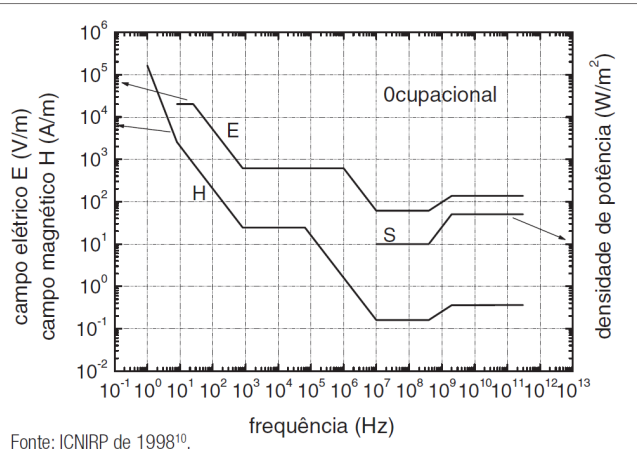
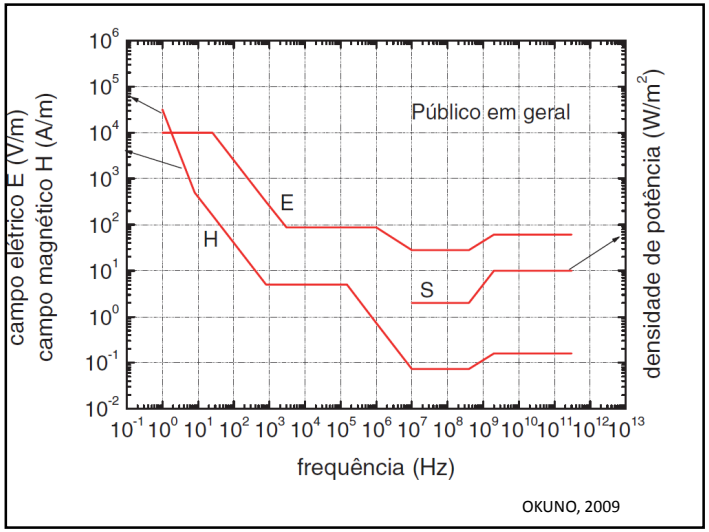


Figura 6. Restrições básicas em função da frequência para trabalhador e para público em geral.

OKUNO, 2009



OKUNO, 2009



OKUNO, 2009

IARC – International Agency for Research on Cancer

Group 1: **The agent is *carcinogenic to humans*.**

This category is used when there is *sufficient evidence of carcinogenicity* in humans. Exceptionally, an agent may be placed in this category when evidence of carcinogenicity in humans is less than *sufficient* but there is *sufficient evidence of carcinogenicity* in experimental animals and strong evidence in exposed humans that the agent acts through a relevant mechanism of carcinogenicity.

Group 2.

This category includes agents for which, at one extreme, the degree of evidence of carcinogenicity in humans is almost *sufficient*, as well as those for which, at the other extreme, there are no human data but for which there is evidence of carcinogenicity in experimental animals. Agents are assigned to either Group 2A (*probably carcinogenic to humans*) or Group 2B (*possibly carcinogenic to humans*) on the basis of epidemiological and experimental evidence of carcinogenicity and mechanistic and other relevant data. The terms *probably carcinogenic* and *possibly carcinogenic* have no quantitative significance and are used simply as descriptors of different levels of evidence of human carcinogenicity, with *probably carcinogenic* signifying a higher level of evidence than *possibly carcinogenic*.

IARC

Group 2A: **The agent is *probably carcinogenic to humans*.**

This category is used when there is *limited evidence of carcinogenicity* in humans and *sufficient evidence of carcinogenicity* in experimental animals. In some cases, an agent may be classified in this category when there is *inadequate evidence of carcinogenicity* in humans and *sufficient evidence of carcinogenicity* in experimental animals and strong evidence that the carcinogenesis is mediated by a mechanism that also operates in humans. Exceptionally, an agent may be classified in this category solely on the basis of *limited evidence of carcinogenicity* in humans. An agent may be assigned to this category if it clearly belongs, based on mechanistic considerations, to a class of agents for which one or more members have been classified in Group 1 or Group 2A.

Group 2B: **The agent is *possibly carcinogenic to humans*.**

This category is used for agents for which there is *limited evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals. It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances, an agent for which there is *inadequate evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data.

IARC

Group 3: **The agent is *not classifiable as to its carcinogenicity to humans*.**

This category is used most commonly for agents for which the evidence of carcinogenicity is *inadequate* in humans and *inadequate* or *limited* in experimental animals.

Exceptionally, agents for which the evidence of carcinogenicity is *inadequate* in humans but *sufficient* in experimental animals may be placed in this category when there is strong evidence that the mechanism of carcinogenicity in experimental animals does not operate in humans.

Agents that do not fall into any other group are also placed in this category.

An evaluation in Group 3 is not a determination of non-carcinogenicity or overall safety. It often means that further research is needed, especially when exposures are widespread or the cancer data are consistent with differing interpretations.

Group 4: **The agent is *probably not carcinogenic to humans*.**

This category is used for agents for which there is *evidence suggesting lack of carcinogenicity* in humans and in experimental animals. In some instances, agents for which there is *inadequate evidence of carcinogenicity* in humans but *evidence suggesting lack of carcinogenicity* in experimental animals, consistently and strongly supported by a broad range of mechanistic and other relevant data, may be classified in this group.

IARC

Group 1	*Carcinogenic to humans*	111 agents
Group 2A	*Probably carcinogenic to humans*	65
Group 2B	*Possibly carcinogenic to humans*	274
Group 3	*Not classifiable as to its carcinogenicity to humans*	504
Group 4	*Probably not carcinogenic to humans*	1