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O'Mahoney, Paul; Eadie, Ewan

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DR. PAUL O'MAHONEY (Orcid ID : 0000-0003-3221-5105)

DR. EWAN EADIE (Orcid ID : 0000-0002-7824-5580)

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HIGHLIGHT ARTICLE

Bring the Sunshine Indoors: Easy Dosimetry for Indoor Daylight Photodynamic Therapy[†]

Paul O'Mahoney^{1,2,3} and Ewan Eadie^{1,2}

1. Photobiology Unit, NHS Tayside, Ninewells Hospital, Dundee, U.K.
2. The Scottish Photodynamic Therapy Centre, Dundee, U.K.
3. School of Medicine, University of Dundee, Dundee, U.K.

Corresponding authors' emails: pzomahoney@dundee.ac.uk (Paul O'Mahoney) and ewan.eadie@nhs.net (Ewan Eadie)

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Abstract:

Daylight photodynamic therapy (DPDT) is an effective and patient preferred treatment for the management of field change actinic keratosis. An important factor in DPDT is light dosimetry, to ensure that patients receive sufficient daylight for effective treatment, and this is the focus of the contribution to this issue by La Rochelle *et al.*(Photochem. Photobiol., 2019, <https://doi.org/10.1111/php.13170>). In this work, the authors present an easy to use method for obtaining real-time information about patient received light dose during treatment, and for determining indoor locations best suited to DPDT.

This issue of *Photochemistry and Photobiology* contains a study by La Rochelle *et al.* [1] concerning daylight photodynamic therapy (DPDT), which has become a popular treatment in Europe for actinic keratoses (AK) since it was first reported on in 2008 [2]. DPDT offers comparative clearance rates to conventional photodynamic therapy (PDT) for treating field-cancerised areas such as the face and scalp, while causing minimal pain.

Whereas light dose in conventional PDT can be closely controlled, in DPDT light dose is dependent on the outdoor conditions over the duration of treatment. This understandably makes practitioners wary about prescribing DPDT. The literature suggests that there is a minimum effective PpIX-weighted dose of light that a patient should receive over a 2-hour treatment to maximise outcomes – below this dose, efficacy falls and above it there is no benefit [3]–[5]. Understanding the dose of light that a patient has been exposed to during DPDT is therefore critical [6], with efforts focused on improving dosimetry to give the user greater confidence in treatment outcome and patient satisfaction.

However, light availability is not the only concern, general weather conditions; rain, wind, temperature etc, may also limit treatment [5]. Indoor DPDT through window glass has therefore become a consideration, protecting the patient from adverse weather conditions and negating the need for sunscreen by attenuating much of the erythemally effective UV radiation [7]. Window glass does however also attenuate useful UVA and visible light [1], [7], [8]. As such dosimetry is of even greater importance in indoor DPDT, to ensure that patients receive an adequate light dose during treatment.

La Rochelle *et al.*, propose a single site analysis alongside automatic data processing from local weather monitoring stations to obtain real-time light dosimetry of DPDT. One of the obvious advantages to such a method is that, other than the one-time site assessment, no specialist equipment is required for day-to-day patient dose assessment in clinic. Thus, there is the potential to streamline indoor DPDT and provide a greater level of confidence to both practitioner and patient. A flowchart in Figure 1 illustrates the proposed workflow for the method.

<Figure 1>

To test the method of La Rochelle *et al.* data from the nearest weather station to our location (Ninewells Hospital, Dundee, 56.46° N, 2.97° W) was obtained. At 12:30 UTC (Coordinated Universal Time), on the 11th of October 2019 the weather station provided a cloud-adjusted daylight irradiance in the horizontal plane of 402.65 W m⁻² and a UV index of 3.55. Using Figure 5 from La Rochelle *et al.*, PpIX-weighted irradiances of 6.33 W m⁻² and 3.69 W m⁻² are determined from the cloud-adjusted daylight irradiance and UV index respectively. These values we compared to our own independent measurement (380–800 nm, WaveGo, Ocean Optics, USA) made inside a window in a southerly facing office at Ninewells Hospital. Our measurement result was a PpIX-weighted irradiance of 5.64 W m⁻². La Rochelle *et al.* predicted values were 12% higher (daylight

irradiance) and 34% lower (UV Index) than our measured value and fall within the authors stated 95% prediction limits (Figure 2).

<Figure 2>

The cloud-adjusted daylight metric was the most accurate in our example and the resulting predicted PpIX-weighted dose is 4.56 J cm^{-2} . This assumes a 2-hour treatment duration but is based on only a single measurement. According to the latest literature, this value verges on what may be considered the minimum dose threshold for effective treatment [5]. Having this knowledge in real-time, made possible by the model of La Rochelle *et al.* allows dose adjustment by the clinician through variation of the exposure time.

In addition, spectral irradiance measurements from the one-time setup described by La Rochelle *et al.* can be used to provide information on the minimum treatment time by depth in tissue [9]. The authors propose that sufficient PpIX-weighted daylight doses could be achieved in under the recommended treatment time of 2 hours. For example, from our measurement the La Rochelle *et al.* model indicates minimum treatment times of 3, 27 and 107 minutes at depths of 0.5, 1 and 1.5 mm respectively. It must be noted that these are currently theoretical values, there is as yet no clinically supported evidence showing that treatment times shorter than 1.5 hours [10] in DPDT will lead to equivalent outcomes - even if the minimum threshold light dose is met. Historically, dosimetry methods in DPDT have focused on surface irradiance measurements, therefore it remains to be seen how clinically useful the dose at depth information might be on a day-to-day basis. However, with this information now readily available, perhaps the link between depth-dependent dose and lesion clearance in DPDT could be elucidated.

We found the determination of PpIX-weighted irradiance using this technique very easy and were pleasantly surprised that the result was within the accepted confidence intervals, particularly as our measurement was performed over 3000 miles from the location of the original research. Convenience and confidence are key in the uptake of any new technology or treatment in clinic. If, as the authors propose, the method described here is packaged into an easy to use software application, it could become a useful tool in supporting the uptake of indoor DPDT. Most centres, in our opinion, would be willing to undergo the one-time setup process in order to facilitate a robust indoor DPDT service. In conclusion, the authors propose and demonstrate a workable solution to increasing uptake of this important treatment by providing crucial information to the prescribing clinician.

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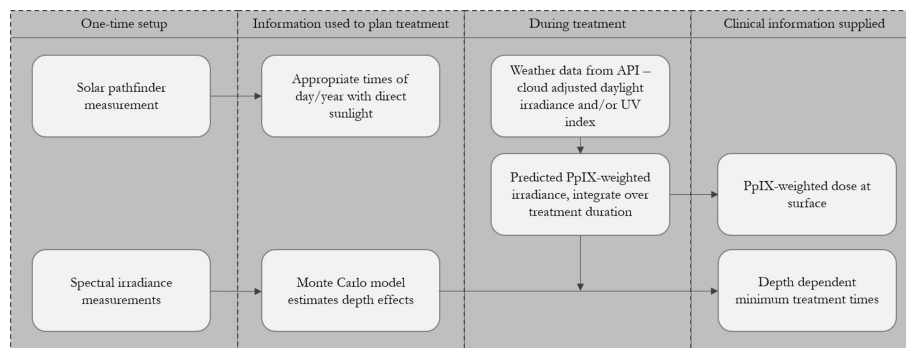
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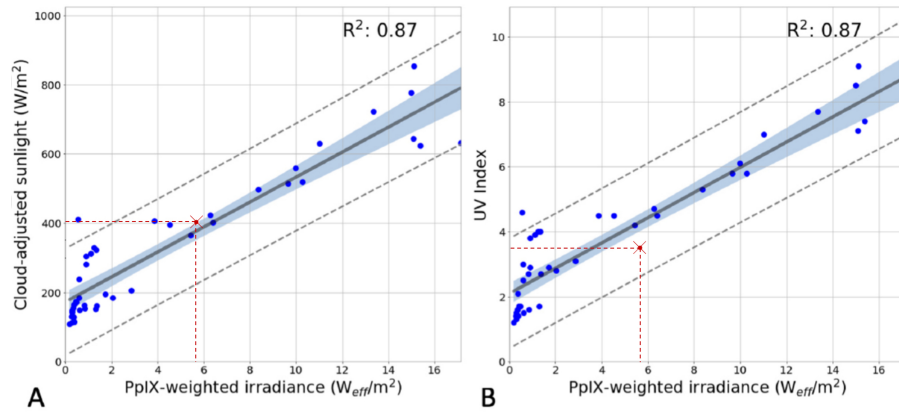
FIGURE CAPTIONS

Figure 1. Flowchart illustrating the proposed workflow for this DPDT dosimetry method. The ‘during treatment’ section is planned to be integrated into a user-friendly, automated application, which would maximise the accessibility of this method.

Figure 2. Reproduced from La Rochelle *et al.* [1], cloud adjusted sunlight and UV index from weather data are plotted against measured PpIX-weighted irradiance (red crosses) for our single measurement.



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