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Public Health Messages Associated with the Low Exposure Category of the UV Index Need Reconsideration

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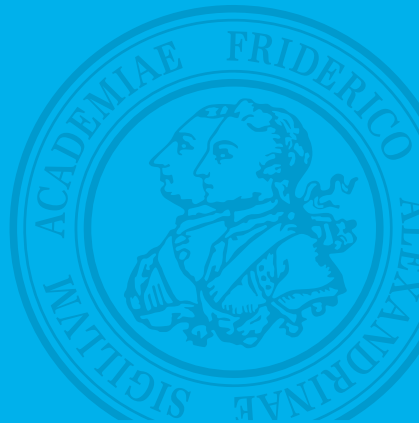

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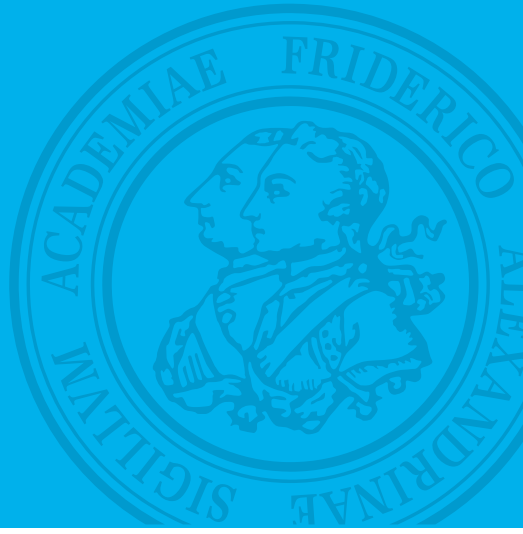
Introduction



- ultraviolet radiation (UVR) carcinogenic according to IARC[1]
- substantial proportion of cases of skin cancer caused by overexposure[2]
- skin cancer largely preventable using appropriate sun protection
- introduction of Global Solar UV Index (UVI) in 1995 by WHO, WMO, UNEP and ICNIRP[3]
  - unitless quantity proportional to daily max. 30-min moving average of intensity of erythemally weighted[4] solar UV irradiance

[1] International Agency for Research on Cancer (2012) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 100D: Solar and Ultraviolet Radiation.
[2] Lucas RM et al. (2008) Estimating the global disease burden due to ultraviolet radiation exposure. *Int J Epidemiol* 37: 654 – 667.
[3] International Commission on Non-Ionizing Radiation Protection (1995) Global Solar UV Index - A Joint Recommendation of the WHO, WMO, UNEP and the ICNIRP.
[4] International Commission on Illumination (1999) CIE S007/E-1998 Erythema reference action spectrum and standard erythema dose.

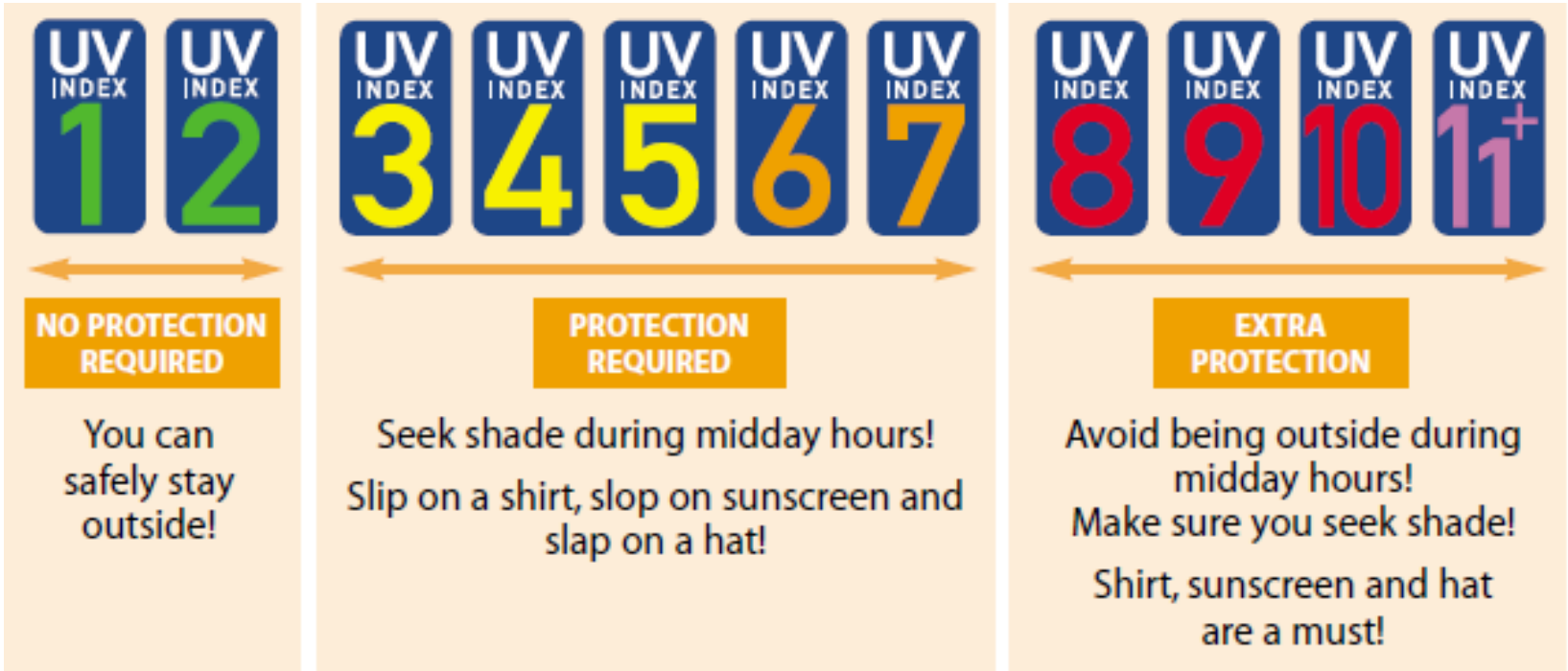


Figure: Sun protection scheme as recommended by WHO[5]

[5] World Health Organization (2002) Global Solar UV Index: A Practical Guide.

Figure: Sun protection scheme for low exposure category as recommended by WHO[5]

- validation of adequacy of UVI health messages unclear
- our focus: low exposure category (UVI values 0-2) with official health message 'No protection required'
- aim of our study: evaluation of potential erythemal effects of exposure to solar UVR on days with low UVI values
  - special focus on differences in susceptibility to UVR-induced damage between distinct skin phototypes

[5] World Health Organization (2002) Global Solar UV Index: A Practical Guide.

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Materials and Methods

- Data Source
  - diurnal courses of erythemal irradiance for days with low UVI values measured at nine stations of the German solar UV monitoring network in the years 2007-2016
- Statistical Analysis
  - Transformation of time base from Coordinated World Time (UTC) to Local Solar Time (LST), where solar noon always occurs at 12:00
  - erythemal irradiance data were integrated over the following time intervals to calculate erythemal doses received therein
    - around solar noon: 11:45-12:15 (0.5 h), 11:30-12:30 (1 h), 11:00-13:00 (2 h), 10:30-13:30 (3 h), 10:00-14:00 (4 h)
    - before noon: 8:00-10:00 (2 h), 7:30-10:30 (3 h)
    - after noon: 14:00-16:00 (2 h), 13:30-16:30 (3 h)
    - full day: sunrise-sunset

- Statistical Analysis (ctd.)
  - comparison of erythemal doses with minimal erythemal doses (MEDs) of Fitzpatrick[6] skin types I through IV
    - MED: erythemal dose which produces minimal perceptible skin reddening (solar erythema) 24 h after exposure
      $\rightarrow$ short-time maximum dose that should not be exceeded to prevent detrimental effects of UVR on the human body[7]

Skin type	Tan	Burn	Minimal Erythemal Dose (SED)
I	Never	Always	2.0
II	Sometimes	Sometimes	2.5
III	Always	Rarely	4.0
IV	Always	Never	6.0

Table: Characteristics of skin types according to Fitzpatrick[6] and corresponding minimal erythemal doses (MEDs) according to ICNIRP[8] in terms of Standard Erythema Doses (1SED = 1 Standard Erythema Dose = 100 J m^{-2} weighted with the CIE erythema reference action spectrum[4])

[4] International Commission on Illumination (1999) CIE S007/E-1998 Erythema reference action spectrum and standard erythema dose.
[6] Fitzpatrick TB (1988) The validity and practicality of sun-reactive skin types I through IV. *Arch Dermatol.* 124: 869 – 871
[7] Feister U, Laschewski G, Grewe RD (2011) UV index forecasts and measurements of health-effective radiation. *J Photochem Photobiol B* 102: 55 – 68
[8] International Commission on Non-Ionizing Radiation Protection (2010) ICNIRP statement on protection of workers against ultraviolet radiation. *Health Phys.* 99(1): 66 – 87

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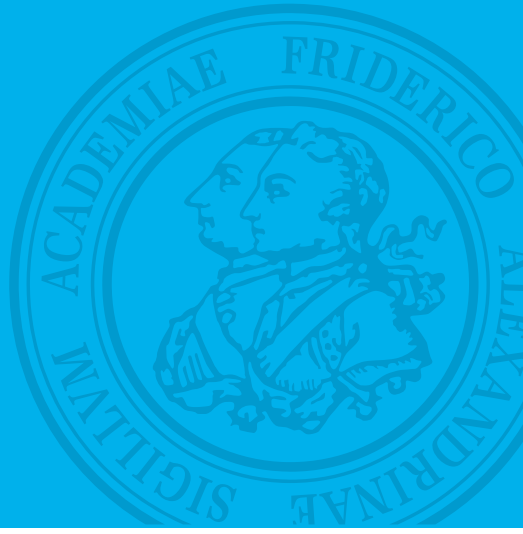
Results



Dataset Description

- UVI 0: n=4,961 days
  - most frequent months of occurence: December (n=1,949; 39.3 %), January (n=1,515; 30.5 %) and November (n=939; 18.9 %)
- UVI 1: n=6,117 days
  - most frequent months of occurence: February (n=1,526; 24.9 %), November (n=1,281; 20.9 %) and October (n=1,047; 17.1 %)
- UVI 2: n=3,353 days
  - most frequent months of occurence: March (n=1,061; 31.6 %) and October (n=913; 27.2 %)

Comparison of Computed Erythemal Doses with MEDs

- UVI 0
  - median erythemal doses are well below 1SED for all intervals considered, except for full day interval
  - full day: MEDs of skin types III and IV never exceeded, and for skin types I and II in only 1.23 % and 0.04 % of days, respectively
- UVI 1
  - median erythemal dose from 4 h-interval around noon and full day interval exceed MEDs of skin types I and I+II, respectively
  - 2 h and 3 h intervals around noon yield doses greater than MEDs of skin types I and II for more than two thirds of days
- UVI 2
  - 2 h around noon: doses resulting from 87.89 % of days exceed MED of skin type I, but MED of skin type IV not exceeded on any day
  - 4 h around noon: interval yields doses exceeding MEDs of skin type III and IV for 84.01 % and 26.39 % of days, respectively, and >99 % of days yield doses exceeding MEDs of skin types I+II

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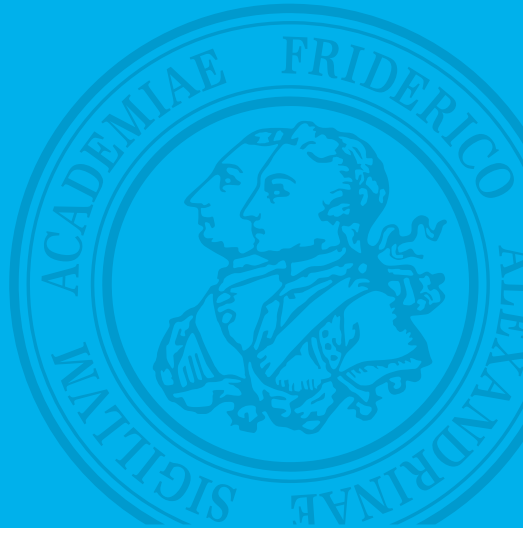
Discussion



Possible Implications of Results

- our study and recent evidence from New Zealand[9,10] suggest recommending sun protection on UVI 2 days for sensitive skin types
- adaptation of UVI guidance to different skin types should also be considered $\rightarrow$ possible solution: preparation of a 'matrix' of health messages for different skin types
  - local authorities could choose entries most suitable for most sensitive major subgroup of local population
- necessity for local adaptation and possibility of including skin type and exposure duration into UVI guidance have been ascertained at WHO UVI workshop in Melbourne in 2015[11]
  - not yet implemented
- future perspective: smartphone applications incorporating individual skin phototype combined with calendar and geotagging data and possibly UVI forecasting

[9] Lucas RM et al. (2018) Are current guidelines for sun protection optimal for health? Exploring the evidence. *Photochem Phobiol Sci.*
[10] McKenzie RL, Lucas RM (2018) Reassesing impacts of extended daily exposure to low level solar UV radiation. *Scientific Reports.* 8: 13805
[11] Gies P et al. (2018) Review of the Global Solar UV Index 2015 workshop report. *Health Phys.* 114: 84 – 90

Strengths and Limitations

Strengths	Limitations
• measurement data of 10 consecutive years from 9 measuring stations of a solar UV monitoring network	• ambient erythemal doses are a potentially weak proxy for individual exposure
→ in total, 14,431 daily UVI time series from the 'low' UVI category	→ clear sky, small solar elevation angle (fall & winter, majority of days in our sample): surfaces facing the sun can receive up to 40 % higher irradiances[12]
→ well-established system of quality control	→ cloudy conditions (spring & summer): UV on tilted surfaces reduced by up to 50 %[12]
	→ exposure ratio highly dependent on individual behavior[13]

[12] McKenzie RL, Paulin KJ, Kotkamp M (1997) Erythemal UV irradiances at Lauder, New Zealand: relationship between horizontal and normal incidence. *Photochem Photobiol.* 66: 683 – 689

[13] Vernez D et al. (2015) A general model to predict individual exposure to solar UV by using ambient irradiance data. *J Expo Sci Environ Epidemiol* 25 (1): 113 – 118

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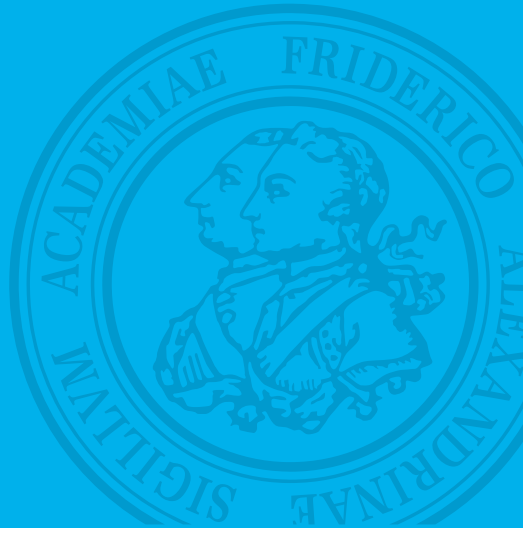
Conclusions



- WHO guidance for sun protection on days with 'low' UVI values needs reconsideration
  - UV exposure for prolonged exposure durations on UVI 2 days and, under certain rare circumstances, even on UVI 1 days, reaches erythemal levels
  - particularly relates to sensitive skin types
    - need for skin type specific public health messages relating to the UVI might be implied