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Solar ultraviolet and the occupational radiant exposure of Queensland school teachers: A comparative study between teaching classifications and behavior patterns

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ABSTRACT

Classroom teachers located in Queensland, Australia are exposed to high levels of ambient solar ultraviolet as part of the occupational requirement to provide supervision of children during lunch and break times. We investigated the relationship between periods of outdoor occupational radiant exposure and available ambient solar radiation across different teaching classifications and schools relative to the daily occupational solar ultraviolet radiation (H_{ICNIRP}) protection standard of 30 J/m^2. Self-reported daily sun exposure habits (n = 480) and personal radiant exposures were monitored using calibrated polysulphone dosimeters (n = 474) in 57 teaching staff from 6 different schools located in tropical north and southern Queensland. Daily radiant exposure patterns among teaching groups were compared to the ambient UV-Index. Personal sun exposures were stratified among teaching classifications, school location, school ownership (government vs non-government), and type (primary vs secondary). Median daily radiant exposures were 15 J/m^2 and 5 J/m^2 H_{ICNIRP} for schools located in northern and southern Queensland respectively. Of the 474 analyzed dosimeter-days, 23.0% were found to exceed the solar radiation protection standard, with the highest prevalence found among physical education teachers (57.4% dosimeter-days), followed by teacher aides (22.6% dosimeter-days) and classroom teachers (18.1% dosimeter-days). In Queensland, peak outdoor exposure times of teaching staff correspond with periods of extreme UV-Index. The daily occupational H_{ICNIRP} radiant exposure standard was exceeded in all schools and in all teaching classifications.

1. Introduction

Limited data on solar ultraviolet radiation (UVR) radiant exposure in predominately indoor occupations highlights that skin cancer and eye disease are rarely considered diseases of occupation [1], yet skin cancer and chronic eye disease such as cataract, and pterygium are a probable consequence of lifetime exposure habits [2–5]. Research measuring annual and/or lifetime UVR radiant exposure and evaluating the associated risks in workers with predominantly outdoor occupations are common. Such studies include: building and construction workers [6–8]; Lifeguards [9]; Gardeners [10]; and Physical Education teachers [11,12]. Consequently, strong evidence is available correlating outdoor occupational radiant exposure with the incidence of non-melanocytic skin cancers. Much effort is required to reduce UVR radiant exposure in these occupations, particularly in tropical and sub-tropical regions which experience high levels of ambient solar radiation.

The intermittent sun exposure hypothesis, which places traditional indoor workers at higher risk, states that cumulative lifetime radiant exposure to solar-UVR, particularly episodes of sunburn, contribute to the risk of cutaneous melanoma in Caucasian populations [13–15]. Recent research by Kitchener [16] has shown there to be limited evidence of elevated risk of melanoma in Australian Navy personnel compared to the general population. The findings of this research contribute toward a recognized complexity in associating occupational exposure, whether acute, chronic or intermittent with increased melanoma skin cancer risk [17–19]. The Kitchener [16] study did however associate a higher risk of melanoma for Naval personnel who spent most of their working life out of direct sunlight. That intermittent exposures among workers who spend most of their time indoors cannot be excluded as a risk factor for the development of melanoma, particularly in populations exposed to high ambient levels of UVR [20–22] makes Classroom teachers an interesting case for studying occupational radiant exposure. The traditional role of a classroom teacher involves supervising children in the playground during meal breaks that generally coincide with periods of peak ambient solar UVR intensity. In Queensland, Australia melanoma rates are among the highest in the world [23–25]. Personal radiant exposures received as a consequence of the occupational requirement to

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be outdoors during periods of peak ambient UVR intensity highlight the potential value of collecting baseline information that may be used to advocate behavioral changes aimed at reducing melanoma risk [26,27], and reduced risk of keratinocyte cancers [28,29].

Queensland employers are legally obliged to provide a working environment that prevents the injury or illness of workers according to the Work Health and Safety Act [30]. Solar-UVR radiant exposure, received as a consequence of the occupational requirement to provide a duty of care to Queensland school children carries the potential to cause harm to teachers due the high levels of ambient solar radiation in school playgrounds [31–33]. The responsibility of employers to provide a safe working environment highlighted in recent research shows that an increasing number of successful worker's compensation claims in Australia have been reported for skin damage resulting from radiant exposure to UVR in the workplace [34]. A position statement by the Cancer Council Australia [35], recommends that workplaces have a comprehensive sun protection program incorporating: assessment of UVR exposure risks, implementation of protective control measures, education and training for employees and the development of written policy. Teachers and teacher aides, as employees are bound by the policies of their designated workplaces and are therefore a population group that have the potential to adopt and follow measures aimed at reducing personal solar-UVR radiant exposure. The role teaching staff play in demonstrating sun safe behavior to school children is also recognized as one of several relevant intervention strategies actively encouraged and supported by the National 'SunSmart Schools' program which has been credited with reducing skin cancer incidence in Australia since its inception in 1988 [36,37].

We report objective measurements of the Spring-time occupational radiant exposure of primary school teachers, teacher aides, and secondary school teachers from sites in tropical (Townsville) and sub-tropical (Toowoomba) Queensland separated by 8.2 degrees of latitude. Radiant exposures are referenced relative to the Australian Radiation Protection Standard (ARPS) [38] and the erythemal action spectrum [39]. For studies in which the personal risk of erythema is of concern, the erythemally effective [39] radiant exposure is often cited rather than ARPS, although the later is more relevant in occupational radiant exposure studies. The ARPS specifically weights solar UV radiant exposure to the hazard sensitivity spectrum of the International Commission on Non-Ionizing Radiation Protection [40] for the skin and eye. According to the standard, exposure of the skin to solar radiation must not exceed a weighted daily UV radiant exposure of 30 J/m^2. Below this limit, the risk of detectable acute or delayed effects are considered extremely small [41].

2. Materials and Methods

2.1. Study Location

The northern Australian state of Queensland, located between the latitude of 10°S and 28°S experiences a warm tropical to sub-tropical climate, a high number of sunshine days and extreme solar UV-levels annually from September through to April in the austral spring, summer and autumn seasons. In this research solar UV radiant exposures were monitored at two sites over a wide latitudinal range in 57 workers employed in teaching roles in November toward the end of the 2014 school semester from schools located in Townsville (19.3°S 146.8°E) and Toowoomba (27.5°S, 151.9°E).

Townsville, a major regional city of 170 000 residents is located in the dry tropics along the north Queensland coast. The monthly average UV-Index range over the year in Townsville ranges from 6 to 13, whilst the daily maximum UV-Index is typically between 10 and 13 during November when this study was conducted [42].

Toowoomba has a similarly large regional population of 110 000 residents and is located approximately 120 km inland of the capital city of Brisbane in the south-east of the state. Elevated to an altitude of 690 m, Toowoomba experiences a temperate seasonal climate with cooler winters and a larger annual variability in the UV-Index. The monthly average peak UV-Index across the year ranges from 6 to 11, whilst Toowoomba's typical maximum November UV-Index ranges between 10 and 11 [43].

2.2. Monitoring Ambient Solar-UVR

The University of Southern Queensland (USQ) and James Cook University (JCU) campuses, located in Townsville and Toowoomba have access to ambient erythemally weighted solar UV data monitored continuously and averaged every 10 min by model 501 Solar light Co (Philadelphia, PA) broadband radiometers. Instruments at both campuses are located on university building rooftop environments with unobstructed sky views. Access to the JCU radiometer was made through the Australian Radiation Protection and Nuclear Safety Authority public website [42]. The Toowoomba radiometer is maintained by the USQ solar radiation research group. Personal radiant exposure measurements expressed relative to the available ambient UVR were determined by comparison to UV-Index measurements recorded by these instruments for the period 7:00 am to 5:00 pm.

2.3. Participants

Human ethics research approvals were obtained from the University of Southern Queensland (USQ) H14REA089; The Queensland Department of Education, Training and Employment ref11/54273 and 550/27/1497; and the Catholic Education Office (Townsville Diocese) 2007–15, to approach schools and recruit volunteer study participants. Primary (prep – grade 7 in 2014; students generally 5–12 years-old) and secondary school teachers (grades 8–12 in 2014) and primary teacher aides working full-time or part-time (at least 3 days per week) were selected to participate over a period of two weeks (10 working days). Eligible participants working in teaching roles were recruited from a convenience sample of 6 government and non-government schools located within 15 km of ambient solar UV monitoring equipment located at either JCU's, Townsville campus or the USQ's, Toowoomba campus.

Each school was visited by a member of the research team and meetings were conducted with all available teaching staff to recruit volunteers. A total of 57 eligible staff provided written informed consent to participate and were issued with study information packs including a 10-day sun diary and 10 personal dosimeter badges. Participants from Townsville and Toowoomba were instructed to wear a new dosimeter daily for ten working days from 10 to 21 November, 2014. Study participants were classified as classroom teachers, outdoor Physical Education/Agriculture (PE/Ag) specialist teachers or teacher aides. The occupational radiant exposure of one school principal was also measured (Table 1).

2.4. Sun Diaries and UV Dosimeters

The pattern of sun exposure of each of the 57 participants was monitored through the use of personal UV dosimeters and the completion of daily sun exposure diaries on scheduled workdays. Sun exposure diaries were divided into 15 min intervals from 7:00 am to 5:00 pm. Participants were instructed to indicate periods of time outdoors of at least 5 min duration by proportional shading of 15 min time intervals indicated on the sun exposure diary. Thus, '0 min' could be recorded as a possible daily exposure time, but brief intermittent periods of exposure of less than 5 min duration were not expected to be noted by the study participants. Outdoor periods were defined for the purposes of this study as those areas not inside a building and may have included open playground areas, as well as shaded and semi-shaded undercover areas including walkways and areas protected by shade sails.

Personal solar UV radiant exposures were monitored using polysulphone film (PS) dosimeters with daily radiant exposure results