Sun protection strategies

Robert Sarkany

Abstract

About 5% of sunlight is ultraviolet (UV). UV causes gene mutations in skin cells, and is the main cause of all forms of skin cancer. Sun protection is crucial for people at high risk of malignant melanoma: those with fair skin, who are moley or have a family history of melanoma. Sun protection is required in patients at risk of squamous and basal cell skin cancers, and is vital in patients with sunlight allergies. There is no agreement about how much sun protection is advisable for healthy adults at low risk of skin cancer. Protecting against UV in sunlight involves a set of behaviours: avoiding the hottest part of the day, wearing hats and long sleeves, and wearing sunscreen. Sunscreens contain chemicals which absorb and reflect UV. The 'sun protection factor' (SPF) measures a sunscreen's effectiveness at protecting against sunburn. Protection in real life is less than the SPF predicts because people apply sunscreens thinly. Patients are resistant to changing behaviour to photoprotect better, even when advised to after having had a malignant melanoma. This is an example of 'non-adherence' to following medical advice that is a major barrier to good health outcomes in all branches of medicine.

Keywords Behaviour; photoprotection; skin cancer; sunscreen; ultraviolet

Key points

- Ultraviolet makes up 5% of sunlight, is mutagenic and is the main cause of all types of skin cancer
- Sun protection is important in individuals who are at high risk of skin cancer, and those with 'sun allergies'
- Sunlight has some beneficial effects: it is unclear how much protection is needed for healthy adults at low risk of skin cancer
- The 'sun protection factor' measures a sunscreen's capacity to protect against UVB-induced sunburn
- Patients find it difficult to improve sun protection in the long term, even when they are being treated for malignant melanoma

Ultraviolet: why sun protection is needed[1]

In sunlight reaching the earth's surface, 95% is visible light or infrared, neither of which are damaging to health. The health problems are caused by the 5% that is 'ultraviolet' (UV) radiation. UV is the portion of sunlight with wavelength 290–400 nm (Figure 1). It is not visible to the human eye.

Photons of UV contain the right amount of energy to move electrons in organic chemicals into higher energy states. So UV, unlike the rest of sunlight, changes the chemical structures of DNA, proteins and lipids. The UV component of daylight continually damages the molecular components of cells in our skin (and eyes). The most worrying target for UV damage is DNA. UV (especially shorter wavelength UVB) crosslinks adjacent bases (cytosines or thymidines) in DNA to form 'dimers' which interfere with DNA replication. This results in cytosines in DNA mutating to become thymidines. The C→T and CC→TT mutations are the fingerprint of UV damage to DNA, and make up 80% of the carcinogenic mutations found in skin cancers.

The skin's own 'strategies for UV protection'[1]

UV is a potent mutagen, present everywhere where there is daylight. The skin has evolved effective strategies to protect against UV. The brown pigment 'melanin' is produced by melanocytes, which deliver it into epithelial stem cells ('basal keratinocytes') in the skin's stratified squamous epithelium ('epidermis'). Melanin within keratinocytes protects nuclear DNA from UV that has penetrated the skin. 'Tanning' is the protective response in which detection of UV-induced damage induces melanin production, to reduce subsequent damage. 'Nucleotide excision repair' identifies the damaged DNA base dimers and replaces them with normal undamaged bases. (Patients with genetically deficient nucleotide excision repair suffer from *Xeroderma Pigmentosum* and develop skin cancers from early childhood.) 'Sunburn' occurs when DNA damage in basal keratinocytes is irreparably severe, triggering apoptosis (cell suicide) to avoid the development of cancer. The apoptotic keratinocytes ('sunburn cells') trigger the inflammatory sunburn response.

If the skin has defences against UV, why worry about sun protection?[1]

Despite the skin's defences against UV, skin cancers are the most common cancers of all. Malignant melanoma causes 2500 deaths per year in the UK. Epidemiological studies demonstrate the critical causative role of UV in skin cancer. In particular, severe sunburn (mainly in childhood) is the only preventable risk factor for malignant melanoma. The predominance of the 'UV signature mutations', C→T and CC→TT, is the fingerprint that identifies UV as the culprit causing most skin cancers.

Who needs sun protection and how much?

Sun protection is crucial in people with risk factors for malignant melanoma skin cancer: the fair-skinned, the moley and those with a family history of melanoma. In these groups, sun protection is particularly important in children because of the importance of childhood sunburn as a risk factor, although adult

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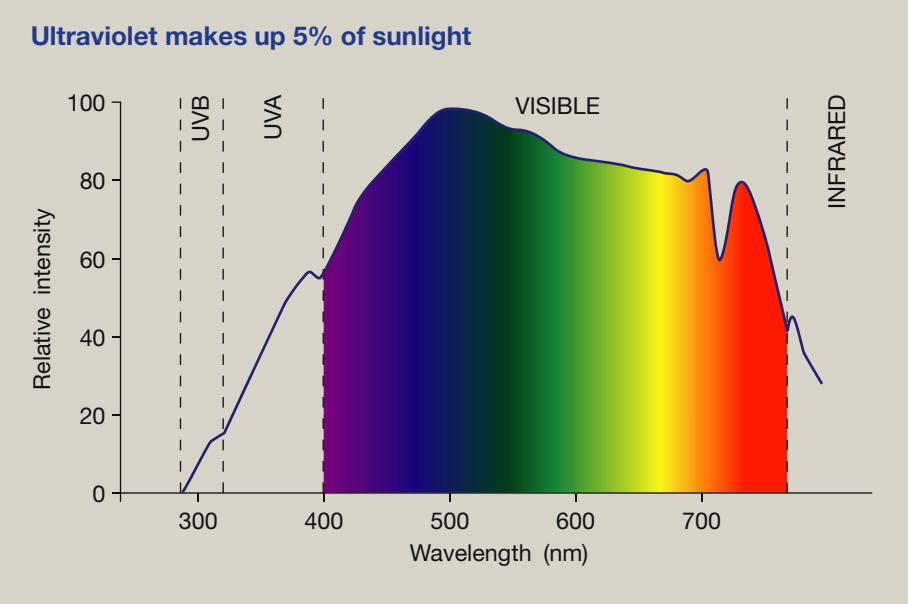

Figure 1

sunburn is also carcinogenic. Sun protection is also needed for individuals at risk of squamous cell or basal cell skin cancers, especially those who have already had *in situ* or invasive forms of these diseases.

There are also a set of patients with sunlight allergic diseases ('photodermatoses'), the most common and mildest of which is the itchy 'polymorphic light eruption' (known colloquially as 'prickly heat'). These individuals need protection from sunlight as the cornerstone of disease management.

The debate about 'how much sunshine is safe'

Vitamin D is synthesized by UVB converting 7-dehydrocholesterol into vitamin D in the skin. UV avoidance can cause vitamin D deficiency, but oral vitamin D supplements mean that we do not have to choose between photoprotection and vitamin D sufficiency for patients who need to UV protect. Other health benefits (particularly lowering blood pressure) have been proposed for sunlight but are still a matter of controversy. The balance between the benefits of UV protection and possible health benefits of sunshine is unresolved.[2] The debate is complicated by a rich and powerful industry on each side of the debate: sunbed manufacturers and operators arguing for the benefits of UV, and sunscreen manufacturers arguing for the hazards posed by UV.

For doctors, the situation is simpler. Patients with fair skin and other risk factors for skin cancer, and patients suffering from photodermatoses, need effective UV protection. For the rest of the UK population, a moderate approach seems sensible, given the link between sunburn and melanoma, the health impact of non-melanoma skin cancer in the elderly and the psychological impact of UV-induced 'skin ageing' in the middle-aged and old. The difficulties in getting even the most high-risk patients to photoprotect are detailed below. These issues around patients not following doctors' advice suggest that the debates around photoprotection advice for lower risk healthy groups may be less relevant than doctors like to think.

UV protection

Protecting against UV involves a set of behaviours: avoiding the hottest part of the day, wearing hats and long sleeves, and wearing sunscreen.

Sunscreens: these contain two types of chemical that protect against UV: 'absorbent' or 'organic' sunscreens contain organic chemicals that absorb UV; 'reflectant' or 'inorganic' sunscreens contain tiny ('micronized') metal oxide particles that reflect UV (while not reflecting visible light, so they remain transparent) (Figure 2). Sunscreens combine reflectant and absorbent ingredients. Creating sunscreens that protect against the right types of UV, in a pleasant non-odorous cream, is a real challenge for even the largest sunscreen and cosmetic companies.

'Factor 50 is not Factor 50': UV (wavelengths 290–400 nm) is divided into shorter wavelength UVB (290–320 nm) and longer wavelength UVA (320–400 nm). UVB causes sunburn and is carcinogenic. UVA is less carcinogenic but is often the problem in sun allergy rashes. It also causes the skin ageing effects of sun exposure. The 'sun protection factor' (SPF) of a sunscreen measures protection against sunburning by UVB. An SPF50 sunscreen increases by 50-fold the time a person can spend in the sun before burning (by cutting out 49/50 of the UVB) when applied to the skin at a thickness of 2 mg/cm^2. The 2 mg/cm^2 is an arbitrary thickness whose origin is lost in the mists of time. On holiday, even under observation by researchers, people apply sunscreen to themselves and their children at 0.5–0.8 mg/cm^2.[3] The 'real-life' SPF of an 'SPF50' sunscreen applied at 0.5–0.8 mg/cm^2 is SPF 3–5: it increases the time to burn by three- to fivefold, not 50-fold. This is still enough to prevent burning in bright sunshine for many people. Because the 0.5–0.8 mg/cm^2 is

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