Actinic UV film dosimetry: Indicators of occupational exposure risk for office workers and school teachers

N. Downs, A. Parisi, D. Igoe, L. Wainwright & H. Butler

School of Agricultural, Computational and Environmental Sciences
Faculty of Health, Engineering and Sciences

13/11/2013
How do we make informed decisions?
Mobile phone technologies have influenced...

- The way we gather and process information.
- The dynamics of social networks.
- The young people in Australia (ownership 83%).
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- Popular among younger age groups.
- Young people (males) are at risk of sunburn.
- Providing mobile access to information increases *instant* awareness.
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*Answer*: It depends.

To be safe requires balancing optimal Vitamin D and over-exposure risk.

Balancing exposure requires detailed information on:
- the geographical location
- the weather
- the season
- the atmospheric conditions
- the individual
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- Experiments can inform us on *where the risks lie* and what *we might be able to do about them* for a given set of circumstances.

  - *Melanoma* - Incidence is high among predominantly indo or workers.
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This study:

- Considers the risk to Australian workers.
- Teachers - potential overexposure risk.
- Office workers - potential Vitamin D risk.

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- Can the ICNIRP EL be used as an indicator of *both* a safe occupational exposure limit and optimal daily vitamin D?
Polysulphone and PPO film dosimetry:

- Change in Absorbency, $\Delta A$ is calibrated against spectrally weighted UV
- Polysulphone:
  $\Delta A = 330 \text{ nm}$
- PPO:
  $\Delta A = 320 \text{ nm}$
- PPO range $= 25,000 \text{ Jm}^{-2}$
- PS range $= 2,500 \text{ Jm}^{-2}$

Measuring the ICNIRP exposure to teachers:

- Measured the ICNIRP weighted exposure to two teachers: 23.5° Emerald, Qld and 27.5° Toowoomba, Qld.
- Recorded weekly ICNIRP exposure to the rear shirt collar and on a horizontal plane over 5 weeks. (10% ± 8%(1σ) of ambient)

<table>
<thead>
<tr>
<th>Week</th>
<th>Days</th>
<th>Collar UV (Jm⁻²)</th>
<th>Ambient UV (Jm⁻²)</th>
<th>Days</th>
<th>Collar UV (Jm⁻²)</th>
<th>Ambient UV (Jm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.10.12-02.11.12</td>
<td>Full</td>
<td>-</td>
<td>5053</td>
<td>W,Th,F</td>
<td>180</td>
<td>2726</td>
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<tr>
<td>05.11.12-09.11.12</td>
<td>Full</td>
<td>453</td>
<td>5513</td>
<td>M,Tu,W,Th</td>
<td>1287</td>
<td>5251</td>
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<td>12.11.12-16.11.12</td>
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<td>6584</td>
<td>Tu,W,Th,F</td>
<td>686</td>
<td>4883</td>
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Measuring the ICNIRP exposure to teachers:

UV heat map - weighted exposure periods:

Participant B received the greater exposure:
1. longer duty
2. playground area.

Participant B spent more time in the open.

UV minimization strategy - Seek shade.

Question: Is there a relationship between time on yard duty and the ICNIRP UV exposure?
Answer: Yes. However, the relationship depends on the outdoor environment.
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Measuring the ICNIRP exposure to teachers:

If playground regions which offer some protection are considered... assuming the exposure is reduced to 10% of that of an open environment

\[ R^2 = 0.77 \]
Measuring the ICNIRP exposure to office workers:

- Measured the ICNIRP weighted exposure to two office workers in Toowoomba, Qld (2008).
- Recorded 12 exposures of 2.5 hours duration (1% ± 1%(1σ) of ambient)

<table>
<thead>
<tr>
<th>Record</th>
<th>Collar UV (Jm⁻²)</th>
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<td>-</td>
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<td>22.02.08</td>
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<td>14.3</td>
<td>-</td>
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<tr>
<td>14.03.08</td>
<td>0.6</td>
<td>116.5</td>
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</tr>
<tr>
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<tr>
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<td>22.3</td>
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<td>13.06.08</td>
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<td>9.2</td>
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<tr>
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<td>18.07.08</td>
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- The office workers are well within the daily ICNIRP EL of 30 Jm⁻².
Balancing exposure risk and Vitamin D:

**Over-exposure Risk:**

- BoM (Australia) issues UV alert times when the UV index is *predicted* to exceed 3.
- Within these alert times sun protective strategies are advised:
  - Seek shade.
  - Wear a hat.
  - Wear protective clothing.
  - Apply sunscreen.
  - Use sunglasses.
- The UV index is a unit-less quantity based on *erythemally effective UVR*.

**Vitamin D deficiency:**

- Awareness of deficiency risk: dark skin, housebound elderly, medical pre-disposition.
- Incidental sunlight exposure is adequate.
- It is not necessary to deliberately seek UV exposure.
- Exposure of a few minutes either side of peak (UV alert) times to the face, hands and arms ($\frac{1}{4}$ of the available skin surface area.)
- For southern states the advice is 2-3 hours exposure spread over a weekly period.
Providing more precise advice:

- Individual advice requires consideration of many factors.
Providing more precise advice:

- Apps are now available for smartphone users - *increasing awareness*
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- Individual advice however requires consideration of many factors.
Optimal Vitamin D:

- All the possible health benefits of Vitamin D can be provided by the equivalent of a daily an oral dose of 1000 IU. (Holick, 2004)
- This can be produced by the full body exposure of pale skin to a UVI of 10 in under 1 min (McKenzie et al. 2009).
- It has also been stated that exposure of 6% of the body to 1 MED will produce the equivalent of 600 to 1000 IU. (Holick, 2002)
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**Seckmeyer et al. 2013: (erythemal UV to Vitamin D)**

\[
\frac{\text{IU}}{\text{min}} = \frac{\text{IU}_{\text{LITERATURE}}}{\text{exposure time}} \cdot \frac{100\%}{\text{skin area (%)}}
\]

where exposure time is the time to receive 1 MED
Some points to consider:

- Care must be taken when using the erythemally weighted UV to predict a vitamin D effect (The two action spectra are different)
- The vitamin D effective UV is has a higher weighting than the erythemally effective UV above 300 nm but does not extend into the UVA.
- **Vitamin D is UVB sensitive** - solar elevation and ozone have a significant influence.
Max exposure times before exceeding ICNIPR EL:

- Considering a full range of ICNIRP and vitamin D spectrally weighted values for Toowomba, 2009 ($n = 14,310$, 265 full days)
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Provided an individual can rise at 5 am
23 September 2009:

MODIS TERRA image, 23 September, 2009.
23 September 2009:

Red Haze Envelopes Sydney Harbour Bridge, ABC 2009.
23 September 2009:

- Mean UVI on 23 September = 0.60
- Max UVI = 2.4
Max exposure time and IU dose, **UVI (low)**:
Max exposure time and IU dose, \textbf{UVI (mod)}:
Max exposure time and IU dose, **UVI (high):**

![Graph showing Vitamin D dose (IU) for Exposure limits ($T_{max}$): UV index=HIGH.](image)
Max exposure time and IU dose, **UVI (vhigh):**

![Graph showing Vitamin D dose (IU) for Exposure limits (T_{max}): UV index=VERY HIGH.](image)

- Y-axis: Vitamin D dose (IU)
- X-axis: Time
- Data points for different exposure times and IU doses are plotted.
Max exposure time and IU dose, **UVI (extreme)**:
Summary of findings:

For pale type I skin exposed up to the ICNIRP EL:

<table>
<thead>
<tr>
<th>UV index</th>
<th>$T_{\text{max}} \pm 1\sigma$ (min)</th>
<th>Vit D dose (IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>69.71 ± 8.65</td>
<td>9848 ± 411</td>
</tr>
<tr>
<td>MODERATE</td>
<td>17.66 ± 2.78</td>
<td>8775 ± 424</td>
</tr>
<tr>
<td>HIGH</td>
<td>11.10 ± 1.02</td>
<td>8272 ± 271</td>
</tr>
<tr>
<td>VHIGH</td>
<td>7.14 ± 0.51</td>
<td>7916 ± 186</td>
</tr>
<tr>
<td>EXTREME</td>
<td>5.58 ± 0.32</td>
<td>7752 ± 149</td>
</tr>
</tbody>
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Max exposure time/8 & IU dose, UVI (low):
Max exposure time and IU dose, UVI (mod):
Max exposure time and IU dose, **UVI (high)**:
Max exposure time and IU dose, **UVI (vhigh):**

Vitamin D dose (IU) for Exposure limits ($T_{\text{max}}$): UV index=VERY HIGH

![Graph showing Vitamin D dose vs Time for Exposure limits.](image-url)
Max exposure time and IU dose, UVI (extreme):
Vitamin D dose summary:

For pale type I skin exposed for $\frac{1}{8}$ of the time to reach ICNIRP EL:

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<tr>
<td>LOW</td>
<td>$8.71 \pm 1.08$</td>
<td>$1231 \pm 51$</td>
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<td>MODERATE</td>
<td>$2.21 \pm 0.35$</td>
<td>$1097 \pm 53$</td>
</tr>
<tr>
<td>HIGH</td>
<td>$1.39 \pm 0.13$</td>
<td>$1034 \pm 34$</td>
</tr>
<tr>
<td>VHIGH</td>
<td>$0.89 \pm 0.06$</td>
<td>$989 \pm 23$</td>
</tr>
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<td>$0.70 \pm 0.04$</td>
<td>$969 \pm 19$</td>
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Summary of Vitamin D dose at ICNIRP EL (30 Jm$^{-2}$):

Considering the 6 skin types, Fitzpatrick (1988):

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<th>VitD type I (IU)</th>
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<td>7916</td>
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The time required for a daily 1000 IU vitamin D dose can be estimated for each of the six skin types.
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<td>5850</td>
<td>3900</td>
<td>2925</td>
<td>1755</td>
</tr>
<tr>
<td>HIGH</td>
<td>11.10</td>
<td>8272</td>
<td>6618</td>
<td>5515</td>
<td>3677</td>
<td>2757</td>
<td>1655</td>
</tr>
<tr>
<td>VHIGH</td>
<td>7.14</td>
<td>7916</td>
<td>6333</td>
<td>5277</td>
<td>3518</td>
<td>2639</td>
<td>1583</td>
</tr>
<tr>
<td>EXTREME</td>
<td>5.58</td>
<td>7752</td>
<td>6202</td>
<td>5168</td>
<td>3445</td>
<td>2584</td>
<td>1550</td>
</tr>
</tbody>
</table>

- The time required for a daily 1000 IU vitamin D dose can be estimated for each of the six skin types.
- This information can be useful for individualising sun exposure times.
Summary:

- Current advice on sunlight exposure for healthy Vitamin D is in agreement with the time limits predicted here, provided a person has type I skin.
- There is room for the individualisation of these limits and integration of these with new technologies.
- An awareness of the exposure time limits for occupational groups will contribute to better health outcomes for the Australian public.


