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

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Introduction
• ultraviolet radiation (UVR) carcinogenic according to IARC\textsuperscript{1}

• substantial proportion of cases of skin cancer caused by overexposure\textsuperscript{2}

• skin cancer largely preventable using appropriate sun protection

• introduction of Global Solar UV Index (UVI) in 1995 by WHO, WMO, UNEP and ICNIRP\textsuperscript{3}
  - unitless quantity proportional to daily max. 30-min moving average of intensity of erythemally weighted\textsuperscript{4} solar UV irradiance

\textsuperscript{1} International Agency for Research on Cancer (2012) IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 100D: Solar and Ultraviolet Radiation.
\textsuperscript{3} International Commission on Non-Ionizing Radiation Protection (1995) Global Solar UV Index - A Joint Recommendation of the WHO, WMO, UNEP and the ICNIRP.
Figure: Sun protection scheme as recommended by WHO\textsuperscript{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

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

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
      → short-time maximum dose that should not be exceeded to prevent detrimental effects of UVR on the human body\(^7\)

<table>
<thead>
<tr>
<th>Skin type</th>
<th>Tan</th>
<th>Burn</th>
<th>Minimal Erythemal Dose (SED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Never</td>
<td>Always</td>
<td>2.0</td>
</tr>
<tr>
<td>II</td>
<td>Sometimes</td>
<td>Sometimes</td>
<td>2.5</td>
</tr>
<tr>
<td>III</td>
<td>Always</td>
<td>Rarely</td>
<td>4.0</td>
</tr>
<tr>
<td>IV</td>
<td>Always</td>
<td>Never</td>
<td>6.0</td>
</tr>
</tbody>
</table>

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 \((1\text{SED} = 1 \text{Standard Erythema Dose} = 100 \text{J m}^{-2}\) weighted with the CIE erythema reference action spectrum\(^4\))

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Results
Dataset Description

- UVI 0: \( n=4,961 \) days
  - most frequent months of occurrence: 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 occurrence: 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 occurrence: 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
Discussion
Possible Implications of Results

- our study and recent evidence from New Zealand\textsuperscript{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 → 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\textsuperscript{11}
  - not yet implemented
- future perspective: smartphone applications incorporating individual skin phototype combined with calendar and geotagging data and possibly UVI forecasting

# Strengths and Limitations

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