

Solar UV radiation-induced non-melanoma skin cancer as an occupational reportable disease: international experience to inform South Africa

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ABSTRACT

Background: Occupational solar ultraviolet radiation (UVR) exposure is a skin cancer risk factor. Outdoor workers have long exposure hours and are in need of photoprotection against solar UVR, a Group 1-defined carcinogen. In South Africa, skin cancers account for one third of all histologically-diagnosed cancers. Physiological presentation of non-melanoma skin cancers (NMSC) is most common on the head in all population groups. It is expected that occupational exposure plays a role in NMSC aetiology in South Africa, although such data are presently lacking. Recognising solar UVR-inflicted skin cancer as an occupational disease occurs in some countries. We consider the experience of other countries in including NMSC as an occupational disease to draw on lessons learnt, and consider a similar approach for South Africa.

Methods: We sourced articles in English on NMSC as an occupational disease. We also sent an open-ended e-mail information request to nine international academic experts from different developed countries. Data on background, legislation, reporting, notification and occupational sectors of concern were analysed.

Results: Several countries, e.g. Denmark, include NMSC as an occupational disease. Despite this, under-reporting is still significant. Agriculture, construction and public service sectors report most commonly, compared to other sectors. National awareness campaigns, careful legal management and improved health care services for patients are key.

Conclusions: Outdoor workers run an increased risk of developing NMSC. For South Africa to register NMSC as a reportable occupational disease, significant efforts relating to local epidemiology, exposure assessment, legal and insurance management, and policy-making, need to be considered.

Keywords: skin cancer, NMSC, occupational disease, legislation, regulation

INTRODUCTION

Levels of ambient solar ultraviolet radiation (UVR) throughout most of the year over much of the African continent, including South Africa, are high (Figure 1) with the UV Index (UVI) being frequently extreme (11+, or > 6400 Jm⁻²/day). Some exposure to solar UVR is beneficial, for example, for the production of vitamin D.¹ Excess exposure to solar UVR is a risk factor for skin cancer. Skin cancer has been deemed one of the large, unmet challenges to modern medicine given that it is the most frequently occurring and fastest growing malignant disease in terms of incidence and prevalence.²

Occupational solar UVR exposure is a risk factor for non-melanoma skin cancer (NMSC). Solar UVR was classified as a Group 1-confirmed human carcinogen by the International Agency for Research on Cancer (IARC) in 1992.³ Outdoor workers typically have long exposure hours and may have practical difficulties in following sun protection recommendations typically made for exposure in the general population. Other considerations are environmental-related modifying factors influencing exposure to solar UVR, such as latitude, time of day, ozone layer, weather conditions, altitude and reflection from the ground or water.⁴ Additional individual factors are sun exposure behaviour, holidays in sunny locations, and continuous

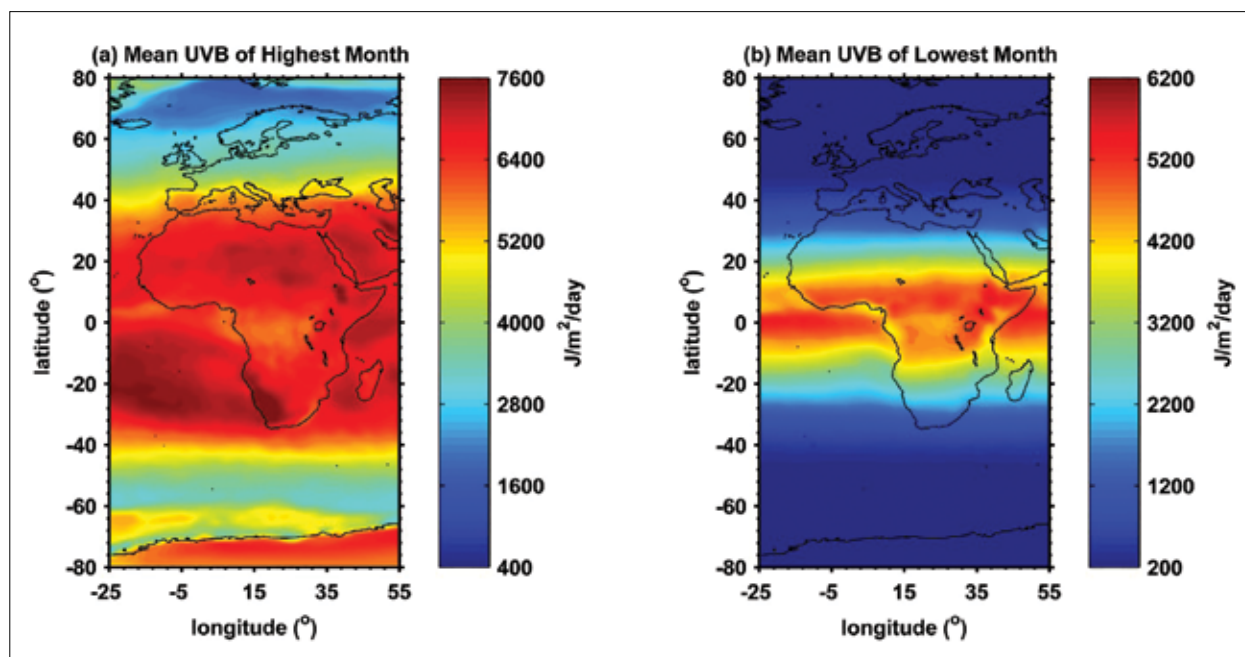


Figure 1. (a) Mean ambient UVB of highest month and (b) mean ambient UVB of lowest month over the continents of Africa and Europe

Figure compiled by Ilias Fountoulakis, Aristotle University of Thessaloniki, Greece

or intermittent exposure (frequent and/or continuous in the case of outdoor workers). Other personal factors include skin type and individual susceptibility, defective DNA repair, skin pigmentation, naevi (skin mole) count, age, gender and use of sun-protection products. The epidemiology of occupational skin cancer and sun exposure is complex. Among a multi-country European case-control study, outdoor workers had more risk behaviour with similar constitutional skin cancer risk factors, as well as more UVR exposure (occupational as well as recreational), less sunscreen use and lower health literacy.⁵

In European countries that legally recognise occupational skin cancer, NMSC (specifically squamous cell carcinoma) is most commonly approved as potentially 'work-induced'⁶ compared to basal cell carcinoma,⁷ actinic keratosis, Bowen's disease and malignant melanoma.⁸ The evidence is unequivocal that outdoor workers run an increased risk for NMSC,^{2,5,8} and for actinic keratosis odds ratios seem to be increased fourfold among those working outdoors.⁹ This is not the case for cutaneous malignant melanoma,¹⁰ where intermittent sun exposure is likely to increase risk while regular exposure seems to protect against melanoma (though caution is warranted in assuming occupational sun exposure is indeed protective, since findings could very well arise from issues in study design, such as exposure misclassification). This was shown among white collar workers who exhibited intermittent sun exposure patterns compared to blue collar workers who spend time working outdoors in the USA.¹¹

Recognising solar UVR-inflicted skin cancer as an occupational disease occurs in some countries but this is currently not the case in South Africa where skin cancers account for one third of all histologically-diagnosed cancers. South Africa is also afflicted with issues of under-reporting¹² and unequal provision of health services in certain parts, contributing to the underestimation of cancer statistics.¹

Physiological presentation of NMSC is most common on the head in all population groups.¹³ It is expected that occupational exposure plays a role in NMSC aetiology in South Africa, although such data are presently lacking. Here, we consider the experience of other countries in including NMSC as an occupational disease to draw on lessons learnt in relation to legislation, reporting, notification and occupational sectors of concern, to inform a similar approach nationally.

METHODS

Using mixed methods, we (1) performed a literature review using PRISMA guidelines¹⁴ to source articles in English on NMSC as an occupational disease, and (2) sent an open-ended e-mail information request to nine international academic experts from five different developed countries, identified from the literature, and asked them to suggest literature on background, legislation, reporting, notification and occupational sectors of concern. Experts from Australia, Canada, Denmark, Germany and New Zealand responded via e-mail. They sent descriptions of the current situation related to NMSC as an occupational disease in their own words, and provided website links and attached documents that they deemed useful for our compilation of international experience on this topic for consideration by the South African occupational health community.

The e-mail was also sent via the World Health Organization (WHO) Listserv for those interested in sun protection (called Intersun), and one plastic surgeon in Israel responded. The Team Leader: Radiation Programme in the Department of Public Health, Environmental and Social Determinants of Health for the WHO also responded by providing input on the international United Nations and WHO perspectives, and this information was included here.

“Given that solar UVR is recognised by the IARC as a Group 1 known human carcinogen, and that solar UVR exposure contributes to 90% of all skin cancers, the need to address occupational sun exposure is emphasised. South Africa can learn from countries where skin cancer is legislated as an occupational disease, and from other countries where this is not yet the case.”

A systematic search was conducted using PubMed, covering the period 1990 to 15 October 2016, and using the terms ‘non-melanoma skin cancer’ AND ‘occupational disease’. By title, 138 papers were found. This number was reduced to 69 after reading the abstracts, excluding four articles not available in English, and removing 49 articles that did not focus on solar UVR exposure. It was further reduced to 56 after reviewing the full reports. Publications involving case reports and clinical management were excluded. Several recent reviews have provided information on skin cancer as an occupational disease,^{2,15,16} and these articles were also considered since the aim was to extract as much useful information as possible to guide South Africa in relation to NMSC as an occupational disease.

Citations were collected in an EndNote library for analysis and full papers were sourced where applicable. Information sent via e-mail from expert respondents were stored in a secure folder and analysed on an individual basis for a descriptive, qualitative reporting in this manuscript. Additional literature sent by the experts was cross-checked for inclusion in the EndNote dataset and, when not present, was included in the analysis where relevant, based on expert opinion.

RESULTS

NMSC recognised as an occupational disease

World Health Organization perspective

At the international UN level, the International Labour Organization (ILO) published its latest List of Occupational Diseases in 2010 in which it lists ‘diseases caused by optical (UV, visible light, infrared) radiations including laser’ (Section 1.2 diseases caused by physical agents, item 1.2.5) as a Group 1 carcinogen.¹⁷ Several countries, including Australia, Denmark, Germany, Austria, Croatia, Portugal, Italy and Romania,² include NMSC in their lists of occupational diseases. Given the pressing nature of the NMSC and occupational sun exposure challenge, the WHO is in the process of establishing a collaborating centre on solar UVR exposure

and occupational health (Dr Emilie van Deventer, Team Leader: Radiation Programme, Department of Public Health, Environmental and Social Determinants of Health, World Health Organization, August 5, 2016, oral communication; unreferenced).

Australia

In Australia, it was estimated that as many as 34 000 NMSCs per year are caused by occupational exposure to solar UVR.¹⁸ The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) provides the maximum exposure guidelines for occupational exposures. The occupational exposure limit is 30 Jm⁻² per day.¹⁹ Legislation for NMSC as an occupational disease comes from state legislation.

Germany

NMSC as an occupational disease was legislated in Germany on 1 January 2015, for the first time acknowledging occupational UVR-induced actinic keratosis (more than five annually) and squamous cell carcinoma as occupational diseases.²⁰ There were more than 7 700 notifications to the statutory social accident insurance in the first year (i.e. 2015). After recognition as an occupational disease, patients are entitled to treatment through accident insurance, preventive measures and pensions. The current definition of this occupational disease excludes basal cell carcinoma (which is the most frequent NMSC) since its epidemiology is not clear. A key lesson learnt in Germany is that an acknowledgement of an occupational disease triggers research and pushes prevention which obviously is the primary goal.

Denmark

In 2015, exposure to solar UVR was legally recognised as a cause of occupational skin cancer.²¹ Before 2015, the recognition included primarily exposure to various chemicals. The legislation was driven, to some extent, by strong labour unions and relatively high solar UVR levels in the country. Specific rules for recognition are noted in terms of exposure to solar UVR and occurrence of skin cancer.

Canada

Findings for the 10 provinces and three territories in Canada were gathered by a Canadian expert and from ‘Sun Safety at Work’.²² It was found that provinces tend to act in similar ways but with varying application of skin cancer compensation. British Columbia is likely to be the most progressive province, having added skin cancer as a compensable disease in 1980. For British Columbia, Workers Compensation Act Schedule B provides a presumption of work causation in favour of a worker who has developed primary cancer of the skin where there is prolonged contact with coal tar products, arsenic or cutting oils, or prolonged exposure to solar UVR.²³ WorkSafeBC provides compensation to such a worker. The province of Alberta also considers skin cancer to be an occupational disease but does not mention sun exposure in its legislation containing Occupational Exposure Limits (OELs). Saskatchewan has presumptions for firefighters but skin cancer is not included in the list of conditions and there

is no mention of sun exposure in the regulations containing OELs.

New Brunswick's regulations containing OELs do include UVR (from the American Conference for Governmental Industrial Hygienists (ACGIH)) but the language strongly implies they only mean UVR generated by machines. Nova Scotia states that skin cancer is covered as an occupational disease but it does not specifically include solar UVR in the definition. Newfoundland and Labrador recognises that an occupational disease can be caused by UVR radiation but whether it includes solar UVR radiation is unclear. Ontario lists skin cancer as an occupational disease but only for exposure to coal tar pitches, bitumen, etc. (not solar radiation). The Manitoba Workers Compensation Act includes skin cancer (skin cancer was added in 2011) but sun exposure is not mentioned in the regulations containing OELs. Quebec, Prince Edward Island and Northwest Territories do not include skin cancer nor mention exposure limits for UVR – solar or anthropogenic.

New Zealand

Skin cancer is not a legislated occupational disease in New Zealand. In countries without NMSC as an occupational disease but with options available for accident compensation, provisions for claims for exemplary damages to be made against employers exist but there are few precedents and a low likelihood of success, given the difficulty in proving which (recreational or work) exposure 'caused' the disease/injury in the case of NMSC. However, since several EU and other countries have overcome the complexity of exposure and causation, it seems possible for countries that do not currently recognise NMSC as an occupational disease to do so in the future. New Zealand does have active skin cancer prevention and awareness campaigns, and local occupational health and safety agencies do try to raise awareness among employers and employees about the risks of excess sun exposure.

Reporting and notification

Reporting and collection of occupational skin cancer data is done through three channels: (1) reporting by employers to labour inspectors in accordance with legal requirements; (2) claims accepted by work injury compensation schemes; and (3) information from medical practitioners.²⁴⁻²⁶ Despite this, there is still substantial under-reporting.²⁷ Occupational diseases, in general, can be invisible in public policy discussions since, in most countries and especially in developing countries, there is very little reporting of occupational diseases.² Occupational cancers tend to be associated with a long latency period and this further aggravates the difficulties in recording and reporting them.² Indeed, in Canada, NMSCs are not routinely or uniformly captured in the cancer registries, leading to great difficulty in enumerating the skin cancer problem.

In Denmark, skin cancer incidence has increased over the last 50 years as has the number of cases reported as being occupationally-related in the past 10 years.²⁴ Sun exposure is listed as an exposure that can lead to an occupational disease. From 2003–2013,⁶⁷ notifications were recorded but only 36 cases were recognised as occupational skin cancer disease

post-evaluation. Considering that 180 000 employees work outdoors in Denmark, this number is deemed to be low, and this group of skin diseases has not traditionally been considered to be occupational.²⁴ Similarly, Germany saw more than 7 700 cases of occupational squamous cell carcinomas or multiple actinic keratoses notified in the first 12 months after NMSC was legally recognised as an occupational disease,²⁷ and NMSC was subsequently second in the ranking of occupational diseases (noise was first). Interestingly, this notification rate lies within the prediction of the German Social Accident Insurance and the Federal Ministry of Labour and Social Affairs. A national awareness and skin cancer prevention campaign may have triggered the notification rate.

Occupational sectors of concern

Solar UVR exposure may be quite different between different occupations. Estimates of risk for different occupations were derived from a Canadian study²⁵ using data from registries worldwide (Table 1). High risk jobs were defined as jobs with outdoor work occurring for 75% or more of the workday.

Table 1. Estimates of risk for different occupations

(adapted from Agner et al.²¹ and Peters et al.²⁶)

Occupation	Risk group
Construction trade helpers and labourers	High
Farmers, farm managers, farm workers	High
Landscaping and grounds maintenance labourers	High
Letter carriers (postal workers, mail carriers)	High
Fishing vessel skippers and fishermen	High
Roofers and shinglers	High
Nursery and greenhouse workers	High
Bricklayers	High
Heavy equipment operators (except crane)	Moderate
Heavy-duty equipment mechanics	Moderate
Carpenters	Moderate
Public works and maintenance labourers	Moderate
Couriers, messengers and door-to-door distributors	Moderate
Delivery and courier service drivers	Low
Truck drivers	Low

Agriculture, construction and public service sectors report skin cancer cases most commonly compared to other sectors in Germany.²⁷

Table 2 presents the PRISMA findings for studies with NMSC as an occupational disease where occupation types were defined and were identified as being of concern in terms of risk. Several studies have measured occupational sun exposure and skin cancer risk. For retrospective considerations, the 'Wittlich algorithm' provides a tool to approximate occupational lifetime exposure that takes into account differences in occupational types and settings.²⁸ By adding 'on-the-job' real measurements, a database is created that continuously adjusts for various scenarios and settings, and becomes a useful tool for

Table 2. Examples of occupational sectors of concern in relation to solar UVR exposure and skin cancer risk

Occupation	Country	Findings	Reference
Pilots*	USA	~ Twice the incidence of melanoma compared to general population	Mills and Shah ³⁰
	Finland	Relative risk for pilots of 1.43 compared to 1.44 for general population (no difference)	Kojo et al. ³¹
	Several EU countries	Increased melanoma mortality among cockpit crew	Hammer et al. ³²
	USA	Childhood sunburn, recreational sun exposure and high flying time at latitude were risk factors for NMSC	Zeeb et al. ³³ Nicholas et al. ³⁴
	Canada	Excess NMSC incidence SIR 1.59, 95% CI 1.10 - 2.20	Band et al. ³⁵
Cabin attendants*	USA	~ Twice the incidence of melanoma compared to general population	Mills and Shah ³⁰
	Sweden	Men and women airline cabin crew had increased incidence of malignant melanoma of the skin: SIR 2.18 and 3.66, respectively	Linnertsjo et al. ³⁶
	Norway	For both men and women elevated risks were found for melanoma and NMSC	Haldorsen et al. ³⁷
Firefighters#	Nordic countries	Skin cancer 30-49 years SIR 1.62, 95% CI 1.14 to 2.23	Pukkala et al. ^{38,39}
Farmers	USA	Significantly less reporting of NMSC among field workers compared to other groups	Susitaival et al. ⁴⁰
	USA	Significantly less reporting of melanoma skin cancer among farmers compared to non-farmers	Fincham et al. ⁴¹
Mountain guides	Germany, Switzerland and Austria	Association between high occupational solar UVR exposure and precancerous skin lesions and skin cancer	Lichte et al. ⁴²
Mail carriers	Denmark	Melanoma skin cancer SIR 0.87	Soll-Johanning and Bach ⁴³
Seafarers	Finland	Cumulative UVR likely doubles the risk of NMSC among older men and repeated sunburns increases melanoma risk in men younger than 30 years	Pukkala and Saarni ⁴⁴

SIR: standardised incidence rate; CI: confidence interval.

*Exposure to cosmic radiation is likely responsible for skin cancer among people spending time at high altitude in aeroplanes, as well as lifestyle exposures.

#Difficult to separate chemical exposure and solar UVR exposure as causative factor.

informing improved health and safety in outdoor workplaces and prevention of occupational actinic damage to the skin. Throughout Germany, extensive measurements of occupational exposure to UVR have been conducted with GENESIS-UV, and the results have been made partly accessible to the public.²⁹ So far, more than 90 jobs have been examined, down to the level of occupational activity.

DISCUSSION

Given that solar UVR is recognised by the IARC as a Group 1 known human carcinogen, and that solar UVR exposure contributes to 90% of all skin cancers, the need to address occupational sun exposure is emphasised. South Africa can learn from countries where skin cancer is legislated as an occupational disease, and from other countries where this is not yet the case.

A large proportion of the South African population is less susceptible to the effects of excess solar UVR due to natural melanin protection. Skin cancer incidence rates are lower among Black

African, Indian/Asian and Coloured population groups compared to the White population group.¹ However, late detection and presentation of more advanced skin cancer cases is more common among the Black African population group, increasing the risk of complication, disfiguration and, in some cases, mortality. Outdoor workers of all population groups are therefore susceptible to the skin effects of excess solar UVR, albeit on a continuum of risk and effect.

Black Africans with oculocutaneous albinism and those with compromised immune systems are at higher risk of the effects of excess solar UVR exposure. Black Africans with HIV/AIDS in the Northern Cape presented with a higher incidence of NMSC compared to other groups.⁴⁵ Therefore, while the epidemiology of skin cancer among population groups with dark skin is not always straight-forward, there is sufficient precautionary evidence to suggest that outdoor workers of all population groups in South Africa should be protected from excess solar UVR exposure. The need to understand local skin cancer epidemiology and exposure assessment better,

particularly among South African outdoor workers, is emphasised.

A recent study estimated the cost of diagnosis and treatment of skin cancers in the public and private sectors in South Africa to be ZAR 92 million per annum.⁴⁶ The proportion of skin cancers and associated costs attributable to occupational exposure remains unknown; however, currently, employers are not carrying any of these costs as they all fall onto the public and/or private health care systems. The need for careful legal management and policy-making that integrates policy-makers, employers, workers, doctors, patients and medical regulators is important.

Careful legal management and policy-making

According to ILO (2013),¹⁷ South Africa mentions the prevention of occupational diseases in its national Occupational Safety and Health policy, and has taken actions to enhance labour inspectorates and occupational safety and health inspection activities, including the prevention of occupational diseases as promoted by the Labour Inspection Convention.⁴⁷ Skin cancer, specifically NMSC, should be officially recognised as an occupational disease. An OEL for solar UVR is required. The Australian ARPANSA standard is based on the principles of the International Commission for Non-Ionising Radiation Protection (ICNIRP) Guidelines on limits of exposure to UVR of wavelengths between 180–400 nm,⁴⁸ but a Solar UVR limit is undefined. The maximum human biologically efficient radiant exposure of 30 Jm^{-2} per 8 hour period (or 1.08 SED/day of solar radiation) includes exposure to artificial and/or solar UVR. In the case of solar UVR, this limit is very quickly exceeded in low latitude countries with high ambient solar UVR levels.

Despite the South African Occupational Health and Safety Act (No 85 Of 1993)⁴⁹ calling for a provision of a workplace that is safe and without a risk to health of workers, no mention is made of solar UVR as an occupational stressor, nor of an OEL in any of the Regulations of the Act. The ACGIH's Threshold Limit Values (TLVs®) are described for broadband UV sources (180–400 nm) for corneal damage, broadband UVA sources (315–400 nm) for lens and retinal hazard, and narrowband sources for both corneal and retinal sources.⁵⁰ However, the guidelines note that "Outdoor workers in latitudes within 40 degrees of the equator can be exposed outdoors to levels above the TLVs® in as little as five minutes around noontime in summer".⁵⁰ The ICNIRP exposure limits state that exposure should be no more than 30 Jm^{-2} effective radiation in an 8-hour day; however, this is difficult to control in natural sunlight, and is less relevant for individuals with dark skin (melano-competent).⁴⁸ To date, those limit values are solely applied to artificial sources of optical radiation.

Improved healthcare services

Mandatory screening of working populations at highest risk of excess sun exposure for early detection of occupational solar UVR-induced skin cancer may be important. A notification system at national level will also help to track skin cancer prevalence and



Superficial spreading MM in White skin



Melanoma in foot of Black African woman

inform prevention campaigns. Workplace-based health practitioners and primary care physicians will need to be provided with the tools and incentives to assess and refer cases of occupational skin diseases to dermatologists. Dialogue between employers, employees, trade unions and insurance/compensation schemes will need to be initiated.

National awareness and prevention programmes

Only a few countries have developed effective implementation of strategies for prevention of occupational skin cancer.⁵¹ The US Preventive Services Task Force on prevention of excess sun exposure confirmed that there is sufficient evidence to show that the use of sun protection in occupational settings is effective for changing behaviour and improving intermediate health outcomes with the long-term goal of reducing skin cancer.⁵²

We know very little about sun protection practices of outdoor workers in South Africa and in different occupational settings. We can assume that a number of challenges, similar to those experienced in Germany,² are also experienced in South Africa. There is likely a lack of sun risk knowledge and higher risk behaviour among outdoor workers. The risk awareness is probably lower

among men than women.^{53,54} It is likely that there is rarely sun health surveillance by the employer, and poor instructions from the employer on adequate sun protection. Whether a guideline document on occupational sun exposure and health risk prevention, such as the one implemented by Work Safe in Australia, would be helpful in South Africa, is unknown. Unanswered related questions are “Who would be responsible for implementing such guidelines?”, and “What would happen in the event that employers neglect to implement the guidelines and put workers at risk?”

Education among outdoor workers on simple and cheap techniques of safe sun behaviour and prevention of skin cancer is necessary. Multi-stakeholder dialogues will need to be initiated to develop tailored and locally-appropriate preventive measures for the South African workforce in the workplace. The media is an important mechanism for risk communication. In the Sun Safety at Work Canada project,¹⁶ a nationally-applicable, evidence-based, effective and sustainable sun safety programme for outdoor workers that addressed both skin cancer and heat stress prevention, to be implemented by individual workplaces, was developed. The programme used a risk management, tiered approach and was embedded in the company’s occupational health and safety policy. Personal protective equipment was recommended as the last line of defence. Several challenges were encountered during the project, including lack of capacity among occupational health and safety staff to influence decision-making, budgetary constraints, competing priorities of workplace hazards, social norms, and societal attitudes and beliefs.¹⁶ What did work well, in some instances, was a workplace champion, often someone who had skin cancer in the past, and who had management support to engage staff actively at all levels to protect themselves.

CONCLUSIONS AND RECOMMENDATIONS

Outdoor workers, including those in South Africa, run an increased risk of developing NMSC. Presently, the invisible risk of excess solar UVR exposure in South Africa is neglected; cases are unnoticed, unscreened, underreported and uncompensated.

In order for South Africa to register NMSC as a reportable occupational disease, significant efforts relating to understanding local epidemiology, exposure assessment, legal and insurance management, and policy-making will need to be considered. Action is needed at a national level to legislate for actinic keratosis and NMSC as occupational diseases.² This has the potential to improve access to compensation and to drive preventive behaviour and activities.

In the European Union, and in Germany in particular, it has been recommended by politicians and policy-makers to collect exposure data as a basis for further action in the field. Recently, those data have been used to develop criteria for mandatory/free choice screening of workers at risk. South Africa should emphasise the collection of measurements to overcome the lack of exposure data.

LESSONS LEARNED

1. Outdoor workers run an increased risk of developing NMSC
2. Several countries around the world acknowledge NMSC as a compensable occupational disease
3. For South Africa to register NMSC as a reportable occupational disease, significant efforts relating to local epidemiology, exposure assessment, legal and insurance management and policy-making, need to be considered
4. Outdoor workers should be encouraged and supported to have screening tests for skin cancer and use sun protection when working outdoors

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DECLARATION

The authors have no conflicts of interest.

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