Sun protection, sunscreens and Vitamin D

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Melanoma
Skin cancer and sunlight

- Exposure to UVR causes > 90% of skin cancers
- Skin cancer is commonest cancer in NZ
  - >50,000 new cases per year
  - ~300 deaths per year
  - ~$33.4 NZ million per year

Melanoma

- 1842 new cases in 2002
- 328 directly attributable to severe sunburn
  (Sneyd and Cox 2006)
- Authors recommended, “to reduce burden of melanoma in NZ, need to prevent excessive sun exposure and (facilitate) early diagnosis”
- Whilst cancer overall is rare in adolescence, melanoma was commonest cancer
Melanoma

- NZ incidence and death rate among world highest
- 56.2/100,000 in European population of Auckland highest reported worldwide
- men >50yrs present with more advanced melanoma and have higher mortality rate
- ↓ incidence in <50yrs of age in NZ
- Projected stable or declining incidence and mortality rates

Most cumulative UV is from childhood
Sun protection

- Avoid sun
- Broad rim hat
- Wrap-round sunglasses
- Large area of skin covered
- Densely woven clothing
- Sunscreen
Avoid the sun?
When?
How Ultraviolet Radiation (UVR) Behaves During a Day
NZ Cancer Society
Earth’s orbit around the sun is elliptical, not circular.
Earth - sun distance varies throughout the year.
Solar radiation received by the Earth varies.
Additionally, the Earth’s axis tilts.

(Seasons Northern Hemisphere Seasons shown).
NZ latitude ~ Southern hot Europe but without the heat!
Geographical differences in erythemally-weighted UV measured at mid-latitude USDA sites

NIWA Richard McKenzie, Greg Bodeker, Gwen Scott, Jim Slusser and Kathleen Lantz
UV issues for NZ

- Peak UV intensities in NZ
  - exceed those at comparable latitudes and altitudes in Northern hemisphere by 41 ± 5%,
  - Comparable to 1 km higher, 5 degrees closer to the equator
  - Anomally extreme high UVI values

- lower ozone amounts + the closer Earth–Sun separation in summer all contribute to the relatively high UV intensities at the NZ

- UVI in NZ winter lower

- large summer/winter contrast in NZ UVI, may be important from a health perspective.
UV index (UVI)  NIWA

- Standard measurement of erythemal (sun-burn causing) tendency
- More objective measure c.f. old “time to burn”
- Open-ended scale: UVI < 3 is low; UVI > 10 is extreme
- Depends on:
  - Sun elevation angle
  - Ozone amount,
  - Cloud cover,
  - Sun-earth separation,
  - Altitude,
  - Pollution,
  - Surface reflections (e.g., snow cover)
- In NZ winter UVI rarely > 3.
- NIWA website provides Daily Predictions and Measurements
Daily UVI predictions

- available on Cancer Society and NIWA websites
- Locate specific areas within NZ
UVI issues for NZ

- NZ UVI anomalously high in summer and low in winter.
- Greater contrast too between Northland and Southland.
Shade reduces UVR
Sun protection

- Avoid sun
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Hats:

variable sun protection for the head, face and neck

- Depending on fabric, design, way they are worn,
- brim width
  - wide (>7.5cm) provide SPF 7 for nose, 3 for cheek, 5 for neck and 2 for chin.
  - Medium (2.5cm-7.5cm) provide SPF 3 for nose, 2 for cheek and neck and none for chin.
  - Narrow (<2.3cm) provide SPF 1.5 for nose and little or no protection for chin and neck
Variable protection from sunhats

Wrap-round sunglasses preferable
Sunglasses

- Cataracts and eye cancer arise from chronic sun exposure to the lens
- Single or several additive exposures relevant
- Sunglasses which absorb 99-100% of the full UV spectrum (up to 400nm) should be worn
- Additional retinal protection can be provided by lenses that reduce violet/blue light transmission
UPF = UV protection factor from clothing

- transmission of UVA and UVB through fabrics measured by spectrophotometry
- UPF should be > 30
- clothing design should cover the upper and lower body
  - (base of neck down to hip and across shoulders down to ¾ of upper arm, and lower body coverage should be from waist to knee)
↑clothing UPF by

- tighter woven fabrics
- darker colours
- optical brighteners
- laundering with UV absorber Tinosorb FD
- distance of fabric from the skin i.e. not too tight
- hydration ↑viscose or silk UPF but↓ cotton UPF

- For adequate photoprotection, denier count needs to be > 40 but popular pantyhose 15 denier provides less than 2 UPF.
Sun protection

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**Sunscreen**

- **SPF** = sun protection factor
- **Burn time with sunscreen compared to no sunscreen**
- **UVB protection factor**
- **No universally agreed measure of UVA protection**
Sunscreens

- Physical / non-chemical / inorganic
- Organic / chemical
Inorganic sunscreen

- Titanium dioxide and zinc oxide
- Photostable
- Not absorbed systemically
- Not been reported to sensitise (cause allergic skin reactions)
- Reflect and diffuse UVR
- ↓ Particle size to microionised form (10-50nm) c.f. 200-500nm of non-microionised form gives better cosmesis but shifts protection towards shorter wavelengths, unless particles coated with dimethicone or silica
Organic / chemical sunscreens

- **absorb UVR energy** converted to unnoticeable heat
- **variable UVL spectrum cover**
  - Classified as UVB or UVA filters
- **Variable duration of effect**
  - photostable: able to absorb UVR photons repetitively
  - photounstable: filter rapidly loses its absorption capacity and protective potency
  - photoreactive if absorbed UV photons create photoexcited molecules reacting with skin biomolecules, ambient O$_2$ or other sunscreen component
Examples of **organic filters**

- **UVA filters**
  - titanium dioxide and zinc oxide
  - benzophenones (oxybenzone, sulisobenzone, dioxybenzone),
  - butyl methoxydibenzoyl methane (avobenzone, Parsol 1789)
  - menthyl anthranilate

- **UVB filters**
  - para-aminobenzoic acid (PABA) derivatives (e.g. Octyl dimethyl para-aminobenzoic acid)
  - Cinnamates (octyl methoxycinnamate,
  - Parsol MCX, cinoxate)
  - salicylates (octyl salicylate, homosalate, trolamine salicylate),
  - Octocrylene
  - phenylbenzimidazole sulfonic acid.
Broad spectrum sunscreens

high level of absorption in both the UVB and UVA ranges
Sunscreen stability variable, so...

- Sunscreens need frequent re-application
  - Prolonged UVA coverage so less frequent for Neutrogena Helioplex, Daylong

- keep sunscreens away from heat and sunlight when not in use

- discard sunscreens after best-before-date
Other aspects of sunscreen

- **Sun sensitivity** re SPF number (fair vs. pigmented skin)
- **Sensitivity / intolerance**
  - non-perfumed hypoallergenic / low irritant sunscreens e.g. *Ego Low Irritant Sunscreen*.
  - Microionised sunscreens cosmetically better tolerated
- **Dryness**
  - sunscreen with a moisturising base e.g. sunscreen creams or ointments. *E.g. Ego Ultra, Ego Daily Face Matt Formula, Neutrogena Age Shield.*
- **oily / acne-prone / hairy skin**
  - lighter base, e.g. lotion or gel. *e.g. Neutrogena Dry Touch, Ego Sports Milk, Ego Sports Gel.*
- **Activity**
  - wet / sweaty – choose water resistant, longer lasting or rub resistant sunscreen *e.g. Day Long SPF 30+, Ego Sports Milk or gel.*
Once daily sunscreen application

- SPF same *not safe to be in sun all day long*
- Extra thorough application to avoid missed areas
- More resistant to rub / sweat / water loss
Wide ranging sunscreens for varied skin types, water resistance etc.
Non-greasy sunscreens
Amount of sunscreen & SPF

- The declared sun protection factor (SPF) is based on the use of a sunscreen layer of 2 mg cm\(^2\).
- Only around 25% (0.5 mg/cm\(^2\)) of this amount is applied by sunbathers.
- at the usual application rate of 0.5 mg/cm\(^2\), the true SPF is a 4th root of the claimed SPF
  - @ 2 mg/cm\(^2\) → SPF 30;
  - @ 1.0 mg/cm\(^2\) → SPF 5.5;
  - @ 0.5 mg/cm\(^2\) → real SPF 2.3

Other aspects of sunscreens
- how much to use?

Average adult size

- 1/2 teaspoon
  - face
  - neck (front & back)
  - ears

- 1 teaspoon
  - each arm and leg,
  - on the back
  - and on the torso

*Sunscreen should be reapplied frequently e.g. every two hours
Future sunscreen improvement

- More photostable
- Progressive UVA protection
- Research in immuno-protective / enhancing properties in sunscreens e.g. photo antioxidants
Do sunscreens make a difference?
Sunscreens

- Regular use of sunscreen SPF > 7.5 can ↓ lifetime incidence of non-melanoma skin cancer by ~80%

- Daily use of high SPF (>17) ↓ development of new solar keratoses (SCC precursor) and ↑ remission of existing lesions AJD 2007;48:67-76
Sunscreens

- Reduce UV-induced $p53$ mutations
- Decrease immunosuppressive effects of sunlight
- Immune protective factor correlated with UVA protection factor of sunscreens (not SPF)
- SPF (sun protection factor) only internationally recognised end-point for the evaluation of sunscreen effectiveness
What about Vitamin D?

- Vit D production from UVB part of UV spectrum
- High SPF sunscreen better protection from UVB
- Regular sunscreen usage and sun protective behaviour does not impair Vit D levels (Marks, ’95)
Vitamin D benefits

- helps bone, joint, muscle and neurological function, calcium regulation, TSH production, hair growth and development
- link between sunlight exposure, vitamin D levels and osteoporosis, well established.

Vitamin D

- may help prevent or improve the outcome of:
  - breast, prostate and colorectal cancer, non-Hodgkin lymphoma,
  - cardiovascular disease,
  - diabetes and
  - autoimmune diseases (e.g. Multiple Sclerosis)
Vitamin D benefits

- mechanism been linked to the regulatory role of 25-hydroxyvitamin D on cellular growth both in normal and cancer cells.
7-dehydrocholesterol (abundant in skin)
▼ UVB (290-320nm)
Previtamin D
▼ skin temperature dependent conversion
Vitamin D3 (cholecalciferol)
▼ liver hydroxylation
Hydroxycholecalciferol
▼ kidney (& paracrine in other organs) hydroxylation
1,25-dihydroxycholecalciferol
Effect of MED on Vitamin D production

Vit D deplete and 1 MED
- 3 x ↑serum Vit D
- 2X ↑ 25OH D
- 8X 1,25(OH)2 D (4 x upper limit of normal)

Vit D replete and 3 MED
- 7-10 x ↑ serum Vit D in 2/7
- Returned to baseline in 1/52
- 2 x ↑25OH D by 2-3/52
- 1,25(OH)2 D remains in normal range

MED = minimal erythema dose
Vitamin D

SKIN (Epidermis)

7-dehydrocholesterol ↔ previtamin D₃ ↔ lumisterol

UVB (295 nm)

skin temp

tachysterol

vitamin D₃

blood

DBP - D₃

Vitamin D binding protein (DBP)

Ergosterol
Dehydrocholesterol
Vitamin D₃ (fungal: food)
Vitamin D₃ (endogenous: hormone)
Vitamin D production regulation

- Maximal at suberythemal UVB dose
- Further UV exposure results in production of biologically inert lumisterol & tachysterol
- If synthesised Vit D > amount leached into circulation, remaining Vit D3 in the skin is further degraded by sun exposure
Optimal Vit D without burning / tanning

- At lower UVB wavelengths more burning, less Vit D production
- Optimal Vit D ~ 308nm (therapeutic nbUVB)
- No vitamin D from Tanning lamps

*Diagram from Solarac Lamps*
Vitamin D production if exercising outdoors
Vitamin D insufficiency at risk groups

- Elderly
- Darkly pigmented
- Covered-up (religious or cultural, extreme sun protection)
- Obese
- Babies of vitamin D deficient mothers
- Housebound or in institutional care

*May require extra oral vitamin D*
Vitamin D_3 vs. Vitamin D_2

- Vitamin D3 from sunlight or animal sources
- Vitamin D2 is synthesised from ergosterol (in plants) also by the action of UVR
- Vitamin D2 follows the same hydroxylation pathway and is equipotent to Vitamin D3
- So dietary vitamin D = skin/ liver / kidney vitamin D
Oral Vitamin D

- **Dietary**
  - Oily fish, liver, kidneys, lamb, sun-treated shiitake mushrooms
  - Eggs, milk
  - Fortified food, e.g. margarine, soy milk, Anchor (Fonterra) milk

- **Cholecalciferol** 1.25mg = 50,000IU on Rx
Skin cancer high risk patients

- Oral or parenteral supplementation works well in correcting the deficiency.
- Treat vitamin D deficiency with oral supplementation not more solar carcinogen.
Vit D supplementation importance

- Vit D supplementation is the logical therapeutic approach to vitamin D deficiency

Vitamin D toxicity

- Difficult to achieve!
- Possible after long-term intake of > 100,000 i.u. daily
- Anorexia, vomiting, diarrhoea,
- Hypercalcemia, hypercalciuria
- Osteoporosis
- Rx withdraw Vit D, low calcium diet, systemic corticosteroids
Future

- Better protection
  - Improved sunscreen
  - Photoprotectant clothing / glasses
  - Fashions
  - Window glass (tint etc)
  - Antioxidant

- Better detection?

- Better treatment for skin cancers
  - further immune modulators
Take home messages 1

- Skin cancers *are* a big problem in NZ
  - Morbidity
  - $cost$
  - mortality
SCC Squamous cell carcinoma
Sun protection *does* help reduce skin cancers (and photoageing)
- Avoid sun when UVI >3
- Broad rim hat
- Wrap-round sunglasses
- Cover large area (3/4) of skin
- UPF clothing >30
- Sunscreen (especially UVA coverage / broad spectrum)
- Healthy diet
Take home messages 3

- Adequate Vitamin D levels important for **optimal health** 80nmol/l?
- Efficient Vitamin D production **by**
  - Keeping pale (non pigmented / non sun damaged skin)
  - Minimal sun exposure (sub MED)
  - But regular outdoor exercise
  - Healthy diet
Conclusion

Health Messages

- **Minimal sun-exposure for optimal Vitamin D production**
  - *promote some regular outdoor exercise, walk / cycle to school / work*
- Antioxidants - *Eat 5+ fruit and vegetables*
- Promote dietary *oily fish*
- Sun protective behaviour lifelong *Support SunSmart*
- Should we promote more Vit D supplementation / food fortification?
- Regular self-skin / cancer checks