A literature review to identify the outdoor occupations with the greatest exposure to solar UV radiation

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List of Abbreviations

AK	Actinic Keratosis
BCC	Basal Cell Carcinoma
CI	Confidence Interval
HR	Hazard Ratios
KC	Keratinocyte Carcinoma
IARC	International Agency for Research on Cancer
MSC	Melanoma Skin Cancer
NMSC	Non-Melanoma Skin Cancer
OR	Odds Ratio
OWs	Outdoor Workers
PPE	Personal Protective Equipment
RCT	Randomised Controlled Trials
SCC	Squamous Cell Carcinoma
SD	Standard Deviation
SED	Standard Erythema Dose
UV	Ultraviolet
UVR	Ultraviolet Radiation

Executive Summary

A systematic literature review using peer reviewed articles in English from 2012-2022 was carried out to assess the outdoor occupations at risk of skin cancer due to their line of work. The objectives of the report were:

1. To identify outdoor occupations at highest risk of UV exposure
2. To identify the characteristics that deem them high risk.

Outdoor workers incur higher solar ultraviolet (UV) radiation exposure. This study aimed to investigate the risk of skin cancers influenced by solar UV radiation (UVR) among international outdoor workers. By conducting this systematic review, the researchers assessed the occupations at highest risk of UV exposure and attempted to investigate the underlying factors associated with skin cancer risks, such as duration of work outdoors, time of day working outdoors and types of outdoor work. This provides informed data on UV exposure among various cohorts of outdoor workers, therefore helping professionals in this field to engage with cohorts of high risk to develop unique skin cancer prevention and intervention programmes aimed at those most at risk of UV exposure and at high risk of developing skin cancer.

Outdoor occupations at high risk of UV exposure and subsequently skin cancer are farmers, gardeners, construction workers, postal workers, state park workers, mountain guides, landscapers, and seafarers. However, other occupations such as sailors and athletes appeared in this review and were discussed where necessary. Risk factors associated with UV exposure and an outcome of skin cancer included gender, education, age, skin type, time spent outdoors, ethnic background and social attitudes and behaviours and have been discussed throughout this report.

In Ireland, almost 13,000 cases of skin cancer are diagnosed annually (National Cancer Registry Ireland, 2021). The National Skin Cancer Prevention Plan is aimed at tackling the most common type of cancer in Ireland. The plan focuses on the fact that most skin cancers could be prevented by protecting skin from the sun and not using sunbeds. There is a focus on high-risk groups, which includes outdoor workers in action area 4 of the plan (Dept. of Health, 2019). Due to the nature of their occupation, they are exposed to high levels of UV radiation from the sun. It is vital to understand the level of UV outdoor workers are exposed to in their work environment in order to develop prevention interventions for outdoor workers in Ireland and in organisations employing such workers. It is also important to look at the level of risk for different occupations.

A summary of our key findings is presented in Box 1. Our results emphasised that all outdoor workers, need to be thoroughly educated on occupational skin cancer risks as all outdoor occupations are at risk of skin cancer, but statistics are highly variable, no doubt due to the multifactorial nature of both the exposure, and individual vulnerability. Women exhibited better knowledge on the topic than men and were more willing to follow sun protection practices but were inclined to use sunbeds outside of work hours. Skin cancer remains a burden for most countries irrespective of daily UV exposure levels per country. White populations with fair skin (Fitzpatrick skin type I) have higher skin cancer risks than darker-skinned individuals but non-white populations are not exempt from sun-related

solar UV radiation problems and can experience other sun-related skin issues (e.g., sunburn, peeling skin). Much of the literature advocates that employers have a responsibility to not only implement occupational sun protection measures but to provide training and information to employees regarding skin cancer risks.

Overall, risk factors are difficult to identify given the variability across different outdoor professions. For these reasons, policies and prevention strategies should be adaptable for workplaces to be able to cater for all outdoor workers at all career levels (i.e., junior and senior staff) and skin types. Unfortunately, national, and international reports alone make it difficult to design customised prevention and intervention plans due to the need for continuous research on this topic and therefore this review cannot guarantee that only the outdoor occupations discussed in this report are at great risk of UV exposure and skin cancers.

Key Findings

Box 1. Key Findings

- Males tend to be exposed to higher levels of UV radiation than women because they are more likely to have outdoor work positions.
- Mountain guides, farmers, gardeners, construction workers, landscapers, park workers, people who work at sea (seafarers) and postal workers are frequently mentioned in this review.
- Melanoma skin cancer (MSC), non-melanoma skin cancer (NMSC) including Basal Cell Carcinoma (BCC) and Squamous Cell Carcinoma (SCC), and Actinic Keratosis (precancer) lesions were commonly reported in outdoor work studies.
- Those with fairer skin are at higher risk of skin damage and skin cancer.
- Those who reside in regions with closer proximity to the equator are most at risk of skin cancer and sun-related skin damage.
- Those who spend 4 or more hours outdoors daily have higher skin cancer risks.
- Sun-safety habits are weak among people with darker skin as they may underestimate their risk.
- Outdoor workers with low education and low-income earnings may have poorer skin cancer knowledge and sun safety habits.
- It is recommended that organisations strategically address skin cancer prevention through training and education, protection control measures, monitoring and policy.
- Outdoor workers are at increased risk of UV exposure and therefore skin cancer. There are other risk factors that can also play a part and that is why employers need to commit to protecting workers and adhere to skin cancer prevention best practice in the workplace.

Introduction

Skin cancer incidences are increasing and skin cancer is most common in white-skinned individuals (Leiter, Eigentler & Garbe, 2014). Buster et al. (2012) reported that non-melanoma skin cancer (NMSC) is less common in those with darker skin (3.4 per 100,00) and black people worry less about skin cancer risks. Furthermore, 28.5 per 100,000 cases of melanoma occur in males and 17.6 per 100,000 in females (Henley et al., 2020). Skin cancer is typically categorised into melanoma and non-melanoma (basal cell carcinoma and squamous cell carcinoma) skin malignancies (Linares, Zakaria & Nizran, 2015). Arguably, if education on skin cancer is not promoted early in life, skin cancer risks increase with age (Diepgen et al., 2012). It was reported that (Oh, Jin & Koh (2021) there is a gradual increase of skin cancer diagnosis with age. In their study of skin cancer cases, there were 8367 (65.9%) cases of BCC, 3598 (28.3%) of SCC, and 727 (5.8%) of melanoma and the mean ages of skin cancer diagnosis were 72.7 years for SCC, 66.9 years for BCC, and 59.8 years for melanoma. Individuals with lighter skin tones suffer more sun-related conditions (e.g., sunburns) and have an increased risk of developing skin cancers (Oh, Jin & Koh, 2021; Horsham et al., 2014; Wright et al., 2017; Coups et al. 2012).

The European Agency for Safety and Health at Work (2019) defines outdoor workers as those who spend 75% of their working hours outdoors exposed to solar UV radiation. Exposure to high and excessive levels of UVR radiation increases one's risk of skin cancer, and outdoor workers spend their working day outside, making them a high-risk population. Skin cancers are prevalent among outdoor workers due to ongoing UV exposure associated with their tasks (Loney et al., 2021; Reinau et al., 2013). It has been shown that occupational UV exposure confers higher risk of developing basal and squamous cell skin cancers (Fartasch et al., 2012). To protect against occupational UV exposure a range of individual and institutional measures could be of use, including protective equipment in a range of forms, education, and regulation and enforcement.

There is evidence that workplaces associated with outdoor labour should implement preventative measures in their workplaces (Trenerry et al., 2022). The implementation of occupational sun safety equipment is likely to make a positive contribution to the sun-safety practices undertaken by outdoor workers (Reeder, Gray, & McCool, 2013) and correspondingly, work-focused interventions can positively impact an employee's beliefs and attitudes towards sun safety, prompting them to engage in self-directive behaviours (Rye et al., 2014). It has been shown that employee motivation to follow a sun protection routine is influenced by the level of skin cancer education provided and the sun safety attitudes held by their employer (Jakobsen, Mortensen, & Grandahl, 2022). Additionally, outdoor labourers could personally have insufficient knowledge on skin cancer risks as education levels tend to be low among outdoor workers, and they can often lack confidence completing medical forms and understanding health-related information (Trakatelli et al., 2016). A possible explanation for skin cancer risks not being taken seriously, is due to lack of coherent data to support that occupation and skin cancer are correlated (Milon et al., 2014) and therefore it is continuously debated as to whether skin cancers (e.g. NMSCs) should be treated as occupational diseases (Apalla et al., 2016).

Workplace culture can work for or against implementation of such measures. For example, it has been reported that incidence of skin cancer is not always reported by staff because companies could face legal or economic repercussions if the disease is traced back to a worker's occupation and those in unstable employment are hesitant to report work-related illnesses for fear of unfair dismissal (Alaguney et al., 2020).

Regardless of this, a wide range of information on skin cancer remains publicly available yet populations and workplaces fail to adhere to best practice public health guidelines around skin cancer (Seité et al., 2017).

Study Rationale

Outdoor workers across various occupations are a high risk of solar UV radiation. The purpose of this commissioned study is to identify which outdoor work populations are at higher risk of developing skin cancers due to frequent sun exposure during work hours, and what characteristics of such occupations confer or protect from risk of skin cancer. The purpose of the literature review is to identify international peer reviewed studies carried out on outdoor workers and skin cancer prevalence to evaluate their findings and locate gaps in current research. Our analysis explores variations across the data relating to gender, age, level of education, types of skin cancer, skin type, duration, levels of UV, UV index, region, nation, latitude, occupation type, ethnics, social behaviour: training, knowledge, attitudes and perceptions and preventive measures associated with outdoor workers.

By identifying peer reviewed articles published in the last ten years (2012-2022), the search will help to identify outdoor occupations that present the highest risk of UV exposure and to understand the specific factors related to outdoor work that can cause skin cancer; in hope of developing strategies to encourage health and safety management systems to reduce ongoing ultraviolet radiation (UVR) exposure and to facilitate long-term prevention plans to decrease rates of occupational skin cancer.

Methods

A systematic literature search for skin cancers in workers affiliated with outdoor occupations was conducted. We applied the PICO system to describe the approach:

P (Population or Problem) represents outdoor workers worldwide;

I (Intervention or exposure) is occupation-specific UV exposure subgroup variables age, gender, types of skin cancer, nations or regions, and duration of exposure to sun were included in this review.;

C (Comparison) as the study has reviewed the prevalence of all types of skin cancers in outdoor occupations there is no mandatory control group, but we expect some research to use national population cancer rates, or indoor workers as comparators.

O (Outcome) is skin cancer: specifically, melanoma skin cancer and non-melanoma skin cancer.

All types of study designs were included in the systematic review if they reported details on cause, effect, prevalence and hypotheses on the association between any type of skin cancer and outdoor occupations, or UV radiation and outdoor workers. The report included an overview of the prevalence of skin cancer in outdoor workers, gender, and region in order to gain a better understanding of skin cancers and outdoor occupations. Peer reviewed journal articles published between 2012-2022 were included.

Sources

Databases searched included: MEDLINE (PubMed), Embase, Web of Science, ProQuest, Scopus. Grey literature was also searched, including via Google Scholar, as well as national reports up until the 31st July 2022.

An additional search (via the Google search engine) for skin cancer studies carried out in Ireland was conducted manually because the electronic databases listed above occasionally exclude research published in Irish journals, despite using key words in the advanced search box.

Search strategies

Key search terms in English for all engines included: outdoor workers, outdoor occupations, UV radiation, UV, UV exposure, cancer, skin cancer, non-melanoma skin cancers, basal cell carcinoma (BCC), squamous cell carcinoma (SCC), melanoma.

Inclusion criteria:

1.1 Peer reviewed articles

1.2 Articles published in English

1.3 Populations of outdoor occupations included all workers at any age stages and not limited by duration of working outdoors, or presence of demographic variables of interest.

1.4 Articles meeting the topic eligibility criteria below

Exclusion criteria:

1. Non-peer-reviewed or non-English articles
2. Peer-reviewed journal articles published before 2012
3. Non outdoor occupations
4. No specific mention of skin cancers
5. No full text available
6. Studies using only non-human subjects.

Search structure

Demographics of the study; countries or regions where study population was conducted, gender, education levels, income, duration of exposure to UV radiation were identified. All types of study designs were included: randomised controlled trials (RCT), cohort studies, case-control studies, cross-sectional studies, prospective or retrospective studies, systematic reviews and meta-analyses, as well as national or international reports. Keywords “skin cancer” or “sun exposure” in the abstract were used as a rapid screen, as most of the investigations in the past 10 years focus on sun exposure and preventative measures rather than skin cancer itself.

This systematic literature review was conducted using searching terms in 5 databases. There were 103 articles from PubMed (Medline), 137 articles from Scopus, 718 articles from ProQuest, 165 articles from Embase, 167 articles from Web of Science. In total 1,290 search results between 2012 to 2022 were returned.

The reviewers screened articles by authors’ names, year of publication, and title in order to identify any duplicated articles for removal. A total of 545 duplicated articles were detected. Occasionally, the researchers reverted to the original article to verify that the title(s) on record corresponded with the article title(s) generated by various search engines to protect against small differences in indexed article titles.

Of the 745 unique articles 328 were non-peer reviewed. Articles that lacked format information on the first page, were verified for presence of results and discussion paragraphs in the articles, resulting in exclusion of newspaper and magazine articles, books, trade journals, letters to the editor, posters, editorials, and theses or dissertations. Non-English articles (17 out of 417) articles were excluded.

Data collection process

The remaining 400 articles were tabulated against the inclusion criteria and the research questions. Articles were reviewed by abstract in pairs to prevent subjective bias, against the following inclusion criteria:

(1) Was a relevant population of outdoor workers studied?

(2) Were the statistical analyses performed correctly?

(3) Was the study design appropriate for the research questions?

(4) Does the study test a stated hypothesis?

(5) Did the methodology address important potential sources of bias?

(6) Is there Information bias, population selection bias etc.?

(7) Do the data justify the conclusions?

(8) Are there any conflicts of interest?

Research Questions

(1) mention prevalence of skin cancer.

(2) mention gender breakdown in the prevalence of skin cancer.

(3) mention most common types of skin cancer.

(4) mention risks of getting skin cancer.

(5) mention outdoor workers.

(6) mention outdoor occupations.

Identifying outdoor worker subgroups

Articles were categorised into subgroups, which were identified in preliminary scope review. From the information provided in the abstract and the method or result paragraph, it was noted whether the following were studied: outdoor workers (non-specific); farmers (gardeners); athletes; military; construction workers (roadwork); airline pilots; welders; children and adolescents; Others.

Identifying skin cancer Type

The following subtypes of skin cancer mentioned, were noted for each article: melanoma skin cancer (MSC); non-melanoma skin cancer (NMSC); squamous cell carcinoma (SCC); basal cell carcinoma (BCC); KC (keratinocyte carcinoma); others.

Final study selection

Full-text reviews of 131 articles were conducted by two reviewers to eliminate the occurrence of subjective bias. The first reviewer read individual articles and summarized and extracted data. The second reviewer independently cross-checked the accuracy of the data that was extracted to verify: study ID, population (gender, nations or regions), study design, data collection period, type of the study, country, UV index, occupations, occupational exposure definition used, ascertainment method (including blinding), sample size (and its calculation), types of skin cancer (melanoma, non-melanoma, BCC, SCC, KC, or other) and reported prevalence, incidence, or comparative effect(s) including odds ratios (OR) or hazard ratios (HR), and their 95% confidence intervals (CI). A third independent review intervened to resolve any occurring conflicts.

Upon completing the full-text reviews, a further 44 articles were eliminated as these were either additional duplicates or comprised non-English texts (131 - 44 = 87). The final 87 journal articles featured a range of methodological approaches. These include all types of studies (retrospective studies, randomised control trials, cross-sectional studies, cohort studies, case-control studies, meta-analysis, intervention and pilot studies, qualitative analysis, systematic/literature reviews and case studies).

Additional Sources

A hand search of the reference lists of all included articles was also conducted. The final research studies were screened once again, as above, before preparing them for data extraction. The flow diagram that is used in this systematic review can be found in Figure 1. A separate search for Irish studies on the topic of skin cancer was carried out as electronic databases do not always include Irish research if they were published in an Irish journal. Therefore, the researchers gathered a combination of 8 journal articles and national reports on skin cancer in Ireland via Google; four of these were peer-reviewed journal articles and five of these were national reports from professional organisations. A further 4 studies were detected using literature from our inclusion criteria and featured in the analysis process (snowballing).

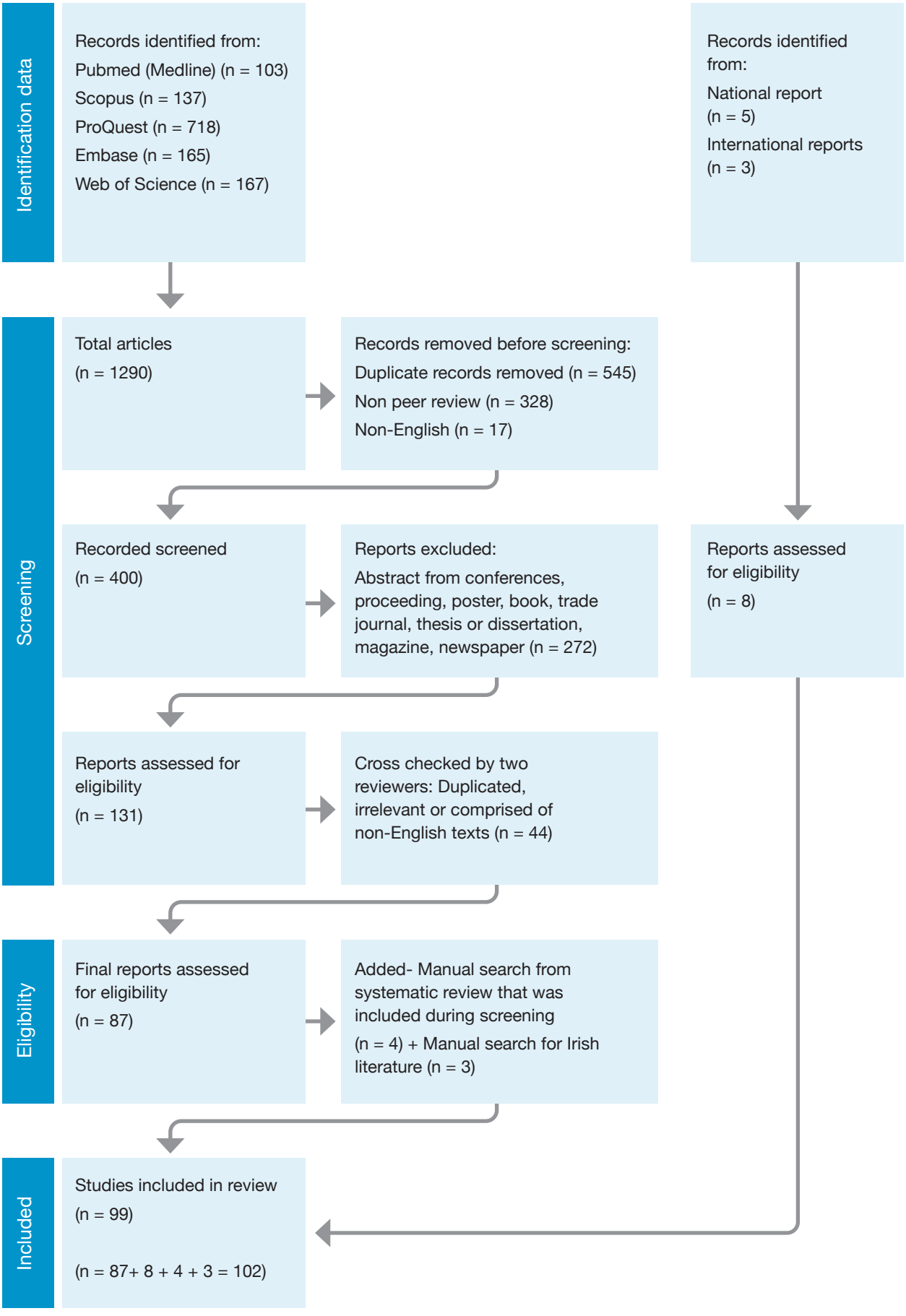

Figure 1: Records screened and included in review

Data analysis

The analysis aimed to review and address the following questions:

1. What is the prevalence of skin cancer in outdoor workers?

   Outdoor workers are at risk of skin cancers due to high exposure to UV radiation therefore the prevalence of skin cancers will be reviewed.

2. What is the most common type of skin cancer found in outdoor workers? The findings will provide relevant information to promote skin cancer prevention for outdoor workers.
3. What is the prevalence of non-melanoma skin cancer in outdoor workers? Prevalence of skin cancer will be reviewed for better understanding.
4. What is the prevalence of melanoma skin cancer in outdoor workers? Prevalence of skin cancer will be reviewed for better understanding.
5. What outdoor occupations present the most risk of getting skin cancer? Outdoor occupations are not limited to farmers, gardeners or construction workers. Various outdoor workers can be affected as there might be behaviours or factors associated with their job that increase their risk of skin cancer, such as the amount of time they spend working outdoors, inadequate use of sun safety measures, failure to avoid UVR at times of prolonged sun exposure.
6. Different prevalence of skin cancer in outdoor workers in different regions.
7. What is the gender breakdown in the prevalence of skin cancer?
8. Assessment of whether data on subgroups and risk factors have been adequately investigated and reported in the literature.

Data extraction

Using an excel spreadsheet, two researchers independently extracted data from the final articles using pre-selected headings that were cognisant of the study's aims. A third reviewer assessed existing variations before final discussions to reach a consensus took place between all team members. Data on (1) study design, (2), occupation, (3) Region/country where the study took place, (4) population/ participants, (5) type of skin cancer (6) measures relating to level/time of exposure, type of labour, gender and education, (7) study outcomes, and (8) study limitations were extracted from the final papers. Whilst data extraction on these factors/aspects were prioritised, the researcher remained open to including additional data that is relevant to the research questions. Such findings were labelled 'miscellaneous' and were included in the final analysis stage where necessary.

Results

From our search, a variety of studies were used in the analysis process. Table 1 provides a breakdown of the different study designs in the literature that was used for this review. Many studies discussed more than one outdoor occupation, however farmers/agriculture workers (including gardening), construction workers, postal workers, mountain guides and seafarers were frequently mentioned. Section 1 onwards of this chapter presents a detailed insight into our reviews' findings.

Table 1: An overview of the types of studies and their mention of various outdoor work professions

Study design (n)	Construction workers (n)	Farmers (n)	Agriculture |workers (n)	Landscaping (n)	Postal workers (n)	Mountain guides (n)	Seafarers (n)	State Park workers (n)	Others (n)
Cross-sectional	9	4	6	4	3	3	1	2	6
Retrospective analysis		3							1
Population-based/cohort	1	1		1	1				1
Pilot studies	1		1						
Case control	2		1						
Case study									
Qualitative study	1	1		1					
Intervention studies	1								1
Descriptive studies									
Longitudinal studies									
Literature/systematic review/meta-analysis	4	2	5	1	1		1		
Combination of studies in one study	1		1						
Randomized control study:							1		1
Unknown/unclear				1					2
Total (n)	20	11	14	8	5	3	3	2	12

1. Outdoor occupations at highest risk of severe UVR exposure

Construction workers

Studies in this review largely discuss construction workers in the outdoor work sector.

In one study, amongst 38 outdoor workers, 25 had 'primary melanoma' and 13 had 'metastatic melanoma', compared to indoor workers where 18 out of 30 had 'primary melanoma' and 12 had 'metastatic melanoma' (Candido et al. 2014). A case-control study also placed construction workers as one of the outdoor occupations at great risk of BCC due to excessive UVR exposure regardless of their skin type, tumour localization and histological subtype (Bauer et al., 2020). Furthermore, in 2011-4,556 cases of NMSC were linked to occupational sun exposure and the majority of these cases were found in construction workers (alongside agriculture employees) (Peters et al., 2019a). Cherrie et al. (2021) stated that long-standing employees in the construction industry (working 30-40 years in the sector) accumulate high levels of solar UV exposure within this time and consequently double their risk of NMSC. Construction workers are also considered to be at risk of developing SCC and AK (Trakatelli et al., 2016).

In a cross-sectional study on 485 outdoor workers, construction staff were one of the outdoor groups likely to be affected by sunburns over a 12-month period at work (Schneider et al., 2018). Due to the type of tasks involved in this industry, outdoor labour cannot be avoided, and employees can spend up 9 hours a day working under the sun; therefore, sunglasses, sunscreens and protective clothing are highly recommended to combat the dangers of persistent UV exposure (Serrano et al., 2013).

High occupational sun exposure may also affect construction workers who have no option but to spend their lunch break outside away from shade (Millon et al., 2014), but use of preventive measures is not always mandatory in outdoor work environments either, which was underpinned by Horsham et al. (2014) whose review on intervention studies found that road workers and construction workers in Australia were not instructed to use sun safety strategies but those who did were less affected by sun damage and skin cancers. Similar findings were depicted in a population-based sample of 149 outdoor workers (85% male) in the landscaping and construction sector, led by Day et al. (2015); Sixty-nine percent of the employees in the study reported never or rarely applying sunscreen at work whereas being female, having high levels of education and residing in higher latitudes was correlated with regular sunscreen use.

A case-control study in Italy with a small minority of construction works (2 in the 'case' group, 3 in the 'control' group) (Larese-Filon, Buric & Fluehler, 2019) found this profession did not confer excess risk of NMSC (OR: 1.01, 95% CI: 0.17 – 6.1).

Farmers

Studies in this review prioritised farmers as outdoor workers by examining UVR levels, sun safety and skin cancer prevalence among this group. In one study among the farmers and fishermen nodular BCC was most common, given that 133 out of 178 in the outdoor work cohort were diagnosed (Husein-Elahmed et al., 2017). Mirroring findings from another retrospective study on farmers (of whom 198 out of 312 were men) that showed that they were more likely to be affected by BCC more than once in their career (Szewczyk et al., 2016) and farmers may develop aggressive BCC subtypes early in life in conjunction with visible signs of skin damage due to insufficient use of preventive measures at work (Apalla et al., 2016). A cross-sectional study by Zink et al. (2018b) included a sample of 563 outdoor workers (38.8% were farmers) found that farmers were the second occupation in the study most affected by pre-cancerous lesions (AK). Furthermore, in 2011- 4,556 cases of NMSC were linked to occupational sun exposure and the majority of these cases were found in 1,051 construction workers (alongside 1,259 agriculture employees) (Peters et al., 2019a).

A retrospective study comprising of 308 participants (178 outdoor workers, 130 indoor workers) showed that fishermen and farmers mostly made up the outdoor workers' sample (Husein-Elahmed et al., 2017). Males accounted for most of the outdoor population (92 out of 178 OWs), whereas females were more associated with the indoor work group (85 out of 130 IWs) (Husein- Elahmed et al., 2017). The study did not specify how many farmers took part in their research, however their report showed that 101 out of 178 farmers and fisherman had a family member who was affected by BCC, compared to only 40 indoor workers. In addition, a cross-sectional study on 238 farmers, showed that only 22% of the participants engaged in skin cancer preventive behaviours (Babazadeh et al., 2017), and again farmers are deemed at risk of developing BCC throughout their career (Trakatelli et al., 2016).

Only 57.8% of the farmers who participated in the study underwent a skin screening examination yet 28.1% of the farmers within the study reported spending more than 6 hours each day outdoors and 44.4% of these farmers did not use sunscreen. Contrasting behaviours were noticed in female farmers, who were more likely to use sunscreen and sun protection compared to men when working outdoors (Zink et al., 2019; Kearney et al., 2014).

A prospective cohort study also reported that European farmers exceed the recommended UVR limit by 56% on their working day (Bodekaer et al., 2015). Another cross-sectional study by Zink et al. (2017) found that 73.3% of farmers out of 213 farmers perceived themselves to be at low risk of developing skin cancer and poor use of sunscreen was reportedly associated with being male, being an outdoor worker and working as a farmer. Similiar research was conducted by D'souza et al. (2021) who claimed that although skin cancer knowledge among 144 farmers (89 of whom were men) was high, there was a tendency to misjudge their risk of developing skin cancer, perhaps influencing poor uptake of sun safety measures. Tizek et al. (2020) study on farmers, foresters, and gardeners, found amongst the 84 farmers in the study, 40 claimed to never or rarely avoid the sun at midday and 52 never or seldom applied sunscreen, but Modenese et al. (2020) found that farmers may be more inclined to wear large-brimmed hats to shield themselves from the sun.

Conversely, a case-control study (n = 126 case group and n = 187 in the control group) in Italy with minor contribution from farmers (3 in the 'case' group and 7 in the 'control' group) (Larese-Filon, Buric & Fluehler, 2019) found that the farming profession did not confer excess risk of NMSC (OR: 0.64, 95% CI: 0.16 – 2.5).

Gardeners

Studies in this review largely discuss gardeners as a key occupation among outdoor workers.

Zink et al. (2018b) study of 348 outdoor workers and 215 indoor workers found that dermatologists diagnosed at least one abnormal skin condition in 310 participants (reaching an overall prevalence of 55.1 %) and these findings indicated that gardeners as well as men and farmers were more likely to suffer from some sort of skin disease (Solar elastosis, Eczema (hand, atopic, seborrheic, nummular), Erythrosis interfollicularis colli, Lentigo solaris, Xerosis cutis, Guttate hypomelanosis, and Psoriasis) than indoor workers.

A cross-sectional study of 175-day labourers showed that gardening was one of the most frequently reported occupations by the workers and during their outdoor workday they were exposed to an average UV index of 9 (which is classified as 'very high') (Niu et al., 2022). Gardeners on average spend more time working outdoors than farmers and mountain guides, usually working outdoors for more than 4 hours a day while wearing SPF 30-50 (Zink et al., 2018a). Another study by Zink et al. (2017) showed that 20 out of 52 gardeners (40 male, 12 female) reportedly spent more than 40 hours a week working outdoors and 42 of these gardeners considered themselves at high risk of skin cancer because of their occupational UV exposure.

A Danish study found that there was no association between sex and UVR exposure among outdoor workers, particularly among gardeners with nearly equal participation between both male and female staff in this profession; in fact, only 0.1 SED difference was recorded between 42 women and 41 men (Borup, Mortensen & Grandahl, 2020). Bauer et al. (2014) also found that gardeners may receive sun safety education from their employers to alert them of the consequences of solar radiations whilst working outdoors.

Postal workers

Studies in this review discuss postal delivery workers as an outdoor occupation. However, none of these directly studied prevalence of skin cancers in postal workers.

Most participants availed of skin protective measures connected to their uniform (e.g., long-sleeved tops and trousers and wide-brimmed hats) (Houdmont, Davis & Griffiths, 2016; Garnett et al., 2016). Postal workers in the studies were male and presented better skin cancer knowledge than females, yet they had poorer sun safety practices than women (Houdmont, Davis & Griffiths, 2016). Occupational intervention programmes are shown to have a positive impact on postal workers as wearing broad-brimmed headgear and sunscreen application was found in postal delivery workers who took part in a sun safety intervention compared to those who did not (Horsham et al., 2014). Additionally, postal workers in Denmark were among the outdoor workers in the country that possess great risk of UVR exposure while working and are at risk of developing skin cancer as a result (Borup, Mortensen & Grandahl, 2020).

A cross-sectional study in the review reported that postal workers in the UK spend 5.4 hours daily in the sun at work and although they received sun safety training within the last year, they required further education (Houdmont, Davis & Griffiths, 2016).

Mountain Guides

Three cross-sectional studies in this review discuss mountain guides in the German region (Zink et al., 2018a; Zink et al., 2018b; Tizek et al., 2017). One study assessed prevalence of NMSC by questionnaire and examination and reported prevalence relative to other professions (Zink et al., 2018b). With a prevalence of 33% in the sample of 90 mountain guides examined. With the best protective measure usage in this study, mountain guides had the lowest rate of "all skin findings", but the highest of NMSC, compared with farmers and gardeners: an odds ratio of 5.9 (95% CI 2.4, 14.6) relative to indoor workers was reported.

The other two articles assessed an intervention (Tizek et al., 2017), or assessed sun safety habits, skin cancer knowledge and number of hours spent working outdoors by questionnaire (Zink et al., 2018a).

Most mountain guides in the studies demonstrated sufficient sun safety behaviour through persistent sunscreen application, attending skin cancer screening appointments and understanding the dangers of excessive UVR exposure (Zink et al., 2018b). Furthermore, having access to a sunscreen dispenser at work was found to make re-application easier/convenient (Tizek et al., 2017). The negative findings from the three studies were that several mountain guides do not carry out a self-skin checks for early signs of skin cancer. Although sunscreen application was found to be adequate among workers in this occupation, some mountain guides perceived themselves to be at low risk of skin cancer and underestimated their need for sunscreen as under half of the participants in one out of the three studies promoted high SPF usage to their colleagues (Zink et al., 2018a; Zink et al., 2018b; Tizek et al., 2017).

Based on the literature, males dominate this occupation, with female mountain guides making up a small proportion of the sample sizes. Mountain guides spent more than 4 hours a day outdoors (Zink et al., 2018a), comparable to gardeners.

People who work at sea (seafarers)

Oldenburg et al. (2013) study found that seafarers affected by pre-cancerous lesions (actinic keratosis) and skin cancers had accumulated around 450 hours at work within a one-year period. Furthermore, Schmalwieser et al. (2021) reported that in the 1970s, skin cancer was known to be a common disease among sea workers (and farmers) until it began affecting other outdoor occupations.

This profession is male dominated, with one of these studies excluding female participants entirely as women do not work in the sector according to the country's (Iran) employment records. Heydari Dehdari, & Solhi, (2021) studies showed that participants were older in age.

Heydari, Dehdari & Solhi (2021) sought to examine if a mobile phone-based text message intervention could encourage seafarers in Iran to adopt sufficient sun safety habits. The results of the study revealed its efficiency in enhancing preventive behaviours among the cohort as protection motivation and fear of skin cancer was significantly higher among the 68 seafarers who availed of the intervention than those who did not use it (the control group). The age ranges of seafarers were 41-60 (n=24), whereas the age range in the control group was 31-40 (n=25).

Neither study specified the gender of the subjects, but the most common age range among the sailors in the two studies was between 31 and 40 years old and the results from each showed that 7 sailors spent 10 years of more working in this sector. However, 8 in one of the studies stated 'yes' to experiencing sunburn while working (Mazloomy-Mahmoodabad et al., 2019) contrary to only 9 being affected in the other qualitative study (Asadian et al., 2021). Results from Asadian et al. (2021) highlighted that sailors believed (and felt concerned) they were at high risk of skin cancer and solar-

induced skin damage, but most felt that they did not have the resources or occupational conditions to introduce protective behaviours that facilitate better skin health. On the other hand, discrepancies in perceived risks and sun safety attitudes were present in the research by Mazloomy-Mahmoodabad et al. (2019); some sailors attempted to avoid sunlight exposure in the summer by working at night, wore long-sleeve protective clothing and some saw cancer as an unbearable and fatal disease that imposed stress on the sufferer and their family.

A case-control study in Italy (Larese-Filon, Buric & Fluehler, 2019) found that combined sailors, fishermen and lifeguards had excess risk of NMSC (OR: 4.3, 95% CI: 1.1 – 16.4).

Landscapers

Peters et al. (2019a) conducted a meta-analysis and formed risk estimates for NMSC among outdoor workers and thus listed landscaping as an occupation in high UV exposure category and at risk of NMSC.

A U.S. cross-sectional study distributed a questionnaire among 109 landscapers (94.5% male and 77.1% of white ethnicity) to investigate their skin cancer knowledge, beliefs, self-efficacy and preventive behaviours as it was assumed that employees in this profession are exposed to high UV levels, increasing their risk of skin cancer (Nahar et al., 2013). In terms of skin cancer knowledge in the study, a mean score of 67.1% was achieved among the sample. A total of 44.9% of landscapers believed they would be affected by skin cancer at some point in their life and 87.2% agreed that skin cancer is a serious disease. Similarly, 73.4 % participants in this study correctly recognised that skin cancer can be fatal, but nearly half of the sample (43.1%) thought melanoma skin cancer was the least critical form of skin cancer and the researcher behind this study concluded that the cohort has not been sufficiently educated on skin cancer and called for educational programmes, considering these workers are subjected to high UVR levels throughout their career.

Day et al. (2015) carried out a population-based study on 149 Hispanic outdoor workers and 14.3% of the sample worked in landscaping. These labourers contributed to the results of poor sunscreen use and were considered to be at risk of melanoma skin cancer, but this study in general did not give weight to landscapers nor did it provide a detailed analysis of their skin cancer risks or perceived risks.

Furthermore, a cross-sectional study featuring 179 outdoor workers (75% male, 75% Caucasian) in Canada aimed to characterize the UVR exposure levels of outdoor workers in the country and found that landscapers had the highest level of sun exposure out of all participants (2.64 SED) (Rydz et al., 2020). Employees in the sample were relatively young (mean age of 37 years old) but 44% of the overall workers exceeded the international occupational exposure limit guidelines, with workers in the landscaping industry (and maintenance, trade and recreational workers) becoming exposed to UVR levels that are 2-4 times the average exposure levels of those working in security or professional services and therefore presenting greater risks of developing skin cancer.

Park Workers

The two cross-sectional studies on park workers in this review predominantly represent male employees in this industry (Nahar et al., 2014; Nahar et al., 2019).

On average staff were middle-aged and had a fairer skin type that could lead to sun burns after sun exposure (Nahar et al., 2019). Wearing work gear was the most common form of sun protection (Nahar et al., 2014; Nahar et al., 2019) with little usage on SPF sunscreen (Nahar et al., 2019). In the second study, park workers were covered under a health insurance plan and when compared to the first study, more employees also had their skin checked for any signs of skin cancer, however this cannot justify if their sun safety behaviours were better than the park workers in the first study, given the differences in sample sizes. Regardless, both studies showed that they spent approximately 4 hours of their working day in the sun and the need for better skin cancer knowledge appeared evident in both studies (Nahar et al., 2014; Nahar et al., 2019).

2. Characteristics and factors of excessive occupational UVR exposure

In this section we review the research on risk factors and subgroups particular to each occupation, in order to elucidate what personal, cultural, environmental, or indeed professional / structural characteristics of each occupation confer that risk.

In many cases these risk factors may interact, or their effects may not be separable, and substantial research gaps remain to be addressed in the field.

1. Gender

Males dominate outdoor professions and are at risk of solar UV exposure

Men are more likely to occupy outdoor work roles and experience exposure to high ultraviolet radiation levels (Mabula et al., 2012). For example, 15 million employees in Italy at risk of solar UV exposure of which 90% are male (Modenese at al., 2018). However, excluding female participants (Boyas et al. 2018) is a study limitation when attempting to assess skin cancer prevalence and preventive behaviour as the research becomes gender restrictive (Babazadeh et al., 2017). Similarly, not stratifying results by gender becomes a limitation in acquiring gender-specific risks (García-Montero et al. 2020).

A higher skin cancer prevalence was found among male farmers and fisherman (Husein-Elahmed, 2017).

Gender has been shown to be an influence, with females being more conscientious (D'Souza et al., 2021; Bauer et al., 2014; Coups et al., 2012; Day et al., 2015).

In conclusion, the literature indicates that males dominate the outdoor work force due to the nature of the tasks. There is tentative evidence that males have higher rates of pre-cancerous lesions than females, but this remains a serious research gap.

2. Age

Younger age in combination with knowledge levels may be a risk factor for exposure.

Research from Poland in a case-only study of farmers indicated they were more likely than non-farmers to spend more than 10 hours outdoors daily before the age of 20 (Szewczyk et al., 2016).

Despite the known risk of cumulative exposure over the course of the lifetime, there is literature showing that older outdoor workers are more likely to follow sun-protective strategies in comparison to younger staff (Nahar et al. 2013; Sena et al., 2016).

In a cross-sectional study on 145 mountain guides, previous skin cancer detected from screening was significantly associated with age (OR=3.5, 95%CI=1.2–10.6) (Zink et al., 2018a).

In summary, although it is well established that cumulative exposure strongly influences risk of skin cancers, few data have been reported on differential age-related risk in outdoor workers specifically.

3. Skin Type

Fair-skinned outdoor workers present higher cases of skin damage and skin cancer

A lack of comparative literature specifically in outdoor workers prevents a presentation of evidence, however attitudes and protective behaviours may be important.

While in one study a majority believe darker skin does not protect from cancer (Niu et al., 2022), in others the opposite was true (Zink et al. 2019; Kearney et al, 2014). It has been shown that paler-skinned people are most likely to use occupational sun protection (Day et al., 2015).

Existing literature exemplifies that fair-skinned individuals are at greater risk of skin cancer and those with paler skin tend to have higher incidences for AK and BCC than dark-skinned cohorts, who nevertheless are not immune. There is no literature comparing risk across skin types specifically in outdoor workers.

4. Time spent outdoors

Time spent outdoors is considered one of the major risk factors for UV exposure, and outdoor workers are often defined by the time spent in the open air during a regular working day. However, very few studies report time outdoors broken down by profession.

A questionnaire study from 1153 UK postal worker conference attendees reported an average of 5.4 hours outdoors per working day (Houdmont, Davis & Griffiths, 2016).

Farmer and gardener participants in Zink et al. (2019) admitted they were conscious of damage to their skin when they spent most of their shift in the sun.

A study of 157 Latino farmworkers found that the workers spent 9 or more hours of their working day outdoors and although correct work attire was worn by participants, 90.8% of the workers did not wear sunscreen and 87.4% did not wear sunglasses. Another sample of 157 Latino farmworkers who spent 9 or more hours working in the sun each day, revealed no cases of skin cancers despite protective measures (sunscreen or sunglasses) being overlooked (Kearney et al., 2014).

Operating engineers (n=232) in Lee et al. (2014) study reported spending 4-5 hours outdoors during the week from 10am-3pm (n=191) and 4-5 hours on the weekend from 10am-3pm (n=158). Seeking shade may also be motivated by avoidance of feeling heated during work rather than to prevent severe UVR exposure (Uejio et al., 2018; Peters et al., 2020. Holman et al., 2018), because dizziness, weakness and disruptions in cognitive functioning are symptoms that can be experienced by outdoor workers (Ioannou et al., 2021). Although seeking shade helps outdoor workers feel less heated it is not enough to prevent skin cancer or sunburns (Tizek et al., 2020). Occupational sun protection must be treated more seriously to assist outdoor workers, as 310 state park workers indicated professional incompetency on the issue, with 12% declaring that their workplace has a sun safety protocol in place, but only 10% received training (Nahar et al., 2019).

Table 2 shows an overview of six studies in mixed populations of outdoor workers featured in the systematic review that disclosed information regarding the number of hours spent working in the sun (See Appendix A1-Table 2: A sample of recent studies reporting outdoor work hours in the Appendices).

5. Level of UV exposure

While some studies simply compare outdoor or indoor worker exposures, some comparative research on professions also exists.

In a cross-sectional study featuring Australian farmers over 45% reported spending more than 6 h in the sun daily (D'Souza, 2021). In an intervention study, Cherrie et al. (2021) reported that daily sun exposure for construction workers (in the control groups) were 1.4 SED for outdoor workers compared to 0.2 SED for indoor workers.

Peters et al (2016b) reported UV exposure in a mixed sample of outdoor workers in Vancouver, Canada, and reported (regression-adjusted) mean SED/day of 1.3 for Marine and for Land-based construction workers, and 0.5 for horticultural / non-construction workers.

Peters et al (2019b) measured UV exposure in a range of outdoor municipal and utility workers in Canada, showing that the highest exposures occurred in Utility line work (10.2 SE/day), followed by General maintenance workers (7.2 SED / day). Landscaping (5.5 SED/day) and supervisory work (4.1 SED/day) had relatively low exposure in this study.

In a national study of outdoor workers in Denmark, Grandahl et al (2018a) reported roofers and other construction workers as having the highest relative exposure, with up to an average of 362 cumulated annual SED exposure. Gardeners had exposure of 211 SED annually similar to postal workers. Dockworkers and carpenters compared better with annual average of approximately 140 SED, while indoor workers averaged 61 SED annually.

6. Ethnic backgrounds among outdoor workers

Outdoor workers from both white and black ethnic groups present poor sun-protection habits and are at risk of skin cancer

Differences in attitudes and perceived risks could also play a role for different ethnic groups and could impact skin cancer prevalence across different cultures.

Cherrie et al. (2021) conducted a study on construction workers in Britain of whom were predominately of white British ethnicity (73.8%) and male (96.7%) and found that those who commit to 30-40 years of work in the industry have severe levels of solar UV exposure, with one study on 67 workers showcasing that the cohort had an SED range of 0 to 13.47 to which the study concluded that employers should introduce sun safety procedures and monitor the skin health of their workers to alleviate the dangers of continuous sun exposure.

Nahar et al. (2014) study of 87 state park workers (71.3% Caucasian and 27.6% African Americans) worked outdoors from 10am-4pm but more than half of the participants did not wear protective clothing (e.g., long-sleeved shirts or headgear) or apply sunscreen.

On the other hand, discrepancies in attitudes were witnessed in mountain and ski guides, who viewed sunscreen as a convenient way to reduce skin damage, which could simply suggest that if workplaces visibly promote sunscreen use throughout the working day (for instance, provide sunscreen dispensers at each workstation), employee uptake of simple protective measures could improve (Tizek et al., 2017).

Skin cancer and sun-related skin damage is most common in white people, but Nahar et al. (2019) found that state park workers (61.6% non-Hispanic white) admitted experiencing sun burns easily whilst working outdoors. Twenty-nine of the subjects had a history of skin cancer and 57 had a relative

who received a skin cancer diagnosis, yet only 46 had had a skin check for signs of skin cancer and 31 underwent a medical skin examination and most participants confessed to rarely practicing sun protection.

These findings, however, cannot be generalised across all backgrounds as a study on outdoor car guards (8 of whom were Black African and 2 white) revealed adequate sun-safety practices at work and more than half of the participants acknowledged their risk of skin cancer despite not having received formal training on the topic (Nkogatse et al., 2019), however, due to the small sample size in this study these findings cannot be validated. Nevertheless, this research concluded that the participants may have naturally abided by safety measures as the protective equipment was part of their uniform however such findings may be relevant to ethnic or cultural attributes.

7. Region, nation, latitude

Skin cancer risk affects outdoor workers globally. Latitude effects are difficult to disentangle from differences in diagnosis rates, and public health, and health service difference.

Perceptions of skin cancer risks vary across different countries. For instance, France, Germany and Denmark operate occupational skin cancer programmes (Ulrich et al., 2016) whereas the UK, Sweden, Romania, Italy and Croatia only offer interventions that respond to occupational dermatitis. Among all countries included in this review, only France established a structured skin screening programme for occupational skin cancer. In Italy and Germany, occupational healthcare physicians can provide workers with a basic skin assessment. In Italy, every company must run a compulsory screening schedule for workers, which is based on one's personal occupational risk assessment. The occupational health workers must include skin cancer surveillance if the risk is deemed important. Whereas these measures in Italy currently include the risk related to artificial UVR, but not solar radiation, contrary (natural UVR but not artificial UVR exposure) to Germany. The costs of each workplace health-care surveillance are fully covered by the employers (Ulrich et al., 2016).

Canada covers a range of latitudes, and the south of the country can exceed a UV index of 8, meaning outdoor workers, including not only those affiliated with farming and sea work, but staff in the construction, maintenance, trade and recreational sectors are at severe risk of unprotected UV radiation (Schmalwieser et al., 2021; Rydz et al., 2020) and therefore require sufficient sun protection.

Poor sun protection habits were observed in outdoor workers in Italy but especially in young people affiliated with construction and agricultural work, most of whom exhibit low health literacy and require sufficient education on UV radiation risks and prevention strategies (Modenese, 2020). A further Italian study showed that outdoor workers had more skin lesions (especially on the face) and incidence of AK and SCC than indoor workers (Modenese et al., 2016)

Given that Spain lies in low latitudes, farmers reportedly made attempts to avoid direct sunlight (i.e., working in shaded areas) than farmers in higher latitudes (Bodekaer et al., 2015). Spain is one of the most popular countries for ski resorts in southern Europe, but the UV index is approximately 3 in winter months, meaning ski resort workers who have remained in the occupation for years are at risk of developing AK (Gilaberte et al., 2020). Another Spanish study concluded that protective measures against UVR are recommended in Spain as outdoor workers were exposed to a median of 6.11 SED per day (Serrano et al., 2013).

Northern Europe

In Ireland, most people have fair skin (Fitzpatrick Skin type I or II), which may cause them to burn easily rather than tan in the sun, leaving them susceptible to UV damage and at risk of skin cancer (Department of Health, 2019). Malignant melanoma is ranked fifth for the most prevalent and invasive cancer in the country (Porter et al., 2022; National Cancer Registry Ireland, 2017) The island has one of the highest melanoma mortality rates in Europe, with 20 per 100,000 cases reported annually (National Cancer Registry Ireland, 2017). Like other countries, professional and public recognition of skin cancer risks is crucial to improve prevention and intervention techniques (Porter et al., 2022). This was underpinned by the Marie Keating Foundation who distributed a national survey about skin cancer knowledge among 1000 Irish participants. The results were that 82% heard about melanoma, 16% heard about BCC and 10% were familiar with SCC, but one in seven participants could not physically identify skin cancer symptoms.

On a positive note, 83% would immediately attend their GP if they spotted issues with a mole, but young adults are likely to delay seeking medical attention in this instance (Menzies et al., 2017). The Healthy Ireland Survey 2019 also found that 92% of survey participants report using a form of sun protection when in the sun for more than 30 minutes. The most commonly used protective measures are sunscreen with factor 30 or higher (68%), sunglasses (60%), and wearing a hat (42%). Thirty-one percent of participants reported that they refrain from spending long durations in the sun and 28% stay in the shade when spending time outdoors. More women (96%) than men (86%) are likely to use a form of sun protection, women are less likely to use the preventive measures mentioned above, with the exception of a hat (men: 49%; women: 36%). However, 79% of women in comparison to 57% men reported applying sunscreen of factor 30 when in the sun longer than 30 consecutive minutes (Healthy Ireland Summary Report, 2019).

Mirroring data from other countries, another Irish survey consisting of 1,051 respondents (43% male, 57% female) showed that knowledge of UV exposure, skin cancer risks and uptake of protective measures was more common among females and 34% of men had experienced sunburns when working outdoors in contrast to 21% of females (Harkin & McGrogan, 2019). In addition, outdoor workers are exposed to 2-3 times more UV radiation than indoor workers, making them a high-risk group. Over 13,000 people are diagnosed each year with skin cancer, and these numbers are expected to rise if people do not use sun protection behaviours (Health Service Executive, 2022; National Cancer Registry Ireland, 2021).

A study on postal workers from the North (Northern Ireland, Scotland, Northern England), East (London, Southeast England), and West (Wales, Southwest England) UK found that those in the west region had noticeably better knowledge and skin care practices than participants from other regions. Those in the East region had poorer knowledge than those from the West and had poor sun safety habits in comparison to the West and North areas combined. Knowledge and practices differed due to personal, occupational, and demographic distinctions (Houdmont, Davis & Griffiths, 2016). With that said, in the UK, BCC increased 39% from 2000 to 2011 in all age groups > 30 years (Reinau et al., 2014).

International Non-melanoma and melanoma skin cancer rates among men and women can be viewed in: Appendix 1- World Cancer Research Funds International

8. Socio-economic factors that influence outdoor workers

8.1 Outdoor workers typically have low education levels

Outdoor workers tend to not to have advanced education levels (university or college) but have either completed primary or secondary school.

Previous research shows that outdoor workers have low education levels with one study (consisting of a range of 643 outdoor workers) reporting that 40% left school after 9 years and 8.5% completing higher than a high school diploma (Bauer et al., 2020). Outdoor workers typically do not have a third-level qualification, but many did complete primary and secondary school (Belete et al., 2021; Schneider et al., 2018). However, those in managerial positions did attain a university or college degree as one study revealed that 54 % of 343 senior managers completed a 4-year college graduate or post-graduate programme (Walkosz et al., 2019).

Education levels overall tended to be lower among males than females, although Haluza et al., (2014) proposed that more male outdoor workers may be inclined to obtain a third-level qualification at any life stage. Such claims need to be challenged further as males in a study on fishermen, construction and agriculture showed 81% of males and only 77% of females did not complete two or more years of higher education (Borup, Mortensen & Grandahl, 2020).

8.2 How low education levels impacts skin cancer knowledge

Minimal education may also be correlated with parental education levels as illiteracy and lower than secondary education was reported among parents of 136 seafarers (Heydari et al., 2021), however this would require further investigation. Out of a sample of 145 mountain guides, most participants held sufficient education to qualify for university (n=86) and nearly all subjects applied sunscreen at work to prevent skin cancer (n=125). Engagement with frequent protective measures appears to be unsubstantial in workers who did not achieve a university or college degree (Nahar et al., 2014). Similarly, a population of Danish outdoor workers (n=380; 303 male, 77 female) had either elementary/ primary or vocation school experience and 188 reported to not thinking about their risk of skin cancer (Grandahl et al., 2018b). This could suggest that those with low education levels may have increased risk of skin cancer due to limited knowledge on sun exposure, which is typically taught at school level (Szewczyk, 2018).

Table 3 showcases a sample of studies featured in the review that address education levels among outdoor worker from 2014-2018. (Appendix A2- Table 3: Level of education among outdoor workers in studies from 2014 - 2018).

8.3 Household income may impact sun-protective behaviours

Research over the last ten years suggests that the income of outdoor workers can influence their uptake of sun-protective behaviours, especially if outdoor workers are expected to invest in and supply their own protective equipment.

Babazadeh et al. (2017) conducted a cross-sectional study on 238 farmers and discovered that farmers with a “good” income (n= 93) applied more sunscreen than farmers with lower incomes. The study hypothesised that financial barriers could prevent workers from using preventive measures especially ones that require self-funding and therefore motivation to protect oneself from skin damage is significantly reduced. This could be linked to a lack of understanding of skin cancer risks due to

earning low incomes and an inability to invest in equipment and correct clothing; to resolve this issue occupational sun safety programmes and interventions should be established to increase sun safety behaviours.

Low-income levels are closely linked to poor education levels and general skin cancer prevention knowledge (Boyas et al., 2018). Such workers demonstrated both poor health literacy and an inability to afford health insurance, potentially leading to poorer health among high-risk populations. This highlights that establishing prevention programmes will promote and communicate the importance of understanding skin cancer risks and hopefully increase health literacy (Boyas et al., 2018).

The literature implies that solar UV protection measures that require self-financing can hinder outdoor workers' ability to protect themselves from occupational sun exposure, especially if workers earn low or average incomes.

9. Social attitudes and behaviours

9.1 A false perception of skin cancer risks among outdoor workers

Unfortunately, many outdoor workers fail to acknowledge their risk of skin cancer development despite spending a large proportion of their working day in the sun. Lack of perceived risk may be more common in non-white populations, including non-white Hispanics as knowledge on skin cancer risks and use of sun protection was found to be low among this ethnic group (Garnett et al., 2016; Roman, Lugo-Somolinos & Thomas, 2013).

Zink et al. (2019) carried out a qualitative study on farmers, 11 of whom were over the age of 60 and 9 between the ages of 9-18. They stressed the need for education to gain a better understanding of the links between skin cancer and sun exposure particularly among male farmers who apparently spend more time outdoors than female farmers.

A study on three outdoor professions (gardeners, farmers and mountain guides) found that among the gardeners in the study; median age was 34.5 ± 13.9 years; 33% of them rarely or never applied sunscreen when performing duties outdoor and 58% never attended a skin screening appointment. The research concluded that outdoor workers including gardeners are at high risk of non-melanoma skin cancer, yet these populations do not understand skin cancer prevalence (Zink et al., 2017).

A U.S. study by Day et al. (2015) on outdoor workers (mainly construction and landscapers) revealed that nearly half (42.9%) of the participants (n=788) aged 19–73 admitted to never applying sunscreen when working outdoors, arguably because of product scarcity and lack of education around sun protection measures. Construction workers among other outdoor workers may be unaware of their risks of skin cancer development since 7 male outdoor workers aged 20-58 years old (mean 39.0) flagged that the implementation of sun protective measures is dependent on the size of their work area and stated that wearing full-length clothing is uncomfortable for them. Participants did not protect their neck throughout the day and although sunscreen application was frequent in this sample, it was applied incorrectly (lack of re-application and poor judgment around the time that it should be applied) (Rocholl et al., 2020).

Skin cancer diagnosis affects 1 in 3 Australians and mortality has increased because of increased disease prevalence. Sideris & Thomas (2019) argue that there is minimal research on the topic and high-risk populations have been neglected in the country. This is inconsistent with other Australian research that suggests that Caucasians over the age of 18 in the country have not been deprived of

skin cancer awareness, but they choose not to practice sun-safety in order to prevent skin cancer (Bryant et al., 2015). Both New Zealand and Australia have the highest incidence and mortality rates of melanoma worldwide, however a decline in mortality was recognised in generations born from approximately 1958 in Australia, but this decrease was only shown in for New Zealanders born from 1968. This poses the question as to whether there is a delay in melanoma control strategies in New Zealand compared to Australia, meaning additional research is required to comprehend and monitor increases in melanoma mortality rates (Sneyd & Cox, 2013).

Religious attitudes could have a minor impact on skin cancer attitudes among outdoor workers as Iranian sailors were convinced that they will not be affected by skin cancer unless God makes this their destiny (Mazloomy-Mahmoodabad et al., 2019). Further research aimed at the Iranian population is necessary due to their lack of skin cancer knowledge and poor sense of urgency in responding to their skin cancer risks (Nahar et al.,2017).

Comparably, risk perceptions can differ in workers of contrasting occupations. This was underpinned by Zink et al. (2017) after examining the views and behaviours of 353 roofers, gardeners and farmers (combined) and concluded that roofers most believe that they were at risk of skin cancer in comparison to farmers who had the lowest perceived risks. A total of 63.6 % of farmers in this sample had undergone skin cancer screening, but inadequate sunscreen application was found among farmers and men overall, whereas sunscreen use and wearing sunglasses was continuous among roofers compared to farmers and gardeners.

The data further emphasised the need for encouragement through public health campaigns, with particular focus on protective measures associated with one's physical appearance (i.e., sunglasses, hats, light clothing) to persuade outdoor workers to take care of and monitor their skin health (Barrett et al., 2019). Eye problems were also deemed a problem for outdoors workers if sunglasses are not worn when exposed to UV radiation (Belete et al., 2021). In saying this, poor social attitudes and stereotyping from colleagues can potentially hinder an employees' decision to partake in sun safety behaviours. This was shown in a study of sailors whereby many participants knew the dangers associated with skin cancers and took direct action to prevent harsh UV exposure but received unsupportive remarks from co-workers (Asadian et al., 2021).

Considering these results, personal beliefs and attitudes can hugely impact one's perceptions towards skin cancer and overall skin health. Table 4 presents a collection of included studies that disclose skin cancer/skin lesions prevalence or subtype proportions, illustrating the variability in reporting, particularly across diverse study types (See Appendix A3 - Table 4: Skin cancer/ skin lesions prevalence found in studies from 2013 - 2022).

Conclusion

This systematic review search illustrated that outdoor work is commonly undertaken by men due to the types of tasks associated with outdoor labour. Mountain guides, farmers, gardeners, construction workers, landscapers, park workers, people who work at sea (seafarers) and postal workers are frequently mentioned in this review.

Furthermore, young and middle-aged workers are most at risk of severe exposure to UV radiation as low health literacy was found among this age group. Females often have greater skin cancer knowledge than males and are more likely to adhere to sun safety recommendations. However, better sun safety practices may increase with age while employees continuing to work outdoors and remain in professions affiliated with sun-exposed labour.

Overall, outdoor workers tend to possess low education levels, which may explain low health knowledge among this population. Additionally, those lacking high incomes can fail to provide self-funded protective measures (e.g., sunscreen, hats, light clothing) when working outdoors and are at greater risk of skin cancer if these safety measures are frequently avoided. For this reason, it is recommended that employers implement practical safety measures throughout their employees' shifts and offer sun-safety training to improve general knowledge on the topic and to instil confidence in outdoor workers when they are required to engage in these measures. This is advised because the literature suggests that outdoor workers may be more likely to comply/conform to sun-safety practices (e.g., applying sunscreen, wearing a hat) if they feel their employer and colleagues encourage it. However, workplace culture and peer influence may prove more difficult to change.

When examining skin cancer prevalence and sun safety attitudes in different countries, no major discrepancies were found, meaning skin cancer remains a global burden worldwide. Nevertheless, many outdoor workers of a non-white ethnicity falsely believe that they cannot experience skin cancer as incidences are reportedly higher in white people. Certainly, white-skinned populations are more prone to skin cancer and sun damage, but darker-skinned individuals can still be diagnosed with skin cancer and sun-related skin problems and therefore should follow a sun-safety routine. Moreover, the literature also uncovered that some populations view skin cancer as a hereditary illness and can only impact those whose relatives received a previous diagnosis. These beliefs can only be changed by promoting awareness of the risks from UV exposure and the use of sun protection measures to reduce the risk.

Findings from this research report highlight information on UV exposure among various cohorts of outdoor workers. Risk factors are so varied and cannot rate which outdoor occupation is at the highest risk of UV exposure as factors such as skin type, age, family history, leisure time outside or work all play a part.

To develop prevention interventions for outdoor workers, and organisations employing such workers, it is important to understand which cohorts are most at risk of UV exposure in their work environment and therefore at higher risk of developing skin cancer.

Recommendations for Employers of Outdoor Workers

It is recommended that employers affiliated with the outdoor workforce provide mandatory Personal Protective Equipment (PPE) such as clothing, hats, UV protection sunglasses or safety glasses as well as providing shade for staff where possible when they are required to work outdoors. Promoting the use of sunscreen while on duty is also an important addition to PPE and shade and it is therefore suggested that employers provide sunscreen dispensers at various locations throughout the workplace as this will enable re-application among outdoor workers when required. Nonetheless, outdoor workers who are expected to frequently travel and spend time away from the primary work facility, such as postal workers are unable to access any sunscreen dispensers made available. As a result, travel-sized sunscreen lotions could also be issued to staff who cannot remain on site throughout the working day.

Employers are also advised to display user-friendly / accessible posters that advocate the importance of sun safety when working outdoors, as well as verbally encourage their employees to practice good sun protection behaviours. Organisations that successfully implement sun safety measures and/ or protocols for their employees may be granted permission to use the Healthy Ireland 'Sun Smart' branding logo following formal review and approval from the National Cancer Control Programme.

Employers should ensure risk assessments are conducted to assess if there is a risk of hazardous levels of exposure to UV radiation from the sun associated with performing tasks outdoors. Employers can also develop a UV Protection Policy which includes why and how UV radiation risk will be managed in the organisation. For more information on how to strategically address skin cancer prevention among outdoor workers visit www.hse.ie/sunsmart

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Appendices

Appendix A1 – Table 2: A sample of recent studies reporting outdoor work hours

Authors	Study title	Year & Country	Occupation	Participants occupational outdoor hours	Findings
Husein-Elahmed et al	Basal cell carcinoma arising in outdoor workers versus indoor workers: a retrospective study.	2017 (Spain).	Mainly fishermen and farmers	>6 hours outdoor daily.	OW were more likely to develop nodular BCC, with no additional risk of superficial BCC. Onset of BCC is older in OWs than INWs.
Zink et al	Do outdoor workers know their risk of NMSC? Perceptions, beliefs and preventive behaviour among farmers, roofers and gardeners.	2017 (Germany)	Farmers, roofers, gardeners	251 out of 353 participants spent 21 hours a week in working outside.	153 out of 353 never wore sunscreen at work but wearing headgear and long trousers was common. Poor sunscreen use was common amongst males and farmers. Low skin cancer risks was greatly associated with poor use of sunscreen, sunglasses, headgear and long-sleeved shirts.
Zink et al	Different outdoor professions have different risks - a cross-sectional study comparing non-melanoma skin cancer risk among farmers, gardeners and mountain guides.	2018 (Germany)	Farmers, mountain guides, gardeners	157 out of 348 participants spent >6 hours outdoors daily.	There were differences in skin cancer screening attendance rates (indoor worker 61.4%, mountain guides 57.8%, farmers 31.9%, gardeners 27.6%), daily UVR exposure during work and protective behaviour such as sunscreen use during work.
Schneider et al	Occupational UV exposure and sun-protective behaviour in German outdoor workers: Results of a nationwide study.	2018 (Germany)	Variety of outdoor workers	The mean time of hours spent working outdoors was 23.6±15.3hours per week.	The 12-month prevalence of getting sunburnt at work was 19%. One-third of outdoor workers reported using five of the most important protective measures "often" or "always." The uptake of sun safety behaviour among high-risk groups is needed.
Peters et al	Burden of non-melanoma skin cancer attributable to occupational sun exposure in Canada.	2019 (Canada)	Agriculture, construction, transportation and warehousing, public administration, forestry and logging.	6 or greater hours spent outdoors daily.	In 2011, 4556 cases of NMSC were assumed to be linked to occupational sun exposure. Most of these cases were in 10.4% of men in the construction and agriculture industry versus only 1.3% women.

Appendix A2 – Table 3: Level of education among outdoor workers in studies from 2014 - 2018

Authors	Study title	Year & country	Occupation / Population	Participants level of education	Findings
Nahar et al.	Skin cancer preventative behaviors in state park workers: a pilot study	2014 (U.S.)	87 state park workers	Many of the participants had attended some college (41 %) or had a bachelor's degree or higher (15%).	Workers reported low levels of sun protective behaviours. The most commonly reported barriers to sun protection were "inconvenient," "too hot to wear," and "forget to protect." Half of the participants (50.6 %) were highly confident in their ability to wear long pants while in the sun. About the same proportion of participants were very confident they could wear a wide-brimmed hat (21.8 %) and sunscreen (20.7%).
Day et al.	Occupational sunscreen use among US Hispanic outdoor workers	2016 (U.S.)	788 Hispanic adults in predominately construction and landscaping.	Less than high school = 38% High school = 27% At least some college = 35%.	69% of the sample reported never or rarely wearing sunscreen while working outdoors. Being female, having a higher level of education and residing at a higher latitude were associated with more frequent sunscreen use.
Babazadeh et al.	Determinants of Skin Cancer Preventive Behaviors Among Rural Farmers in Iran: an Application of Protection Motivation Theory	2017 (Iran)	Farmers (n=248)	Illiterate/primary level 32% Middle level = 38% Secondary level and/or diploma = 30%	Illiterates/those with elementary level of education used hat less than the other two groups (Middle, secondary/diploma level). Rural farmers with lower levels of education were less likely to use hat while carrying out their work tasks.
Schneider et al.	Occupational UV exposure and sun-protective behaviour in German outdoor workers: Results of a nationwide study	2018 (Germany)	485 German outdoor workers in a range of outdoor work professions	12% of respondents had achieved a low level of formal education. 53% had achieved a medium level of formal education. 35% had achieved a higher-level academic qualification.	Women use sunscreen and wear sunglasses more frequently than men and are more likely to have the opportunity to stay in the shade. In contrast, men tended to cover their heads more often. Engagement with sun protective behaviours/strategies varies across different occupations.
Zink et al.	Primary and secondary prevention of skin cancer in mountain guides: attitude and motivation for or against participation	2018 (Germany)	145 mountain guides	Low: 9% of participants Medium: 30% of participants High: 61% of participants.	Previous skin cancer screening was significantly associated with age higher education, a self-reported good or sufficient knowledge about skin cancer screening, regular self-examinations.

Appendix A3 – Table 4: Skin cancer/ skin lesions prevalence found in studies from 2013 - 2022

Authors	Study	Year & country	Prevalence	Findings
Oldenburg et al	Actinic keratosis among seafarers	2013 (Germany)	35-40yrs (n= 43) 7% diagnosed 41-50yrs (n= 162) 7% diagnosed 51-60yrs (n= 179) 18% diagnosed >60yrs (n= 130) 36% diagnosed	AK prevalence increased with age among outdoor workers.
Husein-Elahmed et al	Basal cell carcinoma arising in outdoor workers versus indoor workers: a retrospective study	2017 (Spain)	In both cohorts, the most prevalent histologic subtype was nodular BCC (75% of OWs and 68% of IWs), followed by superficial BCC (10% of OWs and 21% of IWs).	Outdoor workers had a higher prevalence of nodular BCC and lower prevalence of superficial BCC compared to indoor workers.
Szewczyk, et al	Outdoor work as a risk factor for high-grade cutaneous squamous cell carcinoma of the head and neck	2018 (Poland)	Grade 3 cancers increased by 1% per year among older participants.	The data in this retrospective study strongly suggest that outdoor work, low educational level, and age are factors that substantially increase the risk of developing a high-grade cutaneous squamous cell carcinoma tumour.
Peters et al	Strategic Task and Break Timing to Reduce Ultraviolet Radiation Exposure in Outdoor Workers.	2020 (Canada)	Outdoor workers exposed to occupational UVR was estimated to be roughly 1.5 million Canadians in 2006 (an exposure prevalence of 9%).	Outdoor occupations in Canada are at severe risk of UVR exposure and have an increased risk of NMSC.
Gilaberte et al.	Skin Cancer Prevalence in Outdoor Workers of Ski Resorts	2020 (Spain)	Actinic keratosis (AK) but no skin cancers were detected in 15% of 219 outdoor workers.	AK lesion appeared common among this population of ski resort workers.
Tizek et al	Skin cancer risk and shade: comparing the risk of foresters with other outdoor workers	2020 (Germany)	Skin examination revealed an overall Keratinocyte Carcinoma (KC) prevalence of 17% similar to other OWs.	Foresters in this study were not at higher risk of KC than other OWs
Loney et al	Global evidence on occupational sun exposure and keratinocyte cancers: a systematic review	2021 (Germany)	In Germany there are >9000 new cases of KC reported annually.	Incidences of Keratinocyte Cancers as a result of outdoor work are rapidly increasing in Germany each year.
Grandahl et al.	Photoaging and actinic keratosis in Danish outdoor and indoor workers	2019 (Denmark)	The prevalence of AK in outdoor workers was 10.3% in comparison to indoor workers (5.1%).	Outdoor workers were more affected by AK than indoor workers in this study.

Appendix 1 – World Cancer Research Funds International

Melanoma skin cancer rates (total global melanoma skin cancer incidence and rates in 2020, including figures for men and women)

Rank	Country	Number	ASR/100,000
	World	*324,635*	*3.4*
1	Australia	16,171	36.6
2	New Zealand	2,801	31.6
3	Denmark	2,886	29.7
4	The Netherlands	8,310	27.0
5	Norway	2,567	26.4
6	Sweden	4,266	23.3
7	Switzerland	3,357	21.6
8	Germany	31,468	20.5
9	Slovenia	735	19.7
10	Finland	2,090	19.5

Rank (men)	Country	Number	ASR/100,000
	World	*173,844*	*3.8*
1	Australia	9,462	42.9
2	New Zealand	1,541	34.8
3	The Netherlands	4,420	27.1
4	Denmark	1,382	26.2
5	Norway	1,298	25.8
6	Switzerland	1,822	22.8
7	Sweden	2,146	22.2
8	Germany	17,260	21.1
9	Slovenia	379	19.9
10	Finland	1,090	19.5

Rank (women)	Country	Number	ASR/100,000
	World	*150,791*	*3.0*
1	Denmark	1,504	33.6
2	Australia	6,709	30.8
3	New Zealand	1,260	28.9
4	Norway	1,269	27.5
5	The Netherlands	3,890	27.4
6	Sweden	2,120	24.6
7	Belgium	1,951	22.6
8	Switzerland	1,535	20.8
9	Germany	14,208	20.4
10	Ireland	772	20.3

Non-Melanoma Skin Cancer Rates (total global non-melanoma skin cancer incidence and rates in 2020, followed by the figures for men and women)

Rank	Country	Number	ASR/100,000
	World	*1,198,073*	*11.0*
1	Australia	58,839	140.0
2	New Zealand	10,271	127.5
3	US	524,737	64.9
4	Canada	61,645	60.6
5	Switzerland	12,772	49.5
6	Ireland	4,788	46.2
7	The Netherlands	17,413	34.5
8	Germany	90,379	31.3
9	Montenegro	378	29.6
10	Luxembourg	389	27.3

Rank (men)	Country	Number	ASR/100,000
	World	*722,348*	*15.1*
1	Australia	34,318	169.8
2	New Zealand	5,639	148.1
3	US	336,091	92.2
4	Canada	35,186	76.0
5	Ireland	3,075	64.0
6	Switzerland	6,948	60.4
7	The Netherlands	10,179	42.6
8	Germany	55,055	41.6
9	Montenegro	231	40.7
10	UK	32,609	34.8

Rank (women)	Country	Number	ASR/100,000
	World	*475,725*	*7.9*
1	Australia	24,521	111.5
2	New Zealand	4,632	108.7
3	Canada	26,459	47.6
4	US	188,646	42.7
5	Switzerland	5,824	40.3
6	Ireland	1,713	30.2
7	The Netherlands	7,234	28.1
8	Luxembourg	184	24.1
9	Germany	35,324	23.6
10	Belgium	4,149	22.2

Melanoma Skin Cancer Deaths (total global melanoma skin cancer mortality in 2020, including figures for men and women)

Rank	Country	Number	ASR/100,000
	World	*57,043*	*0.6*
1	New Zealand	472	4.7
2	Norway	375	3.2
3	Montenegro	32	3.0
4	Slovakia	317	2.8
5	Slovenia	127	2.6
6	Australia	1,408	2.4
7	Denmark	341	2.4
8	Croatia	236	2.4
9	The Netherlands	906	2.3
10	Serbia	393	2.3

Rank (men)	Country	Number	ASR/100,000
	World	*32,385*	*0.7*
1	New Zealand	321	6.7
2	Montenegro	20	4.0
3	Norway	207	3.8
4	Slovakia	177	3.8
5	Slovenia	76	3.4
6	Croatia	140	3.3
7	Australia	891	3.2
8	Serbia	242	3.1
9	North Macedonia	46	2.8
10	The Netherlands	543	2.7

Rank (women)	Country	Number	ASR/100,000
	World	*24,658*	*0.5*
1	New Zealand	151	2.8
2	Norway	168	2.6
3	Montenegro	12	2.3
4	Slovakia	140	2.2
5	Denmark	164	2.1
6	The Netherlands	363	1.9
7	Slovenia	51	1.9
8	Sweden	233	1.8
9	Australia	517	1.7
10	Serbia	151	1.7

Non-melanoma skin cancer deaths (total global non-melanoma skin cancer mortality in 2020, including figures for men and women)

Rank (men)	Country	Number	ASR/100,000
	World	*63,731*	*0.6*
1	Papua New Guinea	270	5.1
2	Namibia	53	3.8
3	Mozambique	375	2.5
4	Zimbabwe	159	2.4
5	Angola	250	2.2
6	Comoros	8	2.2
7	Togo	85	2.0
8	Eswatini	12	1.9
9	Somalia	138	1.8
10	Ethiopia	1,087	1.7

Rank (men)	Country	Number	ASR/100,000
	World	*37,596*	*0.8*
1	Papua New Guinea	150	6.1
2	Namibia	31	6.0
3	Mozambique	189	3.4
4	Angola	146	2.7
5	Lebanon	100	2.7
6	Georgia	91	2.7
7	Togo	48	2.4
8	Venezuela	323	2.2
9	Zimbabwe	57	2.2
10	Cuba	270	2.1

Rank (men)	Country	Number	ASR/100,000
	World	*26,135*	*0.4*
1	Papua New Guinea	120	4.3
2	Namibia	22	2.5
3	Zimbabwe	102	2.4
4	Burkina Faso	108	2.1
5	Comoros	4	2.1
6	Mozambique	186	2.0
7	Somalia	76	2.0
8	Eswatini	7	2.0
9	Ethiopia	612	1.9
10	Angola	104	1.7

URL Link: World Cancer Research Fund International: https://www.wcrf.org/cancer-trends/skin-cancer-statistics/

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