Sun exposure in outdoor workers: Friend or foe?

Cheryl Peters, PhD

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1. Postdoctoral Fellow, Carleton University & Institut National de la Recherche Scientifique
2. Occupational Exposures Advisor, CAREX Canada, Simon Fraser University
3. Affiliated Scientist, Occupational Cancer Research Centre

Ultraviolet radiation (UVR) and cancer
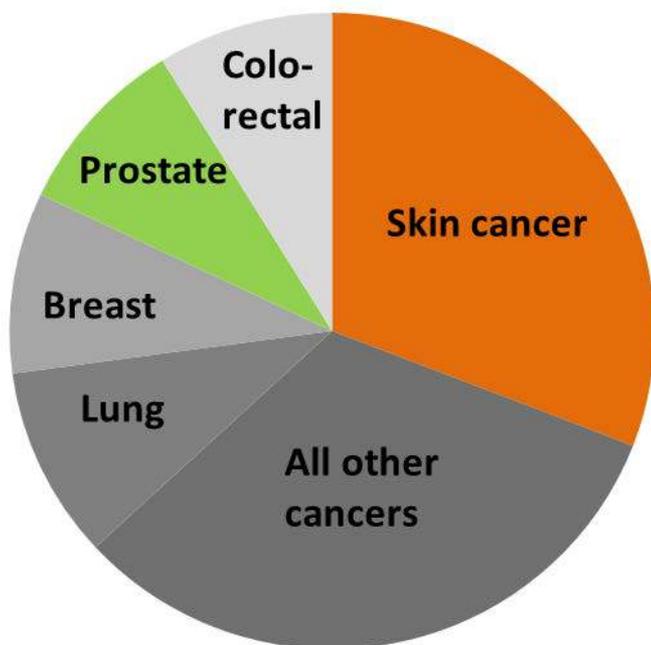
Skin cancer

- ~83,000 of ~267,000 new cancer cases

Prostate cancer

- 2nd most common malignancy in Canadian men – 23,600 of the 140,000 new cancers

- 3rd most common cause of cancer death in men, after lung and colorectal

Canadian Cancer Society's Advisory Committee on Cancer Statistics. Canadian Cancer Statistics 2014. Toronto, ON: Canadian Cancer Society; 2014.

Rationale for my work

1. No objective UVR measures in Canada

2. Solar UVR exposure is mediated by PPE, but information on determinants of protective behaviours is not widely available

3. A general job exposure matrix (JEM) for outdoor work has not been developed

4. Equivocal epidemiology for a protective effect of UVR against prostate cancer

# What is UV radiation?

Lucas and Ponsonby 2002, *MJA* 177(2):594-8
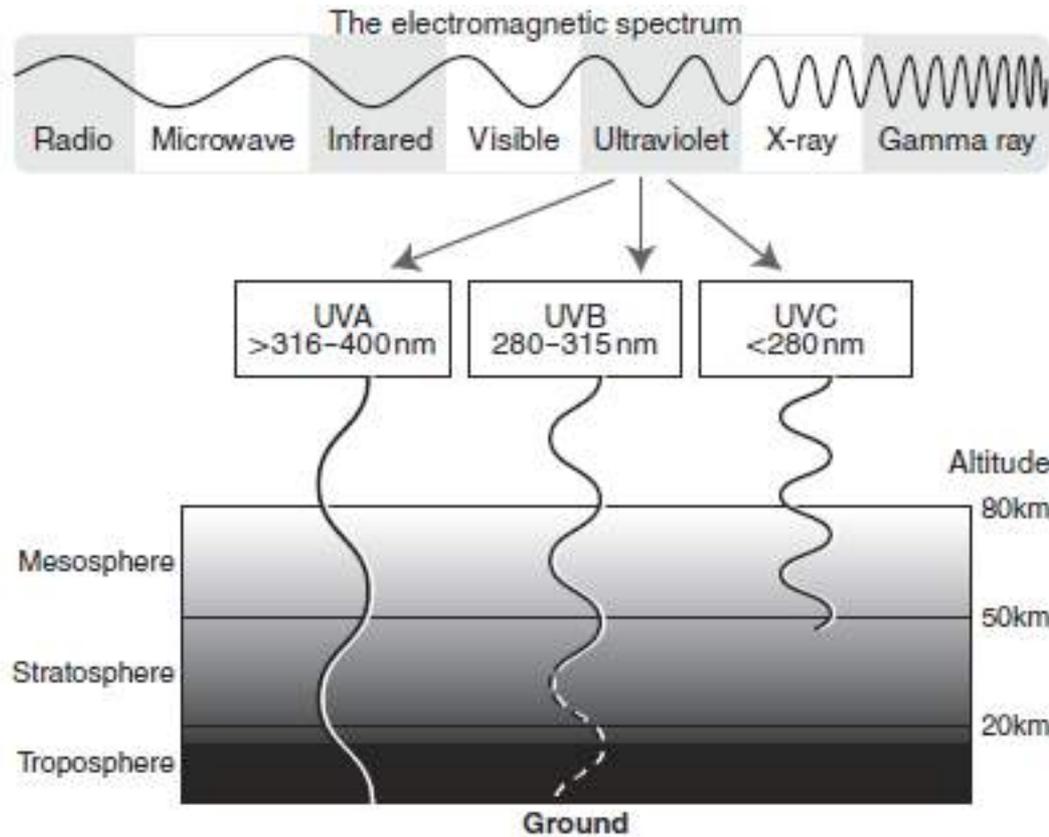
Negative health effects of UVR exposure
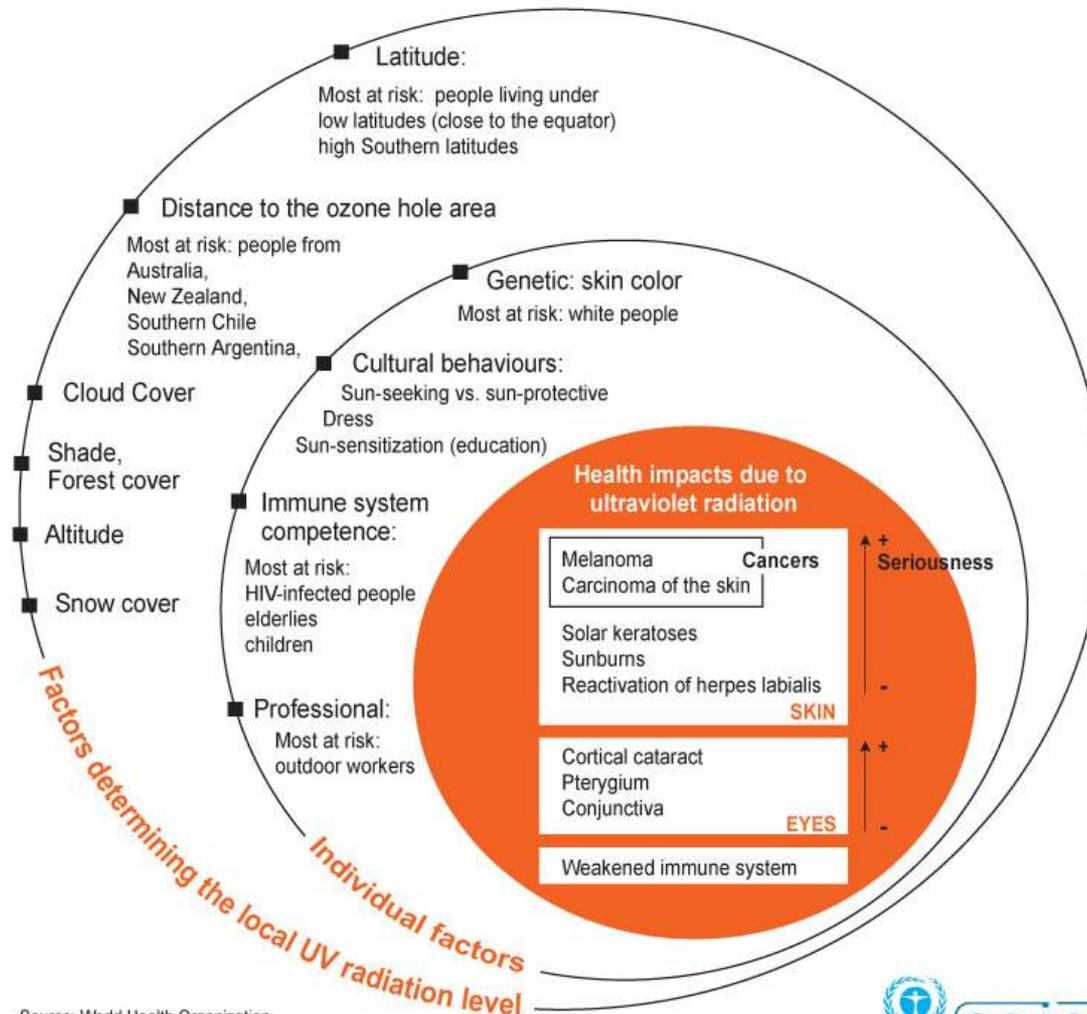
Source: World Health Organization,
Global burden of disease from solar ultraviolet radiation, 2006.

The complication: vitamin D
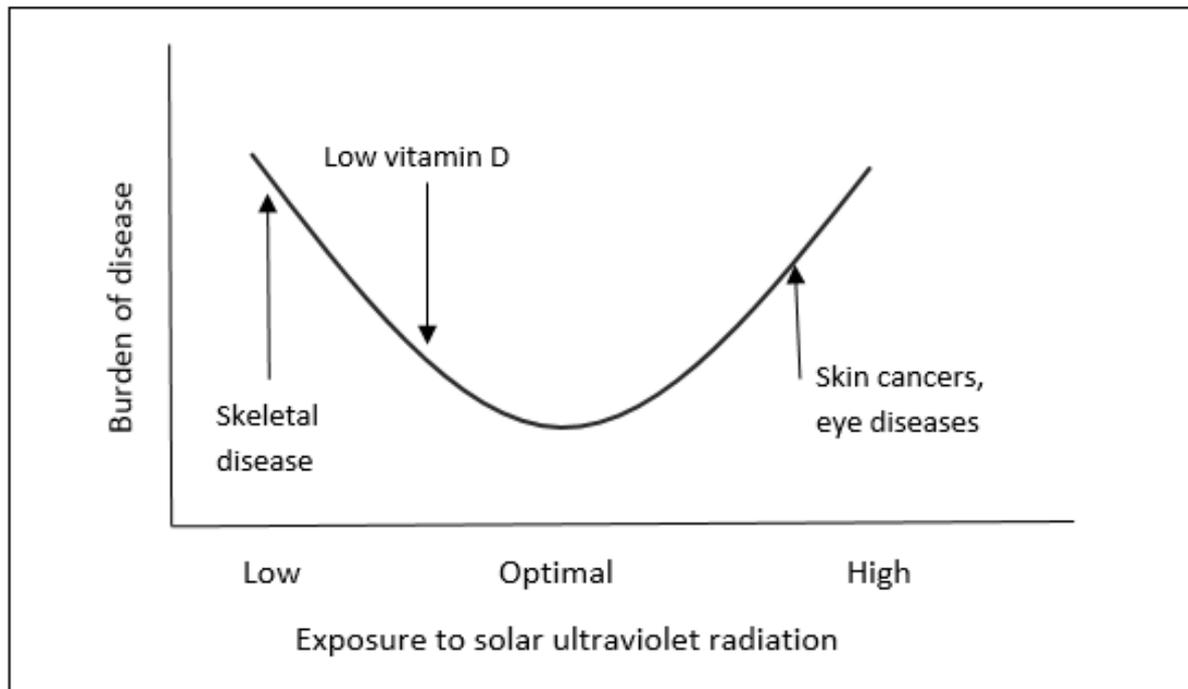
*Ultraviolet radiation and health: friend and foe. Med J Aust 2002; 177(11):594-598. © Copyright 2002 *The Medical Journal of Australia* - adapted with permission. The Medical Journal of Australia does not accept responsibility for any errors in adaptation.

# UVR exposure: occupation is important

- Outdoor workers receive ~6-8 times the yearly exposure of indoor workers[1]

  – More likely to get skin cancer (non-melanoma); relative risk ~ double, but likely an underestimate


1. Nahar et al. 2013. Sociodemographic and psychological correlates of sun protection behaviors among outdoor workers

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Exposure assessment methods

1. Questionnaires or JEMs

- 'Yes-no'
- Self-reported time outside
- Instances of sunburn

2. Environmental measures
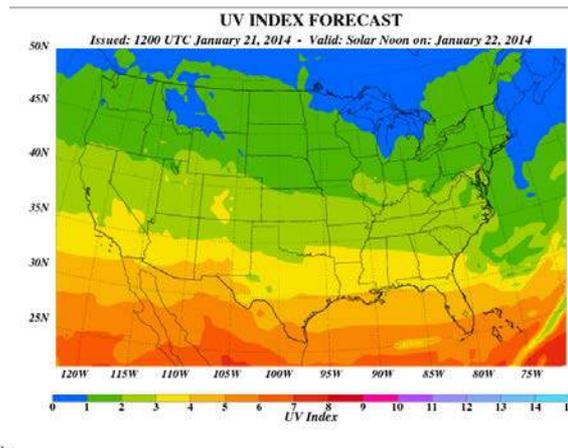
3. Personal dosimetry

- Chemical
- Biological
- Electronic
- Skin measures

For each question listed, please select the one answer that is the best response to the question.

Section 1 - Sun Habits

1. In the summer, on average, how many hours are you outside per day between 10 AM and 4 PM...on WEEKDAYS (Monday-Friday) ?
30 minutes or less .... ○
31 minutes to 1 hour .... ○
2 hours .... ○
3 hours .... ○
4 hours .... ○
5 hours .... ○
6 hours .... ○

2. In the summer, on average, how many hours are you outside per day between 10 AM and 4 PM...on WEEKEND DAYS (Saturday & Sunday) ?
30 minutes or less .... ○
31 minutes to 1 hour .... ○
2 hours .... ○
3 hours .... ○
4 hours .... ○
5 hours .... ○
6 hours .... ○
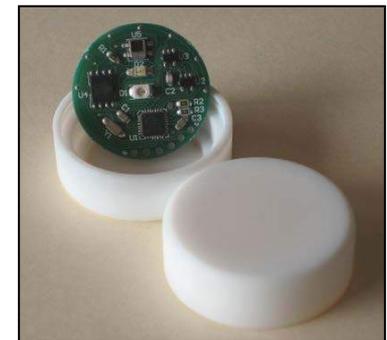
Concepts on quantifying UVR
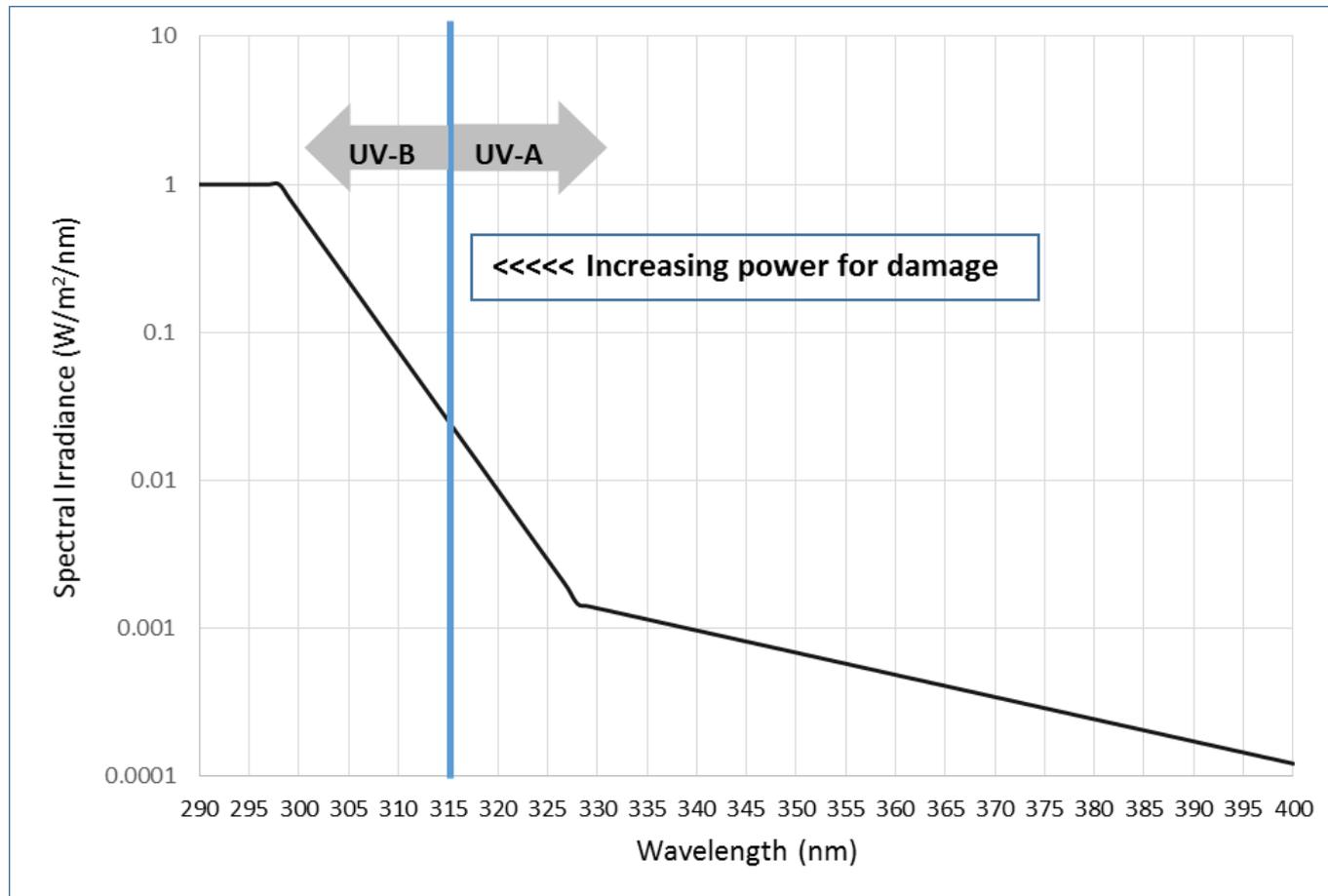
Standardized questionnaires → JEMs

For each question listed, please select the one answer that is the best response to the question.

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3 hours .... ○
4 hours .... ○
5 hours .... ○
6 hours .... ○

3. In the past 12 months, how many times did you have a red OR painful sunburn that lasted a day or more?

| 0	1	2	3	4	5 OR MORE
○	○	○	○	○	○

For the following questions, think about what you do when you are outside during the summer on a warm sunny day.

	NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
4. How often do you wear **SUNSCREEN?**	○	○	○	○	○
5. How often do you wear a **SHIRT WITH SLEEVES** that cover your shoulders?	○	○	○	○	○
6. How often do you wear a **HAT?**	○	○	○	○	○
7. How often do you stay in the **SHADE** or **UNDER AN UMBRELLA?**	○	○	○	○	○
8. How often do you wear **SUNGLASSES?****	○	○	○	○	○

9. How often do you spend time in the sun in order to get a tan?**

NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
○	○	○	○	○

10. What is the color of your untanned skin?**

Very Fair .... ○
Fair .... ○
Olive .... ○
Light Brown .... ○
Dark Brown .... ○
Very Dark .... ○

Environmental measures

## Satellite –Derived Estimates of Solar Irradiance
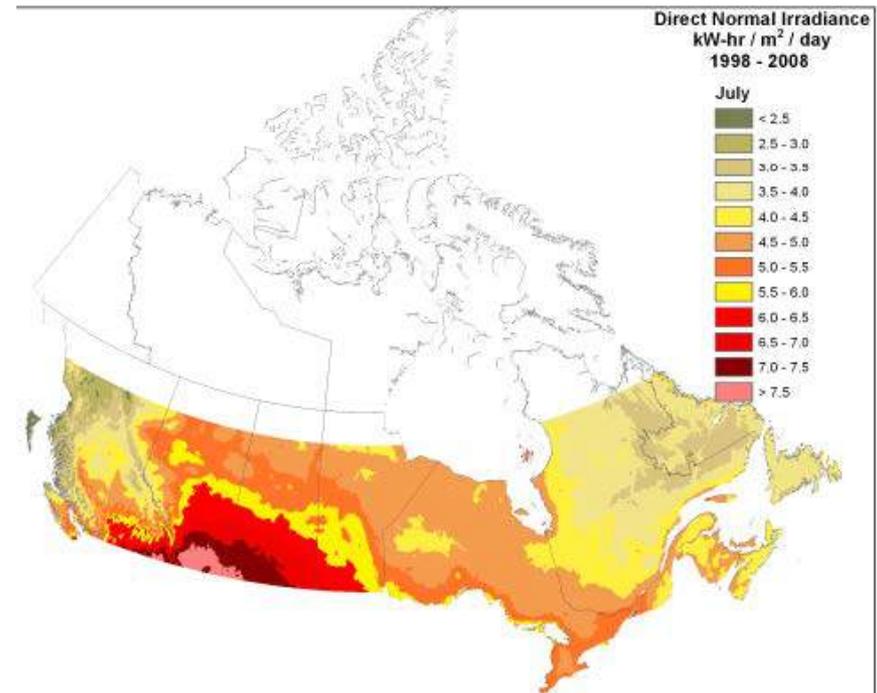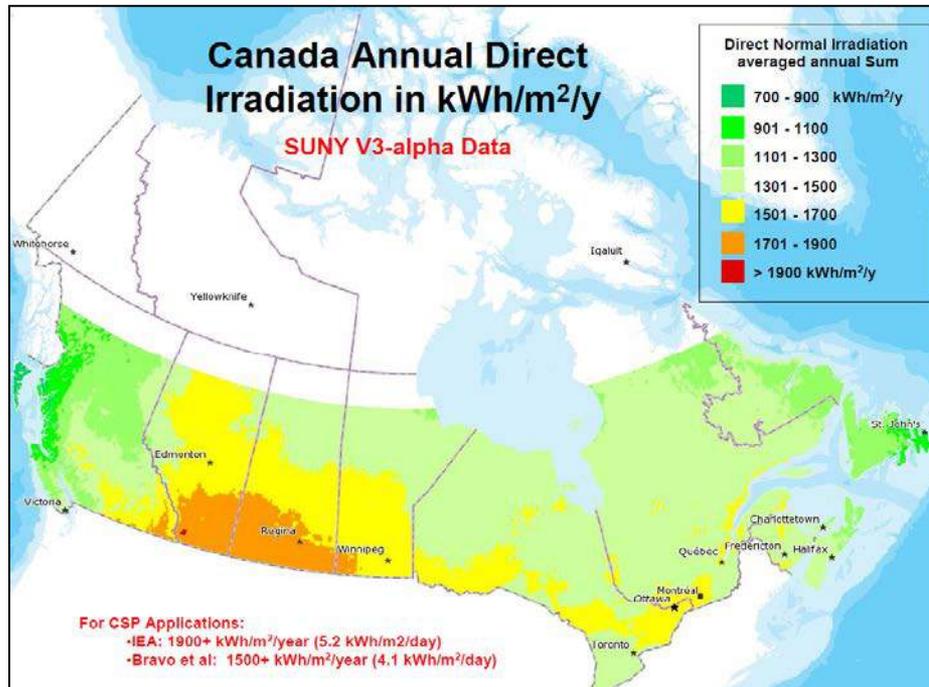
Dosimetry

1. Biological
   - UV sensitive spores (measure inactivation), DNA (measure DNA damage)

2. Chemical (measure a predictable colour change
   - Normally polysulfone

3. Electronic (photodiodes)

4. More unique: monitor vitamin D levels, change in skin colour
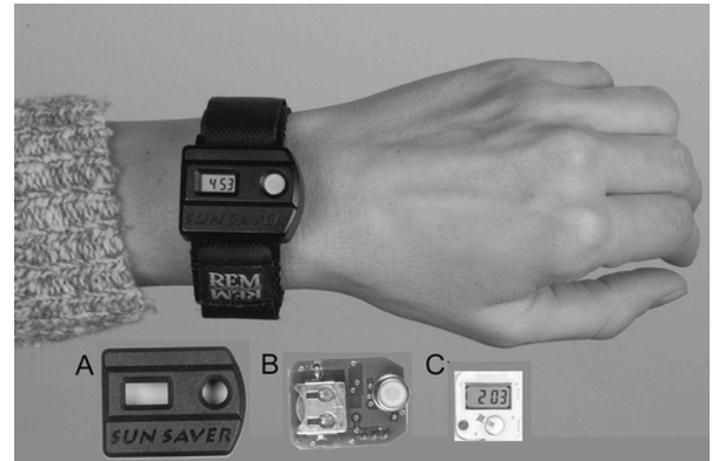
Rationale for my work

1. No objective UVR measures in Canada

2. Solar UVR exposure is mediated by PPE, but information on determinants of protective behaviours is not widely available

3. A general job exposure matrix (JEM) for outdoor work has not been developed

4. Equivocal epidemiology for a protective effect of UVR against prostate cancer

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The Outdoor Workers Project:

Objectives:

1. To understand the determinants of sun protection use

2. To measure ultraviolet radiation exposure in BC's outdoor construction workers

Outdoor Workers Project: Methods

1. UV dosimeter

2. Questionnaire

3. Activity diary

Sun protection score

Work protection score
- Sunscreen
- Sleeved shirt
- Hat
- Seek shade
- Sunglasses

Score each from 0 (never) to 4 (always), summed and ÷ by 5
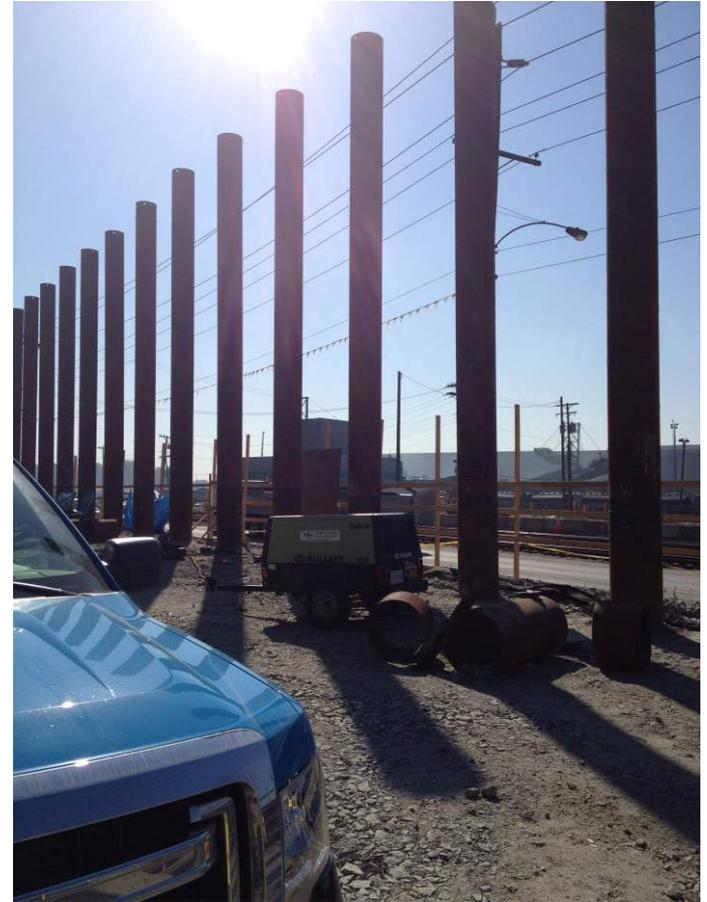
Statistical analysis

- **Behaviours:** GLM used to model the determinants of sun protection scores, separately for work and leisure

- **Exposure level**: Marginal models to allow repeated measures (person and day), outcome either SED_{day} or $SED_{\%max}$ (ln-transformed)

Results: Recruitment and demographics

Characteristic	Outdoor workers
Total number	77
Sex (n males, %)	73 (95%)
Age (mean, range)	38 (18 - 69)
Race (n Caucasian, %)	73 (95%)
Yes to childhood sunburn (n, %)	45 (58%)
Blonde or red hair (n, %)	9 (12%)
Light-coloured eyes (n, %)	49 (64%)
Skin types I or II (n, %)	11 (14%)

Sun protection behaviours (n=77)

Behaviour	Never/Rarely/ Sometimes (%)	Often/always (%)
Wear sunscreen	71	29
Wear a shirt with sleeves	18	82
Wear a hat	21	79
Stay in the shade or under umbrella	92	8
Wear sunglasses	26	74

Determinants of sun protection scores

Effect	Determinants of work protection score	
	Mean score (SE)	**p-value**
Skin type		
Fairest	2.73 (0.18)	0.002
Medium	2.27 (0.12)	
Darkest	1.92 (0.17)	
Eye colour		
Blue, grey or green	2.42 (0.11)	0.105
Brown and darker	2.20 (0.15)	
Hair colour		
Blonde or red	2.09 (0.20)	0.051
Brown and darker	2.52 (0.09)	
Job group		
Land construction	2.41 (0.13)	0.182
Marine construction	2.41 (0.13)	
Horticultural/other	2.10 (0.18)	

Other variables considered: race, sex, childhood sunburn, family hx of skin cancer, # of sunburns in previous summer, education, job tenure, hours spent outside at work.

Distribution of UVR dose measurements
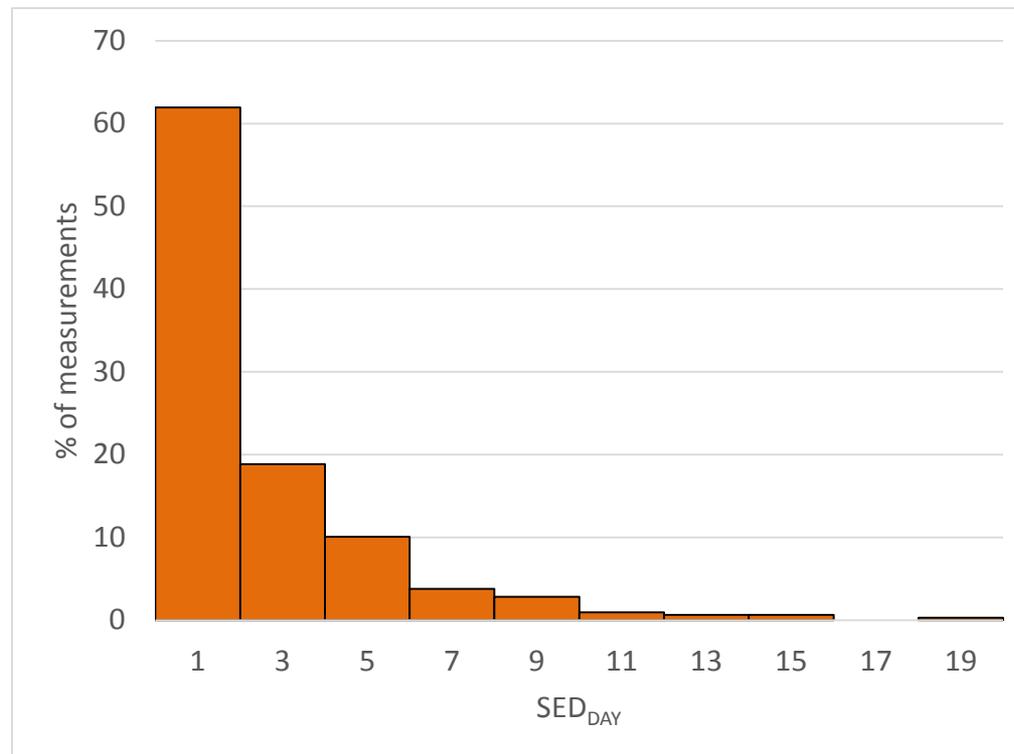
UVR dose results, corrected for repeated measures

Corrected for repeated date and subject	SED_{day} (SE)	p-value
Mean		
All subjects (n=73)	1.08 (1.14)	-
Sex		
Male (n=70)	1.04 (1.15)	0.161
Female (n=3)	2.69 (1.93)	
Age		
All subjects (β, SE)	-0.015 (0.011)	0.169
Race		
Caucasian (n=70)	1.06 (1.15)	0.495
Other (n=3)	1.70 (1.97)	
Skin type		
I and II (very fair and fair) (n=11)	1.05 (1.04)	0.124
III (white to olive) (n=40)	0.87 (1.20)	
IV - VI (olive to brown and darker) (n=22)	1.62 (1.27)	
Job group		
Marine construction (n=31)	1.28 (1.22)	0.021
Land-based construction (n=28)	1.30 (1.23)	
Horticultural/non-construction (n=14)	0.50 (1.35)	
Placement of badge		
Lapel (n=62)	1.05 (1.16)	0.519
Hard hat (n=5)	1.87 (1.68)	
Wrist band (n=6)	0.90 (1.60)	
Hours outside per day (at work)		
All subjects (β, SE)	0.35 (0.03)	<0.0001

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Predictors of SED$_{day}$

Predictor	SED$_{day}$ model[*]	
	Coefficient (SE)	p-value
Intercept	-2.7 (0.50)	<0.0001
Time outside		
Hours outside / day	0.31 (0.03)	<0.0001
Forecast		
Cloudy	-0.90 (0.32)	0.008
Mixed	-0.24 (0.16)	0.153
Sunny	0	.
Predicted UV Index		
Continuous variable (1 – 8)	0.13 (0.07)	0.052

[*]Other variables considered: race, sex, age, education, job group, job tenure, skin type, hair and eye colour, placement of badge

Summer 2013: Driest and sunniest EVER

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Summer 2013

Summer 2013

Rationale for my work

1. No objective UVR measures in Canada

2. Solar UVR exposure is mediated by PPE, but information on determinants of protective behaviours is not widely available

3. A general job exposure matrix (JEM) for outdoor work has not been developed

4. Equivocal epidemiology for a protective effect of UVR against prostate cancer

Objectives: SUNJEM and prostate studies

1. To create a job exposure matrix for use in population-based studies

2. To apply the JEM in a case-control study of prostate cancer → reduced risk in outdoor workers?

Sunlight and prostate cancer (?)

Cancer Mortality Rates by State Economic Area (Age-adjusted 1970 US Population)
Prostate Gland: White Males, 1970-94

US = 22.01/100,000

- 24.39-27.63 (highest 10%)
- 23.74-24.38
- 23.23-23.73
- 22.67-23.22
- 22.25-22.66
- 21.83-22.24
- 21.31-21.82
- 20.69-21.30
- 19.76-20.68
- 13.84-19.75 (lowest 10%)
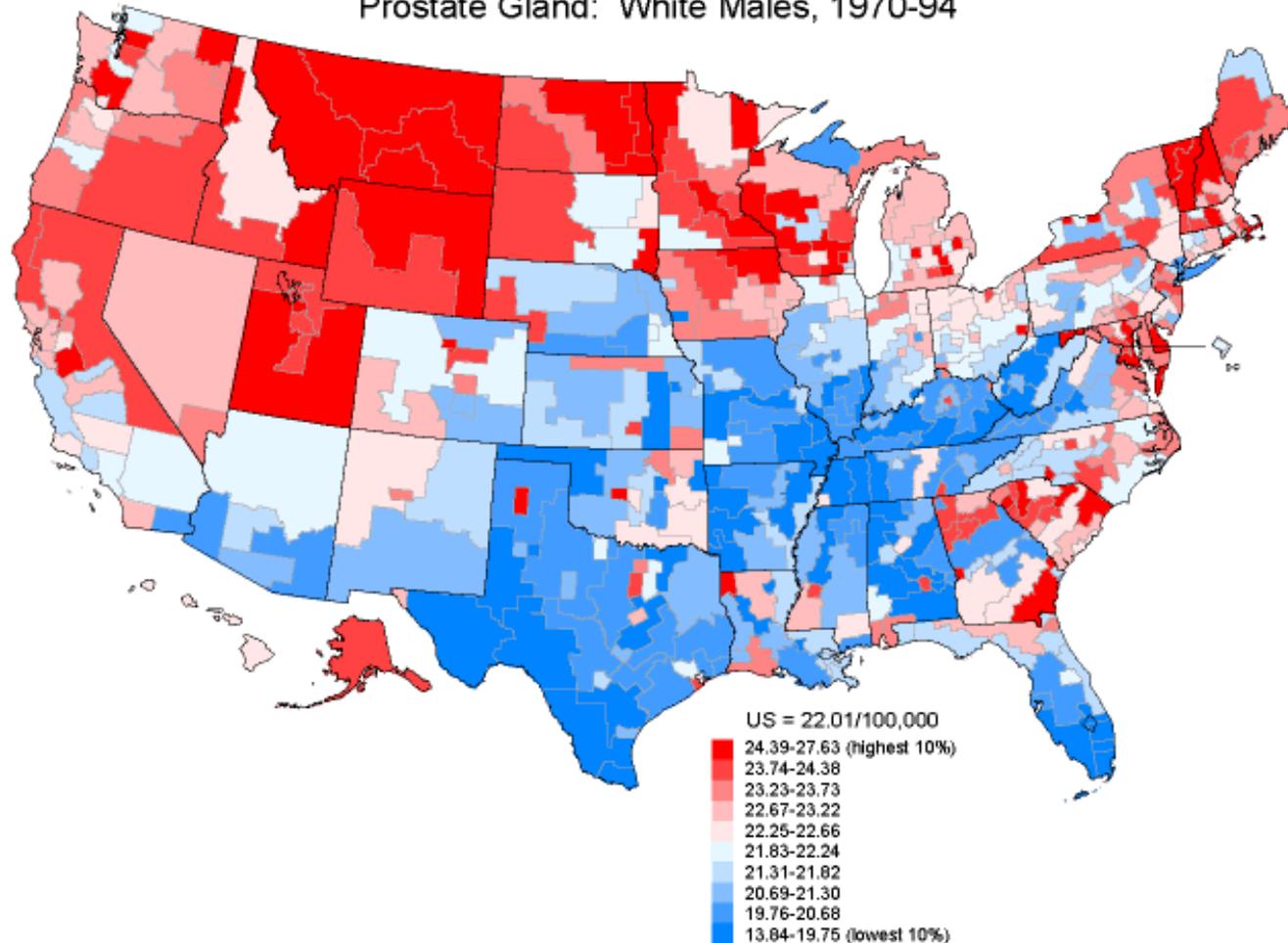
SUNJEM (Chapter 2)

DEFINITION   **EXAMPLES**   **EXPOSURE LEVEL**

Job works outside >75% of the time

HIGH

Job has indoor and outdoor work

MODERATE

Outdoor work less common or intense

LOW

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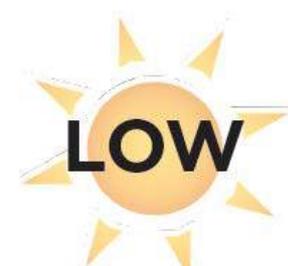
Example of prevalence → JEM

National Occupational Classification – Statistics 2006 (NOC-S)

		Occ 1	Occ 2	…	Occ 519	Occ 520
North American Industry Classification System 2002 (NAICS)	**Industry 1**	L/0.2	L/0.8	…		
	Industry 2			…	H/0.9	M/0.1
	…	…	…	…	…	…
	Industry 327	M/0.6		…	L/1.0	L/1.0
	Industry 328	L/0.5	L/0.1	…	L/0.8	

Number of outdoor workers in Canada

- 1.5 million exposed

- 8.8% of the working population

- Most of those exposed are men (82%)
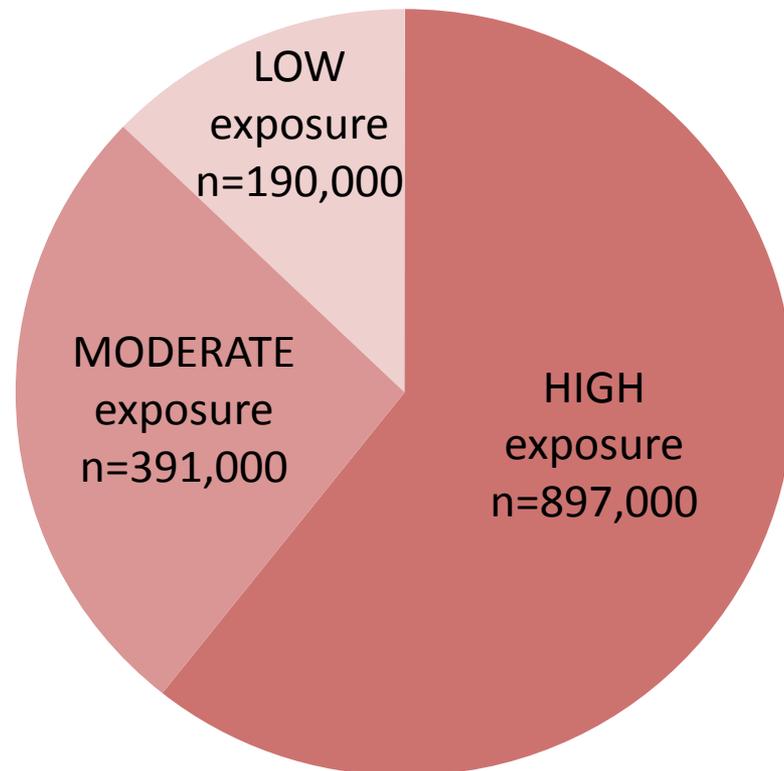
Peters CE, Nicol AM, Demers PA. Prevalence of exposure to solar ultraviolet radiation (UVR) on the job in Canada. Can J Public Health. 2012. 103(3):223-6

Methods

Study population

- National Enhanced Cancer Surveillance System (NECSS), 1994-97

  – Case-control study of 14 cancers, including prostate; limited to those aged 50 to 75

  – Full job and residential history

Exposure assessment

- SUNJEM: Developed as described, enhanced with Global UV (gIUV)

- Jobs classified as outdoors were weighted with gIUV measures in SEDs summed over working life

- Logistic regression, controlling for personal factors

Inclusion criteria
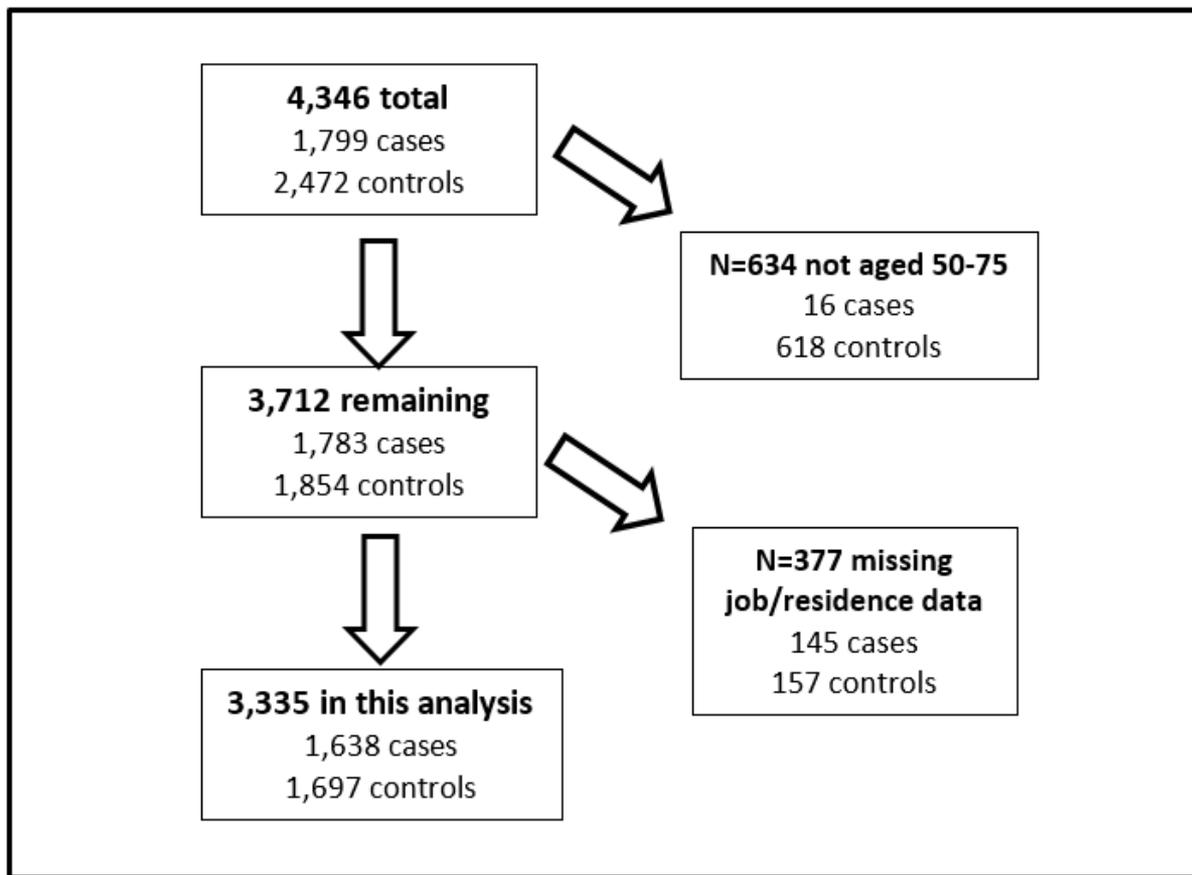
Results: Mean SED/day in highest month, Mean SED/day over the year
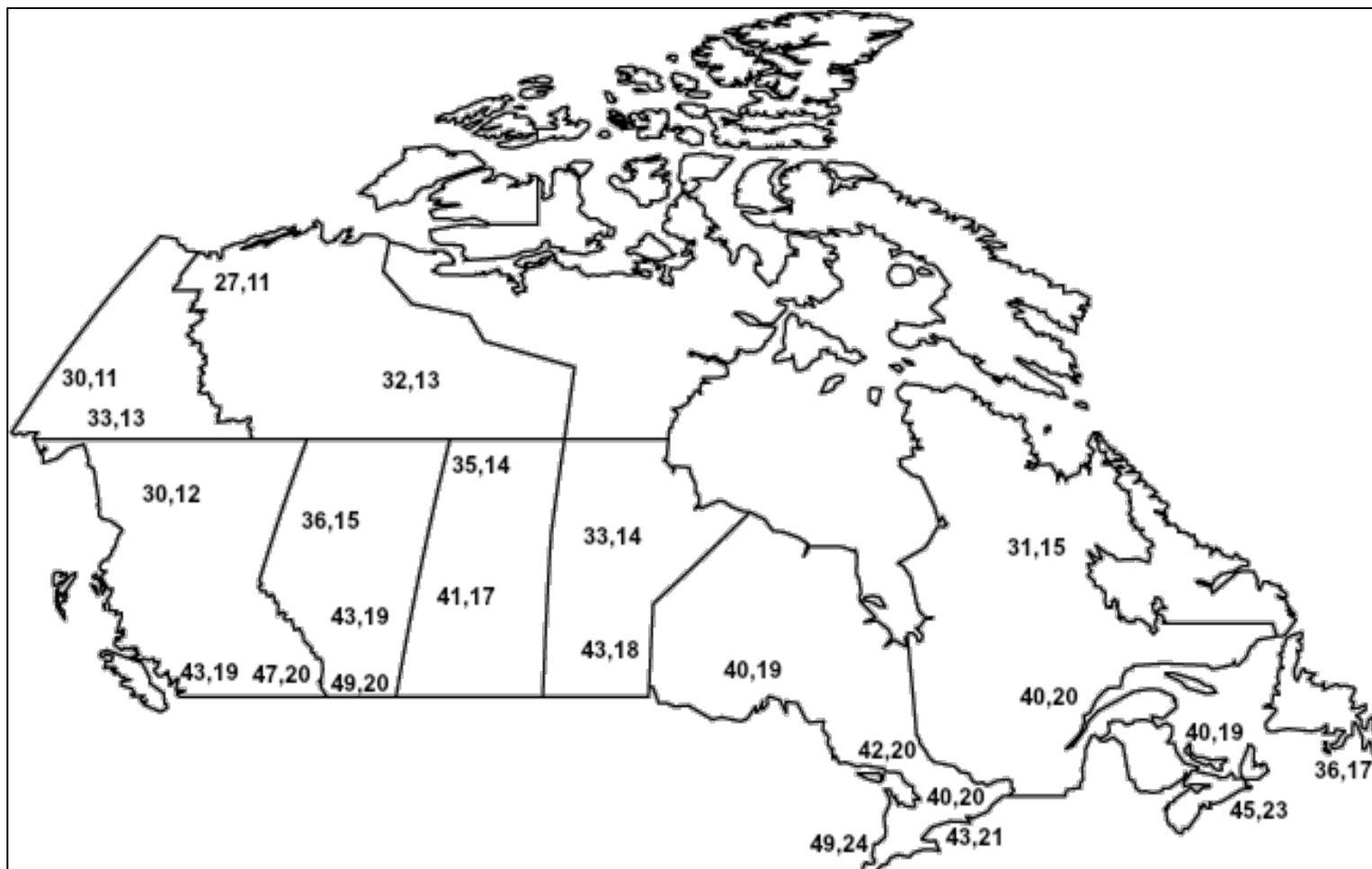
Model results: Reduced prostate cancer risk with long-term outdoor work

| Variables	Cases (n=1638)	Controls (n=1697)	Minimally adjusted odds ratio (OR)[*]	Fully adjusted odds ratio (OR)[†]
UV quartiles, all exposed jobs				
0	55%	58%	1.0	1.0
>0 – <76 SED-yrs	11%	10%	1.17 (0.93 – 1.48)	1.08 (0.86 – 1.37)
76 – <232 SED-yrs	12%	10%	1.20 (0.95 – 1.51)	1.07 (0.84 – 1.36)
232 – 523 SED-yrs	11%	11%	1.07 (0.85 – 1.35)	0.95 (0.74 – 1.21)
≥523 SED-yrs	10%	11%	0.96 (0.75 – 1.21)	0.78 (0.60 – 1.03)
p-value for trend			*0.738*	*0.229*
UV quartiles, only high category jobs				
0	64%	66%	1.0	1.0
>0 – <86 SED-yrs	9.0%	8.5%	1.07 (0.84 – 1.38)	0.99 (0.77 – 1.29)
86 – <245 SED-yrs	9.4%	8.4%	1.09 (0.85 – 1.40)	0.97 (0.75 – 1.26)
245 – 629 SED-yrs	9.4%	8.1%	1.14 (0.83 – 1.46)	0.99 (0.76 – 1.29)
≥629 SED-yrs	8.1%	9.4%	0.85 (0.66 – 1.10)	0.68 (0.51 – 0.92)
p-value for trend			*0.849*	*0.087*

***Minimally adjusted:*** *Adjusted for province and age*
†Fully adjusted: *Adjusted for province and age, as well as race/ethnicity, relationship status, percent of time lived in urban areas, and total career length*

Some limitations of this work

- SUNJEM conveys relative exposure levels, does not convey risk

- Potential for healthy worker effect?

For SUNJEM and prostate cancer studies

For exposure and behaviour studies

- Homogeneous participants

- Underestimating exposure

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Strengths of this work

- Increased detail in SUNJEM (coding and use of satellite data)

- First study to objectively characterize UVR exposure in Canada

- Raising awareness and building capacity for prevention programs

So…
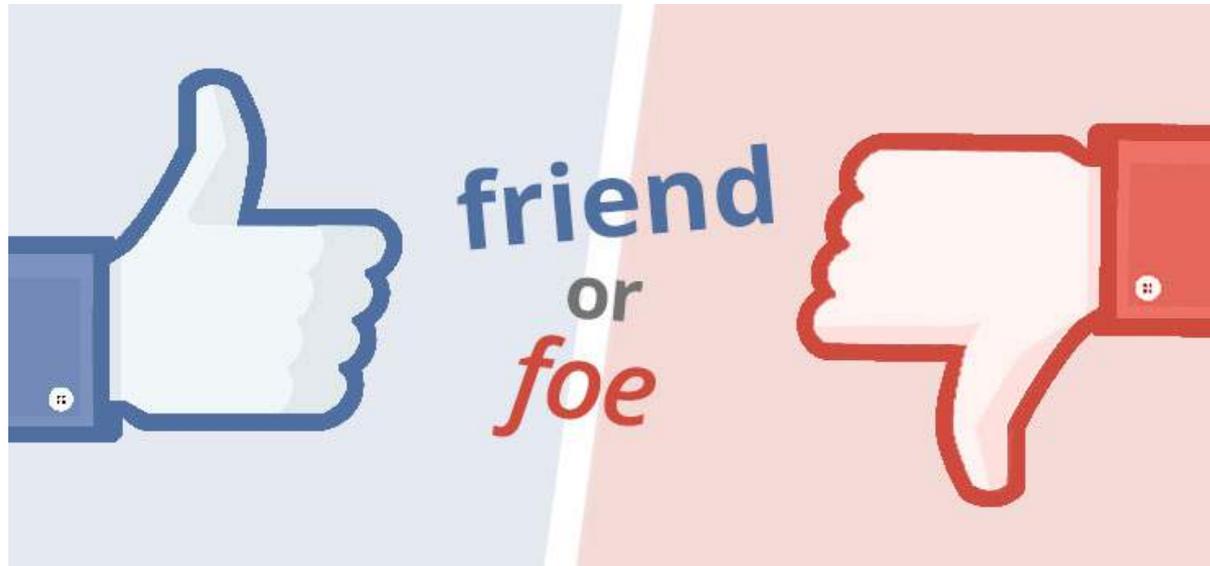
Occupational health and safety?

UV Index	Time to exceed TLV (minutes)	Time to get sunburned (min)	Ambient UVR (SEDs/hour)
3	26	44	3
4	20	33	4
6	13	22	5
8	10	17	7
10	8	13	9

Adapted from Gies et al. 2009. *AJIM* 52:645-53

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Prostate cancer risk factors?

Known risk factors	Possible risk factors
Family history	High fat diet
Age	High red meat consumption
Racial background	Being overweight/obese
	Inherited gene mutations
	Inflammation of the prostate
	Exposure to high levels of testosterone
	Tall adult height
	Exposure to pesticides
	Occupational exposures (cadmium)
	STIs
	Lack of physical activity
	Low levels of vitamin D

Risks vs. benefits

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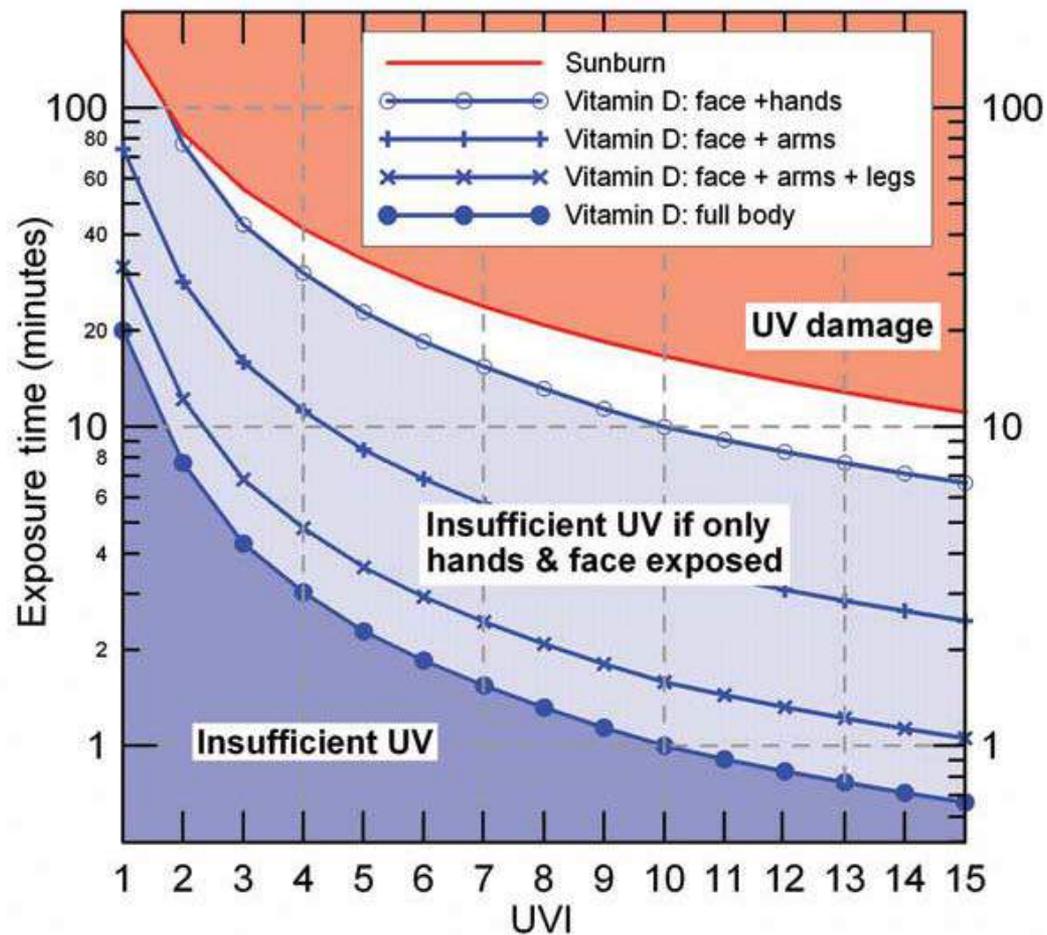
Conclusions
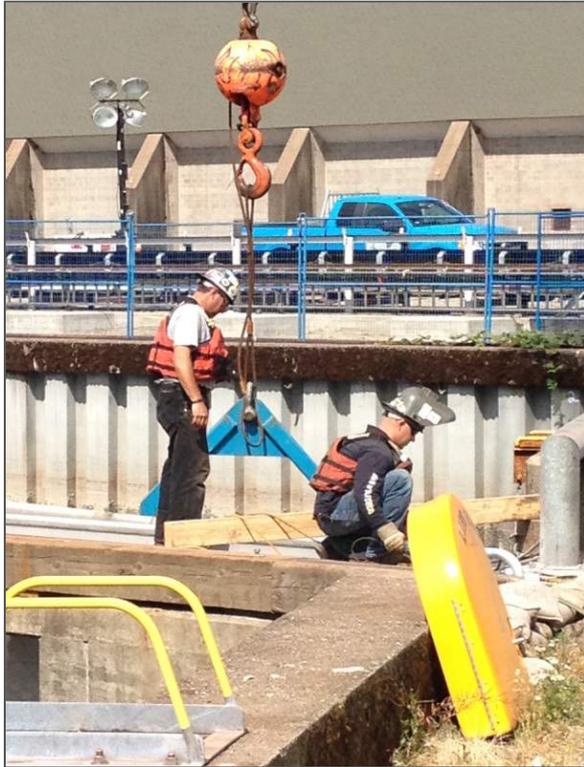
- 1.5 million Canadians exposed to solar UVR on the job

- Exposure to solar UVR is high enough in Canadian settings to be a concern

- Measuring exposure objectively is required for risk assessment, but JEMs are useful for population-level studies

- Sun exposure on the job may also decrease the risk of prostate cancer, BUT!

  – This isn't a reason to under-protect workers (or go sunbathing!)

Acknowledgements

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- Outdoor Workers Project participants

CIHR IRSC
Canadian Institutes of Health Research / Instituts de recherche en santé du Canada
Institute of Gender and Health
Institut de la santé des femmes et des hommes

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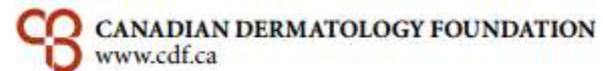
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CANADIAN PARTNERSHIP AGAINST CANCER
PARTENARIAT CANADIEN CONTRE LE CANCER

CAREX CANADA

Fitzpatrick skin types

Skin type	Example	Sun History	UVR dose causing burn on untanned skin
I. Pale white skin	Red-headed, freckles	Always burns, never tans, extremely sun sensitive	2 – 3
II. White	Fair-skinned, fair-haired, blue or green eyed, Caucasian	Always burns, rarely tans, very sun sensitive	2.5 – 3
III. White (Average)	Average Caucasian skin	Sometimes burns, tans gradually to light brown, sun sensitive	3 – 5
IV. Beige or lightly tanned	Mediterranean-type Caucasians	Burns minimally, always tans to moderate brown, minimally sun sensitive	4.5 – 6
V. Moderate brown or tanned	Middle Eastern, some Hispanics, some African-Americans	Rarely burns, tans well, sun insensitive	6 – 20
VI. Dark brown or black skin	African-Americans	Never burns, deeply pigmented, sun insensitive	6 – 20

Amusement & Recreation
45,000 exposed

Farming
264,000 exposed

Foundation & Building Exterior Contractors
68,000 exposed

Residential Building Construction
108,000 exposed

Services to Buildings
83,000 exposed