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**Concise Report**

# Black ceiling tiles reduce occupational ultraviolet light exposure from phototherapy cabinets

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## Abstract

Phototherapy clinics administer ultraviolet (UV) light to patients using phototherapy cabinets. The UV radiation from these cabinets is reflected on the white ceiling tiles of the clinic and is then redirected toward both staff and patients in the area. This is particularly problematic for clinical technologists who must undertake dosimetry in these areas and have a specific time (often as low as 30 min) before they reach their maximum exposure limit. By replacing white tiles with black ones, which absorb any stray radiation, we were able to reduce stray reflection by almost 90%, prolonging the time to maximum exposure by nearly 10 times. We present these findings to encourage other similar clinics to undertake the simple protocols outlined in this article, which will significantly improve staff and patient safety.

Ultraviolet (UV) light in the UVA and UVB wavelengths is used to treat several skin conditions, including psoriasis, eczema, cutaneous T-cell lymphoma, vitiligo and fibrosing skin diseases, such as localized morphoea, among others.[1–3] To this end, phototherapy cabinets are used, whereby a patient is positioned inside the cabinet while a precise light dose is administered by the surrounding UV lamps. Phototherapy cabinets are typically open at the top to allow for heat dissipation, which in turn allows stray UV radiation (UVR) to reflect from the white ceiling tiles (CTs), thus presenting an exposure risk to both patients and staff working in the area. For this reason, areas around cabinets are often demarcated or shielded to mitigate this risk. Working practices and local regulations help ensure that staff time within the shielded area is minimized to achieve occupational exposure that is as low as reasonably practicable (ALARP), as required by the Control of Artificial Optical Radiation at Work Regulations 2010 (CAOR 2010), Section 4.[4]

However, staff may need to spend prolonged periods of time inside the demarcated area, for example when undertaking dosimetry measurements. In such circumstances, staff rely on personal protective equipment (PPE) as an important control measure. Previous risk assessment at the Phototherapy Unit in Ninewells Hospital, Dundee, highlighted that the legal exposure limit value (ELV) of UV light within the demarcated area could be as low as 30 min.

## Report

White CTs are commonplace in phototherapy units and the hospital environment. Previous studies demonstrated that the varying reflectance of CTs is of interest in the context of UV germicidal irradiation; however, to our knowledge, it has not been explored in phototherapy.[5–7] Therefore, we present a practical and cost-effective measure for reducing stray UVR by replacing white CTs with black ones, whose light-absorbing surface helps to reduce reflected UV light.

Firstly, we tested black CTs (Thermatex Alpha Black, 600 × 600 mm Square Edge; AMF, Cheltenham, UK) under laboratory conditions and compared them with our existing white CTs of the same style. Each CT was suspended facing a UV light source; both broadband fluorescent UVA and narrowband (NB)-UVB lamps were used. A detector was placed between the lamp and the CT, facing toward the CT. Measurements taken at different distances revealed that when a white CT was replaced with a black CT, the reflected light received by the detector was reduced by approximately 80% for UVA and 75% for UVB. This significant reduction in reflected UVR supported our justification in replacing all white CTs above our phototherapy cabinets with black ones.

Our phototherapy area consists of four phototherapy cabinets: (1) Waldmann-UV5040ALfor UVA (Waldmann, Villingen-Schwenningen, Germany); (2) Waldmann-5000 (Waldmann); (3) NeoLux (Daavlin, The Hague, The Netherlands) for NB-UVB; and (4) Waldmann-7001 (Waldmann) for UVA1 (Figure 1a). We measured the maximum irradiance at a height of 163 cm within the demarcated area with both white and black CTs and compared the results. Then, we calculated the time taken to reach the ELV for UVA to the eye ($H_{UVA} = 10\,000$ mJ cm$^{-2}$) and for actinic UV ($E_{eff} = 3$ mJ cm$^{-2}$).

For the UVA cabinets (1 and 4), the highest irradiance $E_{UVA}$ values were 208.2 μW cm$^{-2}$ (cabinet 1) and 255.5 μW cm$^{-2}$ (cabinet 4). With regard to the International Commission on Non-Ionizing Radiation Protection guidelines,[8]

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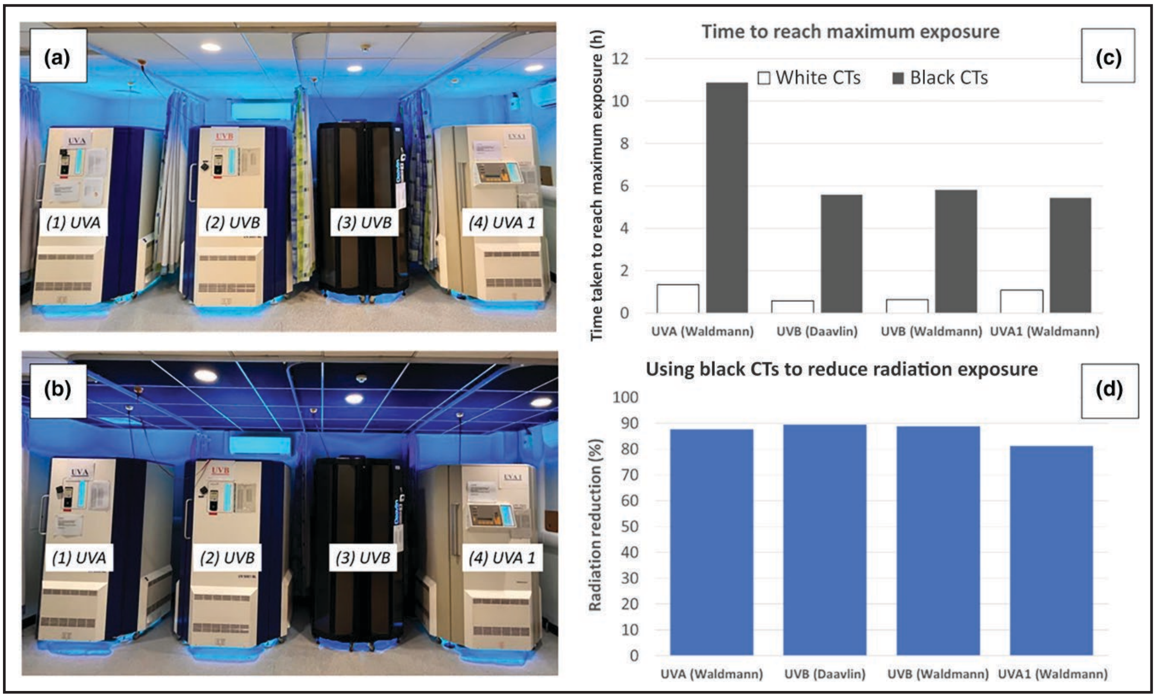


**Figure 1** Phototherapy cabinets 1–4. Cabinets with (a) white and (b) black ceiling tiles (CTs) are shown. (c) Number of hours required to reach the exposure limit value for white and black CTs. (d) Percentage reduction of reflected stray ultraviolet (UV) light from black CTs after they replaced white CTs.

the time to maximum exposure, $t_{ME}$, was then calculated as $t_{ME} = H_{UVA}/E_{UVA}$, that is, 80 min for cabinet 1 and 65 min for cabinet 4. Similarly, for the UVB cabinets (2 and 3), the highest effective irradiance values $E_{eff}$ were 1.43 $\mu$W cm$^{-2}$ for cabinet 2 and 1.29 $\mu$W cm$^{-2}$ for cabinet 3. The time to maximum exposure was 35 min for cabinet 2 and 39 min for cabinet 3.

After replacing white CTs with black ones (Figure 1b), the new time to maximum exposure for cabinets 1–4 was calculated as 10.9 h for cabinet 1, 5.6 h for cabinet 2, 5.8 h for cabinet 3 and 5.4 h for cabinet 4 (Figure 1c). Owing to reductions in reflected irradiance, these maximum exposure times were calculated as 87.7% (cabinet 1), 89.6% (cabinet 2), 88.9% (cabinet 3) and 81.2% (cabinet 4), giving a mean (SD) reduction of 87% (3.3) per phototherapy cabinet (Figure 1d). We attributed minor variations between cabinets to slight differences in physical surroundings resulting in variations in reflective surfaces.

Given that CTs in hospitals undergo replacement due to wear and tear, protocols for replacement were already in place; thus, the entire process of changing white CTs to black ones was completed by our estates team within an afternoon, causing minimal disruption to our clinic. Although blinding was not possible in our experiments, we are satisfied with a demonstrable reduction in UV exposure.

Black CTs are an effective engineering control measure that exemplifies the ALARP principle, increases compliance with CAOR 2010 and reduces reliance on PPE. We recommend that other clinics with similar stray radiation issues adopt this simple, low-cost and effective strategy of replacing tiles to protect both staff and patients from unwanted UV exposure.

## Learning points

- White surfaces reflect stray ultraviolet radiation (UVR) from phototherapy cabinets back into the clinical environment.
- Staff and patient exposure to UVR must be carefully controlled and monitored.
- Exposure limit values (ELVs) can be as short as 30 min in clinical scenarios.
- Replacing white surfaces, such as ceiling tiles, with black alternatives reduces reflection by up to 90%.
- ELVs can be increased to hours, prolonging the time to maximum exposure by nearly 10 times before the ELV is reached.


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## Conflicts of interest

The authors declare no conflicts of interest.

## Data availability

The data underlying this article are available upon request from the corresponding author.

## Ethics statement

Not applicable.

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