Original research

Risk assessment of occupational skin cancer among outdoor workers in southern Spain: local pilot study

Magdalena de Troya Martín ,[1] Sierra Aguilar,[2] José Aguilera-Arjona ,[3] Francisco Rivas-Ruiz ,[4] Alba Rodríguez-Martínez ,[4] Guillermo de Castro-Maqueda ,[5,6] Jacobo Cambil-Martín ,[6] Victoria de Gálvez-Aranda ,[7] Nuria Blázquez-Sánchez [1]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/oemed-2022-108454).

[1]Department of Dermatology, Sun Coast Hospital, Marbella, Spain
[2]Occupational Risk Prevention Service, Fuengirola City Council, Fuengirola, Spain
[3]Photobiological Dermatology Laboratory, Medical Research Centre, Department of Medicine and Dermatology, University of Malaga, Malaga, Spain
[4]Research Unit, Sun Coast Hospital, Marbella, Spain
[5]Physical Education Department, Education Science Faculty, University of Cadiz, Cadiz, Spain
[6]Nursing Department, Health Science Faculty, University of Granada, Granada, Spain
[7]Department of Medicine and Dermatology, University of Malaga, Malaga, Spain

Correspondence to
Dr Magdalena de Troya Martín, Department of Dermatology, Sun Coast Hospital, Marbella, Andalucía, Spain; magdalenatroya@gmail.com

Received 5 May 2022
Accepted 25 August 2022

To cite: de Troya Martín M, Aguilar S, Aguilera-Arjona J, *et al*. *Occup Environ Med* Epub ahead of print: [please include Day Month Year]. doi:10.1136/oemed-2022-108454

ABSTRACT

Objective Overexposure to ultraviolet (UV) radiation is the main preventable cause of skin cancer. Outdoor workers, exposed to the sun for many hours throughout their working lives, are at special risk. The aim of this study is to determine occupational photoexposure and photoprotection among outdoor workers employed by a municipality in southern Spain.

Methods Cross-sectional descriptive study focusing on outdoor workers employed by the municipality of Fuengirola (in areas such as construction, gardening, urban cleaning and beach maintenance). The participants were monitored by personal dosimetry, participated in a dermatological check-up and answered a validated questionnaire (CHACES) on their habits, attitudes and knowledge related to sun exposure.

Results The median effective erythema dose of exposure to solar UV radiation during the working day (n=20) was 379.4 J/m^2, equivalent to 3.8 standard erythema doses, almost 3 times higher than the recommended limits for an 8-hour workday. Skin examination (n=128) revealed the presence of actinic lentigines (79.7%), actinic keratoses (8.6%) and skin cancer (3.9%). The CHACES questionnaire (n=128) revealed a sunburn rate of 50.0%. Photoprotection practices were markedly deficient: only 16.7% of the survey respondents sought protection in the shade, 20.3% avoided exposure during the peak exposure hours and 33.1% applied sunscreen.

Conclusions This is the first study to evaluate UV radiation exposure, occupational sun protection practices, sunburn and actinic injuries of different outdoor workers in one of the sunniest regions of Spain and underlines the need for effective interventions to protect outdoor workers' health.

WHAT IS ALREADY KNOW ON THIS TOPIC

Studies carried out in other geographical and cultural settings have shown that outdoor workers are exposed to dangerous levels of ultraviolet (UV) radiation with few photoprotection measures, and therefore have a high prevalence of skin cancer.

WHAT THIS STUDY ADDS

This is the first study to evaluate UV radiation exposure, occupational sun protection practices, sunburn and actinic injuries of different outdoor workers in one of the sunniest regions of Spain.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

The results of this study show the need to develop policies and practices in Spain for photoprotection and skin surveillance in the workplace to prevent skin cancer in outdoor workers.

INTRODUCTION

There is much epidemiological and biological evidence of a cause-effect relationship between overexposure to ultraviolet (UV) radiation and certain diseases. For example, a report published in 2006 by WHO[1] associated UV exposure with nine pathologies: melanoma, basal cell carcinoma (BCC), squamous cell carcinoma (SCC), solar keratitis, cortical cataract, pterygium, carcinoma of the cornea, carcinoma of the conjunctiva and reactivation of herpes labialis.

Skin cancer is a major health problem worldwide[2 3] and its incidence is increasing faster than that of any other malignant neoplasm, due to population ageing, the reduction of the ozone layer and changing lifestyles. Exposure to UV radiation is the main preventable cause of skin cancer. In this respect, two main types of risky behaviour have been highlighted: the first is recreational, acute and intermittent, and related to an increased risk of melanoma and BCC; the second is professional, chronic and cumulative, associated with an increased risk of SCC and its precursor, actinic keratosis.[4]

As an occupational group, outdoor workers are especially vulnerable to skin cancer. However, in many countries, including Spain, skin cancer is not recognised as an occupational disease. Our research group, through the *Soludable* campaign, has studied the habits, attitudes and knowledge related to sun exposure and photoprotection of different population groups, including health professionals,[5] the educational community,[6] beachgoers,[7] specific groups of athletes[8 9] and workers highly exposed to solar radiation, such as lifeguards[10] and physical education teachers.[11] In Spain, little previous research has been conducted to determine the typical values of effective erythema dose of solar

UV exposure received by outdoor workers. To our knowledge, dosimetry of UV radiation received have only been performed in Spain for construction workers in Valencia,[12] gardeners and lifeguards in Valencia[13] and lifeguards in Malaga.[10]

In the present study, we evaluate the occupational sun exposure risk of different groups of outdoor workers (construction, electricity, carpentry, painting, gardening, cleaning and beach maintenance). Areas of specific interest include levels of effective UV environmental irradiance, the levels of effective personal UV irradiation, outdoor workers' habits, attitudes and knowledge related to sun exposure and the presence of actinic lesions including skin cancer. The resulting description of the current situation of outdoor workers employed by a municipality will facilitate the future design of campaigns and interventions to reduce the incidence of skin cancer among this and similar populations.

MATERIALS AND METHODS

For this research, an observational cross-sectional pilot study was implemented in Fuengirola, a municipality in the province of Malaga (southern Spain), from May to June 2019. Participants were recruited to this study during a photoprotection training course offered to 204 of the 224 outdoor workers employed by the Department of Public Works in Fuengirola. This course was organised by the dermatology area of the Sun Coast Hospital in collaboration with the Fuengirola occupational risk prevention service. All participants were municipal employees who habitually worked outdoors (in areas such as gardening, construction and maintenance, cleaning and beach management), had an adequate command of the Spanish language and voluntarily decided to take part in the study.

Procedure

- *Questionnaire on habits, attitudes and knowledge related to sun exposure*: at the beginning of the photoprotection training course, all attendees were invited to complete the CHACES questionnaire. The survey has 42 items grouped into the following sections: (1) demographic data (12 items), (2) skin colour and sun-reactive skin type, according Fitzpactrick classification[14] (2 items), (3) sun exposure habits (6 items), (4) sunburn in the last year (1 item), (5) sun protection practices (9 items), (6) attitudes related to sun exposure (10 items), (8) knowledge related to the sun and skin cancer (10 items). The validity of this instrument was demonstrated in the first phase of the analysis by the Cronbach's α values obtained, ranging from 0.45 to 0.8 for all components except knowledge (0.335). In the second phase, test–retest reliability was demonstrated (absolute agreement >60%).[15]
- *Environmental dosimetry:* data for solar irradiance with erythematic potential in terms of UV index and erythemal dose (J/m^2) were obtained from the Spanish Meteorological Agency[16] for the third week of June 2019, at Malaga Airport meteorological station (latitude: 36° 41′ 6.8872″; longitude: 4° 30′ 0.6405″, altitude 16 m), located 25 km from Fuengirola). The erythemal irradiance was obtained by a Yankee UVB-1 Ultraviolet Pyranometer (Yankee Environmental Systems, Massachusetts, USA). The UV index was calculated following World Meteorological Organization and WHO recommendations by multiplying the UV erythemal irradiance value (expressed in W/m^2) by 40.
- *Personal dosimetry*: a convenience sample of outdoor workers from all professional groups were monitored by personal UV dosimetry. Participation was voluntary and a commitment to responsibility in the care of the dosimeter was signed by the workers. Each of these workers wore an individual dosimeter on the wrist of their non-dominant arm during the third week of June 2019 for 3 days during working hours. This instrument incorporates VioSpor blue line type III sensors, manufactured by Biosense (Bornheim, Germany), based on a biological film sensitive to UV rays,[17] in which sensitive DNA molecules of the immobilised spores produce a response profile that corresponds to that of human skin for triggering sunburn. This film is covered by a filter system with optical properties that simulate the erythematous response of human skin, in accordance with the reference erythematous action spectrum described in ISO/CIE 17166:2019. The data accumulated (expressed in J/m^2) were normalised to equivalence with a 7-hour workday (the most frequent length of workday among these workers). Transformation into standard erythema dose (SED), the standardised measure of erythemogenic UV radiation (1 SED=100 J/m^2 of effective radiant exposure) was also performed. According to the manufacturer, data reproducibility of the equipment ranges from 5% to 20% (dose-dependent).[18]
- *Personal dosimetry/environmental irradiation ratio*: percentage of personal dosimetry/environmental irradiation median (3 days) was calculated. The exposure ratio represents how directly the dosimeter worn by the worker is exposed to the sun.
- *Dermatological examination:* participants were invited to take a full-body (head, trunk, back, upper and lower limbs) skin exam in a conditioned room to guarantee their privacy. Two experienced dermatologists from the Sun Coast Hospital performed a systematic cutaneous check-up including ocular inspection, dermatoscopy (Dermlite DL100) and Wood's lamp (Dermlite Lumio 2) examination. The specialist used the 'skin cancer form' to record the following information: demographic data, skin cancer risk factors and skin exam findings: presence/absence of solar lentigo, actinic keratosis, atypical nevus, suspected skin cancer. Any participant presenting suspicious lesions was re-examined at the Hospital, where the lesions were biopsied and histologically analysed.

Statistical analysis

In the descriptive analysis performed, measures of central tendency, dispersion and position were obtained for the quantitative variables, and of frequency distribution for the qualitative ones. The data are expressed using mean and SD or median and IQR, according to their distribution. An analysis by subgroups was performed using the Kruskall-Wallis test and the Mann-Whitney U test for the quantitative independent variables; χ^2 test was used for dichotomous (absence/presence) variables. Correlations between the variables were calculated using the Spearman's test. The level of statistical significance was established at $p<0.05$. Statistical analyses were performed using IBM SPSS Statistics (V.22.0 for Windows, IBM).

RESULTS

In total, 169 outdoor workers employed by Fuengirola City Council met the inclusion criteria and began the study. However, 41 were subsequently excluded for one or more of the following reasons: failure to participate in the skin examination (n=16); occupational exposure to UV radiation of <1 hour/week according to the CHACES questionnaire answer (engineers, drafters, technical construction personnel, etc) (n=10);

Table 1 Sociodemographic characteristics and skin type

	Total (n=128)	
	N	%
Sex		
Male	116	90.6
Female	12	9.4
Age		
Mean—SD	*48.5*	*8.7*
Education (1)		
Primary-Secondary	95	74.8
Higher	32	25.2
Occupational group		
Construction and maintenance	64	50.0
Gardening	36	28.1
Urban cleaning	14	10.9
Beach management	14	10.9
Skin colour* (2)		
Very light to light	30	24.2
Intermediate	56	45.2
Dark	38	30.6
Black	0	0
Sun-reactive skin type* (3)		
I–II	23	19.3
III–IV	96	80.7

Missing data: 1=1; 2=4; 3=9.
*Fitzpactrick skin type classification based on the amount of pigment in the skin and its reaction to sun exposure. Skin reactiveness: (I) always burn, never tan; (II) usually burn, tan with difficulty; (III) sometimes mild burn, tan about average; (IV) rarely burn, tan more than average (with ease).

full section of CHACES questionnaire without answer (n=10); profession not included in the CHACES questionnaire (n=5). Thus, 128 workers were included in the final analysis. Of these, 90.6% were male, the mean age was 48.5 (SD: 8.7) years and 25.2% had postobligatory education. The workers were employed in four broad sectors: (1) construction and maintenance (including masons, carpenters, electricians, painters, drivers, engineers, draughts people, mobile machine operators, mechanics and managers); (2) parks and gardens maintenance; (3) urban cleaning personnel, including operators and drivers; (4) beach cleaning, maintenance and surveillance.

By skin colour, 24.2% were very light-skinned or light-skinned and 19.3% are classed as sensitive skin type in terms of reactivity (I–II) according to Fitzpatrick classification (table 1).

Dosimetry

The personal dosimetry was performed between 18 and 21 June 2019, which were cloudless days with a maximum UV index median of 9.3 (range (8.8–9.8), SD: 0.41). During the 4 days when the dosimetry was performed, the median values of solar irradiance were 5672 J/m^2 (SD: 216) for the entire day, from sunrise to sunset. The participants worked either morning (07:00–14:00 hours) or afternoon shifts (13:00–20:00 hours), and therefore the potential irradiance was calculated for each one. The value obtained for the afternoon shift was 1.8 times greater than that for the morning (4180.3 J/m^2; SD: 84.8 vs 2275.5 J/m^2; SD: 158.6) (online supplemental table 1).

The personal dosimetry values obtained by 20 workers (table 2 and online supplemental table 2) revealed a median effective dose during the working day of 379.4 J/m^2 (IQR: 242.6) equivalent to 3.8 SED, with a maximum of 730.7 J/m^2, 7.3 SED. The

Table 2 Dosimetry results, by professional group

Professional group	Dosimetries assessed		J/m^2		SED	
	N	%	Median	IQR	Median	IQR
Construction and maintenance	7	35.0	312.00	352.40	3.13	3.53
Gardening	4	20.0	373.50	295.60	3.74	2.96
Urban cleaning	4	20.0	371.50	309.30	3.72	3.11
Beach management	5	25.0	405.30	283.50	4.07	2.82
All	20	100.0	379.40	242.60	3.80	2.43

Normalised dose for a 7-hour workday.
SED, standard erythema dose.

beach workers recorded the highest levels (405.3 J/m^2, IQR: 283.50) and maintenance and construction workers, the lowest (312 J/m^2, IQR: 352.4). The afternoon shift workers presented higher levels (523.3 J/m^2, IQR: 299.60) than those who worked in the morning (313.3 J/m^2, IQR: 223.9). There were no significant differences between the different professional categories (p=0.875), or between the work shifts (p=0.0983).

We also calculated the exposure ratio (relation between environmental dosimetry values and those obtained by personal dosimetry) obtaining 13.76% for those who worked the morning shift (n=15) and 12.5% for those in the afternoon shift (n=5) and 13.44% for the whole population.

Skin examination

Of the 128 participants who agreed to have a dermatological check-up, 6 (4.7%) indicated they had a personal history of skin cancer (1 melanoma and 5 carcinomas). The skin examination revealed the presence of actinic lentigines in 102 (79.7%) workers, actinic keratoses in 11 (8.6%) and suspected skin cancer in 8 (6.2%). These suspected cases were analysed by biopsy, which confirmed four cases of BCC and one of SCC (3.9%). The distribution of detected lesions (actinic keratosis and suspected skin cancer) across professional groups did not reveal a significant association (online supplemental tables 3 and 4).

Solar exposure and photoprotection practices

In relation to sun exposure, the respondents of CHACES questionnaire work outdoors an average of 33.2 (SD: 10.8) hours/week (of the total 35–40 hours), and had been doing so, on average, for 24.6 (SD: 10.0) years. In their leisure time, outdoor activities were practised for 12.3 (SD: 7.7) hours/week. Thus, average total outdoor solar exposure was 45.5 hours/week (table 3). Half of these workers (95% CI: 40.9% to 59.1%) had suffered at least one sunburn during the last year.

Among the photoprotection practices commonly adopted, long trousers were worn by 85% of participants and sunglasses by 65.3%, the latter especially by beach workers (92.9%), compared with 57.9% of construction workers (p=0.014) and 50.0% of cleaning workers.

By contrast, only 16.7% habitually sought shelter in the shade. In this respect, there were no significant differences among the different occupational groups. Similarly, only 20.3% took care to avoid solar exposure during peak sun hours (11:00 to 16:00 hours). However, in this case there were significant differences between groups, from the 69.2% of cleaners who avoided peak sun hours (p<0.001) to the 16.9% of the construction and maintenance group and to the 2.9% of gardeners (p=0.04).

Table 3 Sun exposure habits and protection practices

	Total (n=128)		Construction and maintenance (n=64)		Gardening (n=36)		Urban cleaning (n=14)		Beach management (n=14)	
	N	%	N	%	N	%	N	%	N	%
Outdoor activity										
Years of work experience (1) (mean—SD)	*24.6*	*10.0*	*27.5*	*9.9*	*22.3*	*9.2*	*22.0*	*9.7*	*20.1*	*9.2*
Weekly hours worked (2) (mean—SD)	*33.2*	*10.8*	*31.4*	*11.6*	*35.9*	*5.9*	*36.2*	*13.4*	*31.2*	*12.3*
Weekly leisure hours (3) (mean—SD)	*12.3*	*7.7*	*12.7*	*7.1*	*12.6*	*9.3*	*9.4*	*6.9*	*12.2*	*6.1*
Sunburn events in last year (4)										
No	63	50.0	27	43.5	18	50.0	8	57.1	10	71.4
Yes	63	50.0	35	56.5	18	50.0	6	42.9	4	28.6
SPP: when I can, I stay in the shade (5)										
Never-arely-Sometimes	95	83.3	48	84.2	29	90.6	8	57.1	10	90.9
Usually-Always	19	16.7	9	15.8	3	9.4	6	42.9	1	9.1
SPP: I wear sunglasses (6)										
Never-Rarely- Sometimes	41	34.7	24	42.1	10	27.8	7	50.0	1	7.1
Usually-Always	79	65.3	33	57.9	26	72.2	7	50.0	13	92.9*
SPP: I wear a wide-brimmed hat (7)										
Never-Rarely-Sometimes	88	79.3	43	76.8	28	80.0	9	81.8	8	88.9
Usually-Always	23	20.7	13	23.2	7	20.0	2	18.2	1	11.1
SPP: I wear a long-sleeved shirt/T-shirt (8)										
Never-Rarely-Sometimes	77	67.0	38	66.7	27	77.1	5	41.7	7	63.6
Usually-Always	38	33.0	19	33.3	8	22.9	7	58.3	4	36.4
SPP: I wear long trousers (9)										
Never-Rarely-Sometimes	18	14.8	8	13.1	5	14.3	3	25.0	2	14.3
Usually-Always	104	85.2	53	86.9	30	85.7	9	75.0	12	85.7
SPP: I use sunscreen (10)										
Never-Rarely-Sometimes	79	66.9	47	82.5	19	54.3	9	69.2	4	30.8
Usually-Always	39	33.1	10	17.5	16	45.7*	4	30.8	9	69.2*
SPP: I stay out of the sun between 11:00 and 16:00 hours (11)										
Never-Rarely-Sometimes	94	79.7	49	83.1	33	97.1	4	30.8	8	66.7
Usually-Always	24	20.3	10	16.9	1	2.9*	9	69.2*	4	33.3
SPF used (12)										
<30	47	39.2	31	51.7	12	35.3	3	23.1	1	7.7
30 or more	73	60.8	29	48.3	22	64.7	10	76.9	12	92.3*
SPP: I reapply sunscreen (13)										
Every 2 hours or more	72	74.2	26	57.8	24	85.7	11	91.7	11	91.7
Every hour or less	25	25.8	19	42.2	4	14.3*	1	8.3	1	8.3

Missing data: 1=3; 2=1; 3=3; 4=2; 5=14; 6=7; 7=17; 8=13; 9=6; 10=10; 11=10; 12=8; 13=31.
Regular/Habitual use (usually-always); infrequent use (never-rarely-sometimes).
*P<0.05 with respect to the construction and maintenance group.
SPF, sun protection factor; SPP, sun protection practice.

Among the study participants, few habitually wore a wide-brimmed hat or long-sleeved shirt/T-shirt (20.7% and 33.0%, respectively).

Finally, only 33.1% regularly used sunscreen during the working day, although this practice was significantly more common among garden workers (49.7%; p=0.007) and beach workers (69.2%; p=0.001) compared with builders (17.5%). While 60.8% of the workers used sunscreen with sun protection factor (SPF) >30, especially beach workers (92.3%; p=0.01), only 25.8% reapplied the sunscreen hourly during sun exposure. This value was even lower for gardeners (14.3%; p=0.025), urban cleaners (8.3%) and beach workers (8.3%).

Attitudes

Regarding attitudes towards sun exposure (table 4), a minority of those surveyed stated that they liked sunbathing (28.3%), being tanned (32.5%) and that sunbathing was good for them (33.9%). Regarding protective attitudes against harm from sun exposure, 90.0% acknowledged the value of using sunscreen and only 22.5% reported that they did not like using it; 83.7% of the participants found it easy to protect themselves from the sun with a hat and suitable clothing, and 92.6% preferred being in the shade. More than 90% were concerned about harmful effects such as burns, accelerated ageing or skin cancer.

Knowledge

Regarding their knowledge of UV radiation and health, these outdoor workers obtained an average score of 6.23 (SD: 1.4) points out of a maximum of 10. Three of the 10 items on knowledge of photoprotection were answered correctly by <33% of the outdoor workers (table 5).

Table 4 Attitudes towards sun exposure, among all respondents.

Statements (I agree)	Total (n=128) N	%
I like sunbathing (1)	34	28.3
I like to be tanned (2)	39	32.5
Sunbathing makes me feel good (3)	40	33.9
I don't like using sunscreen (4)	27	22.5
It's a good idea to use sunscreen (5)	108	90.0
At midday, I'd rather stay in the shade than be in the sun (6)	112	92.6
When I'm sunbathing, I worry about getting burned (7)	110	90.2
I'm worried about the spots and wrinkles I may get from the sun (8)	110	90.2
I'm worried I may get skin cancer from the sun (9)	121	96.8
It's easy to protect yourself from the sun by wearing a hat and suitable clothing (10)	103	83.7
Frequency and percentage of responses "I agree" or "I totally agree". Missing data: 1=8; 2=8; 3=10; 4=8; 5=8; 6=7; 7=6; 8=6; 9=3; 10=5.		

DISCUSSION

To our knowledge, this is the first study carried out to evaluate the sun exposure, sun protection practices and actinic damage among outdoor workers in Spain. The study was carried out in Andalusia, one of the most populated and sunniest regions in Spain, where annual UV index values are among the highest in Europe.[19] The study results highlight a number of risk factors for the development of the photoinduced skin cancer to which these outdoor workers are exposed, and the need to implement effective strategies for occupational photoprotection and the early detection of skin pathologies. The study findings also indicate areas of key importance for the design of future educational interventions aimed at populations at risk.

The European Agency for Safety and Health at Work defines outdoor workers as those whose professional activity takes place outdoors for 75% of the working day.[20] In our study population, the workers spent 83% of their working day outdoors and on average had over 20 years' experience in this field.

Table 5 Knowledge about photoprotection, among all respondents

Knowledge (correct responses)	Total (n=122) n	%
1. The use of UV cabins before the age of 30 increases the risk of melanoma by 75%.	59	48.4
2. UV radiation accelerates skin ageing and causes various forms of skin cancer.	114	93.4
3. There is no risk of harm from solar radiation if you stay in the shade.	60	49.2
4. Using sunscreen is the best way to protect yourself from the sun and to prevent skin cancer.	29	23.8
5. Once the skin has tanned, sunscreen is no longer necessary.	103	88.4
6. Babies under 1 year old should not be exposed to direct sunlight.	112	91.8
7. Extreme measures of sun protection should be adopted when the UV index is >3.	100	82.0
8. Dark clothes gives more protection from the sun than light clothes.	40	32.8
9. The skin should be exposed to at least 1 hour of sun a day to ensure adequate levels of vitamin D.	40	32.8
10. Children should use sunscreen with SPF of at least 30.	103	84.4
Total number of correct responses (0–10)		
Mean—SD	*6.23*	*1.4*
*Individual unanswered questions are counted as 'incorrect'. SPF, sun protection factor.		

Corroborating previous research, the results obtained in our dosimetry study show that these outdoor workers received biologically harmful doses of UV radiation during their working day. All participants exceeded the limit of 1.3 SED or 0.3 minimal erythema dose for Fitzpatrick phototype II=250 J/cm^2[21] after 8 hours' occupational exposure, as recommended by the International Commission on Non-Ionizing Radiation Protection.[22]

In the early 2000s in Australia, the average daily dose of SED received by workers was 4.53 SED, rising to a maximum of 9.9 SED.[23] Comparable results have been obtained in more recent studies from Europe.[24–26] In 2018, Modenese *et al* conducted a comprehensive review of studies related to UV radiation exposure and the consequent skin damage suffered by outdoor workers, showing that dosimetry levels measured in Spain are, in general, higher than those obtained at other latitudes.[27]

Serrano *et al* studied construction workers in Valencia (Spain), monitoring sun exposure by the same methods as in our work, and concluded that the mean level received was 6.1 SED,[12] which is somewhat higher than our finding. Another study, performed in 179 outdoor workers in Canada, reported an average exposure of 1.93 SED (range: 0.03–16.63) and maximum values for maintenance and landscaping workers (2.64 SED).[28] In our study, the highest values were obtained for beach workers (4.04 SED), ahead of those in gardening (3.74 SED) and construction and maintenance (3.13 SED).

In another study, as an important contribution, the authors suggested that sun exposure could be reduced substantially by implementing rational, strategic interruptions to the working day. If performed optimally, this approach could achieve a reduction of 0.18 SED per hour, a total of 15.9% less sun exposure during the day.[29]

The environmental dosimetry in a given location reflects the potential exposure that the workers would receive if exposed directly and perpendicularly to the sun during the entire working period. Changes in the solar angle as part of the daily cycle, the position and movement of a person create a difference between the environmental measurement and personal dosimetry. Hence, the placement of the personal dosimeter in different areas of the body (head, shoulder, wrist) is of great importance in the ratios obtained. The exposure ratio values we present are consistent with the 13.9% obtained by Serrano *et al*,[12] but higher than the 8.3% obtained elsewhere for environmental agents.[30] Average ratios of 20% (measured on the back) have been reported for workers in New Zealand[23]; 29% (measured on the arm) for Italian grape pickers[31] and 12% (measured on the face) for farmers in Austria.[32]

Despite the following experimental differences between the studies presented: (1) in the use of polysulfone film, biological or electronic dosimeters, the results of which can vary by up to 30%, especially when a high proportion of radiation comes from a wide angular range of the sky[33 34]; (2) in the differing locations for the dosimeter (mainly the head, shoulder or wrist),[25] the findings obtained point in the same direction.

Our study revealed the presence of actinic keratosis in 8.3% of the workers studied, a similar value to that reported in a recent study comparing the actinic keratosis prevalence recorded among outdoor workers (16/155, 10.3%) and indoor workers (4/79, 5.1%) in Denmark.[35] Actinic keratoses are precancerous lesions and risk markers for non-melanoma skin cancer. The skin check-up showed that 3.9% of the workers presented some form of histologically confirmed non-melanoma skin cancer. An additional 4.7% reported a previous history of skin cancer.

According to Butacu *et al*, in comparison with those who work indoors, outdoor workers are at 4.6 times greater risk of developing aggressive forms of non-melanoma skin cancer, and have a 24-fold increased risk of developing non-melanoma skin cancer with poorly defined margins.[36]

According to WHO, employees should use individual UV protection equipment when working outside. The sun protection practices most commonly used by the workers included in our study, namely the use of long trousers and sunglasses, coincide with those described for similar outdoor workers[20] and for physical education teachers,[11] but differ from those reported for outdoor athletes.[37] This discrepancy may be related to the different design of work and sports clothing, and/or the impracticability of wearing sunglasses in certain sports disciplines. In contrast, the scant use of wide-brimmed hats, according to our survey of outdoor workers (20.7%), is striking compared with the 79% value reported in this respect for Canadian construction workers[20] and the 49% for physical education teachers.[11] In our case, less than a third of the workers habitually used sunscreen, with notable differences among the occupational groups. This practice is well accepted among beach workers, but much less so among construction and maintenance workers, whose reported values in this respect are lower than those obtained in earlier research for lifeguards,[10] and lower than those reported for other professional sectors in the same geographical area.[11 38] Finally, although most of the workers who use sunscreen choose one with SPF ≥30, very few systematically renew its application, and so their protection against UV radiation decreases during the working day.

Another significant finding is that the two most effective sun protection practices, namely avoiding sun exposure during the midday period and seeking protection under shade, are the least frequently adopted, by <20% of the workers surveyed. In the latter respect, there were no significant differences between the different professional groups, but the question of avoiding peak sun hours (11:00 to 16:00 hours) revealed a stark contrast; only 2.9% of gardeners did so vs 69.2% of the cleaners. We emphasise the importance of workers making use of shaded areas and of work schedules being designed accordingly, since this factor largely determines the amount of solar radiation received during the working day.

In contrast with the deficits found in sun protection practices, the workers showed favourable attitudes towards photoprotection and acceptable knowledge about UV radiation risks and skin cancer prevention. Moreover, the participants were highly satisfied with the intervention, which suggests that skin cancer prevention programmes in the workplace would be well received.

The findings highlight the need to develop effective strategies for the prevention of skin cancer in the workplace, by reducing the sun exposure among outdoor workers and thus alleviating its well-known negative impact on health.[39] Such strategies should include improved training for outdoor workers, the promotion of safer work environments and of skin check-ups in health surveillance programmes. For risk groups in particular, achieving these health objectives is of crucial importance to reducing the incidence, morbidity and related costs of occupational skin cancer.

Limitations

The multifocal observational design employed is broad-based and assesses the research questions using a variety of methods, including a previously validated questionnaire (CHACES), skin examination by expert dermatologists and objective measurement of environmental and received UV doses according to established methodological standards.

However, our study presents some limitations, chiefly its geographical circumscription to a single municipality, the limited number of participants, the fact that the results are partially based on the content of the self-administered questionnaires and on the participants' accounts of self-perceived variables without collection of the body location of the lesions.

The variability of personal dosimetry results in the same professional category, even in the same shift, limits the reliability of the measurements and highlights the need to control the correct use of measurement instruments in future research.

Future investigation with a large number of participants will be necessary to determine whether comparable findings are obtained in other Andalusian municipalities, or even in the rest of the country, in order to extend our conclusions/recommendations to other contexts.

CONCLUSIONS

This pilot study is the first to integrate evaluation of sun exposure, the photoprotection practices employed and the actinic damage caused to outdoor workers in a municipality in southern Spain. The results obtained highlight the risk of photoinduced skin cancer to which these workers are exposed, due to the high levels of UV radiation received and because their sun protection practices are often inadequate. To extend the research presented in this paper, we intend to conduct a regional-level study of municipal outdoor workers and to pilot intervention strategies based on enhanced training and promoting a safer work environment with respect to protection against UV radiation.

Acknowledgements The authors thank Fuengirola City Council and the outdoor workers who generously collaborated in this study. We also thank ISDIN for providing the free samples of sunscreen that were given to the study participants. We appreciate the support of the Research Unit of the Sun Coast Hospital in the translation of the manuscript.

Contributors Concept and design: MdTM and NB-S. Data collection, analyses and interpretation: MdTM, SA, JA, FR-R, AR, JC-M, VdG-A and NB-S. Drafting of the manuscript: MdTM, FR-R, AR and NB-S. Supervision, critical revision and approval of the manuscript: all authors. MdTM acts as guarantor of this work.

Funding No external funding for this study was received.The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests The authors have no conflict of interest to declare.

Patient consent for publication Consent obtained directly from patient(s).

Ethical approval Approval for this study was obtained from the Sun Coast Research Ethics Committee (April 2019; No. 002_abr19_PI2). The study data were recorded anonymously, in strict accordance with all applicable laws and regulations on data protection and confidentiality. All participants signed an informed consent form before starting the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information.

is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs
Magdalena de Troya Martín http://orcid.org/0000-0003-1098-6195
José Aguilera-Arjona http://orcid.org/0000-0002-1911-111X
Francisco Rivas-Ruiz http://orcid.org/0000-0002-8894-0501
Alba Rodríguez-Martínez http://orcid.org/0000-0002-9652-1550
Guillermo de Castro-Maqueda http://orcid.org/0000-0001-5744-7901
Jacobo Cambil-Martín http://orcid.org/0000-0002-9107-0068
Victoria de Gálvez-Aranda http://orcid.org/0000-0002-5863-495X
Nuria Blázquez-Sánchez http://orcid.org/0000-0003-4055-4174

REFERENCES

1 Lucas R, McMichael T, Smith W. Solar ultraviolet radiation : global burden of disease from solar ultraviolet radiation 2006:viii, 250 p.
2 Leiter U, Eigentler T, Garbe C. *Epidemiology of Skin Cancer. In: Sunlight, Vitamin D and Skin Cancer*. New York, NY: Springer New York, 2014: 120–40.
3 Armstrong BK, Kricker A. The epidemiology of UV induced skin cancer. *J Photochem Photobiol B* 2001;63:8–18.
4 Tejera-Vaquerizo A, Descalzo-Gallego MA, Otero-Rivas MM, *et al*. Skin cancer incidence and mortality in Spain: a systematic review and meta-analysis. *Actas Dermosifiliogr* 2016;107:318–28.
5 de Troya-Martín M, Padilla-España L, Férnandez-Morano T, *et al*. Sun protection habits and attitudes among healthcare personnel in a Mediterranean population. *J Cancer Educ* 2016;31:789–95.
6 García-Harana C, de Gálvez Aranda MV, Blazquez-Sanchez N. Sun Protection Policies and Practices in Preschool and Elementary Schools in Andalusia (Spain). *Journal of Cancer Education* (Published Online First: 6 October 2020).
7 de Troya-Martín M, Delgado-Sánchez N, Blázquez-Sánchez N, *et al*. Skin cancer prevention campaign aimed at beachgoers on the Costa del sol (southern Spain). *Int J Dermatol* 2014;53:e526–30.
8 Gutiérrez-Manzanedo JV, De Castro-Maqueda G, Caraballo Vidal I, *et al*. Sun-related behaviors, attitudes and knowledge among Paralympic sailors. *Disabil Health J* 2021;14:101095.
9 de Gálvez MV, Ruiz Sánchez JM, Navarrete-de Gálvez M, *et al*. Sun exposure risks in athletes who were recipients of solid organ and bone marrow transplants. *J Am Acad Dermatol* 2019;81:253–5.
10 de Troya Martín M, Blázquez Sánchez N, García Harana C, *et al*. "Beach Lifeguards' Sun Exposure and Sun Protection in Spain". *Saf Health Work* 2021;12:244–8.
11 Castro-Maqueda GD, Gutierrez-Manzanedo JV, Fernandez-Santos JR, *et al*. Sun protection habits and sun exposure of physical education teachers in the South of Spain. *Photochem Photobiol* 2019;95:1468–72.
12 Serrano M-A, Cañada J, Moreno JC, *et al*. Solar UV exposure in construction workers in Valencia, Spain. *J Expo Sci Environ Epidemiol* 2013;23:525–30.
13 Serrano MA, Cañada J, Moreno JC, *et al*. Erythemal ultraviolet exposure in two groups of outdoor workers in Valencia, Spain. *Photochem Photobiol* 2009;85:1468–73.
14 Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. *Arch Dermatol* 1988;124:869–71.
15 Blázquez-Sánchez N, Rivas-Ruiz F, Bueno-Fernández S, *et al*. Validation of a questionnaire designed to study knowledge, attitudes, and habits related to sun exposure among young adults: the CHACES questionnaire. *Actas Dermosifiliogr* 2020;111:579–89.
16 Agencia estatal de meteorología (AEMT). Available: http://www.aemt.es/ [Accessed 14 December 2020].
17 Moehrle M, Korn M, Garbe C. Bacillus subtilis spore film dosimeters in personal dosimetry for occupational solar ultraviolet exposure. *Int Arch Occup Environ Health* 2000;73:575–80.
18 BioSense. VioSpor blue line technical data. Available: http://www.biosense.de/blue-e.htm [Accessed on 01 June 2022].
19 European Agency for Safety and Health at Work. *Outlook 1 – new and emerging risks in occupational safety and health*, 2009.
20 Peters CE, Koehoorn MW, Demers PA, *et al*. Outdoor workers' use of sun protection at work and leisure. *Saf Health Work* 2016;7:208–12.
21 Fitzpatrick TB. The validity and practicality of sun-reactive skin types I through VI. *Arch Dermatol* 1988;124:869.
22 The International Commission on Non-Ionizing radiation protection. guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). *Health Physics* 2004;87:171–86.
23 Gies P, Wright J. Measured solar ultraviolet radiation exposures of outdoor workers in Queensland in the building and construction industry. *Photochem Photobiol* 2003;78:342.
24 Boniol M, Koechlin A, Boniol M, *et al*. Occupational UV exposure in French outdoor workers. *J Occup Environ Med* 2015;57:315–20.
25 Kovačić J, Wittlich M, John SM, *et al*. Personal ultraviolet radiation dosimetry and its relationship with environmental data: a longitudinal pilot study in Croatian construction workers. *J Photochem Photobiol B* 2020;207:111866.
26 Grandahl K, Eriksen P, Ibler KS, *et al*. Measurements of solar ultraviolet radiation exposure at work and at leisure in Danish workers. *Photochem Photobiol* 2018;94:807–14.
27 Modenese A, Korpinen L, Gobba F, *et al*. And outdoor work: an underestimated occupational risk. *International Journal of Environmental Research and Public Health* 2063;2018:15.
28 Rydz E, Harper A, Leong B, *et al*. Solar ultraviolet radiation exposure among outdoor workers in Alberta, Canada. *Environ Res* 2020;189:109902.
29 Peters CE, Tenkate T, Heer E, *et al*. Strategic task and break timing to reduce ultraviolet radiation exposure in outdoor workers. *Front Public Health* 2020;8:354.
30 Serrano M-A, Cañada J, Moreno JC, *et al*. Occupational UV exposure of environmental agents in Valencia, Spain. *Photochem Photobiol* 2014;90:n/a.
31 Siani AM, Casale GR, Sisto R, *et al*. Occupational exposures to solar ultraviolet radiation of vineyard workers in Tuscany (Italy). *Photochem Photobiol* 2011;87:925–34.
32 Schmalwieser AW, Cabaj A, Schauberger G, *et al*. Facial solar UV exposure of Austrian farmers during occupation. *Photochem Photobiol* 2010;86:1404–13.
33 Zölzer F, Bauer S. Solar ultraviolet radiation risk Estimates-A comparison of different action spectra and detector Responsivities. *Int J Environ Res Public Health* 2021;18:4887.
34 Strehl C, Heepenstrick T, Knuschke P, *et al*. Bringing light into Darkness-Comparison of different personal dosimeters for assessment of solar ultraviolet exposure. *Int J Environ Res Public Health* 2021;18:9071.
35 Grandahl K, Olsen J, Friis KBE, *et al*. Photoaging and actinic keratosis in Danish outdoor and indoor workers. *Photodermatol Photoimmunol Photomed* 2019;35:201–7.
36 Butacu A-I, Wittlich M, John SM, *et al*. Is occupational skin cancer more aggressive than sporadic skin cancer? *Maedica* 2020;15:155–61.
37 Gilaberte Y, Trullàs C, Granger C, *et al*. Photoprotection in outdoor sports: a review of the literature and recommendations to reduce risk among athletes. *Dermatol Ther* 2022;12:329–43.
38 del Boz J, Fernández-Morano T, Padilla-España L. Skin cancer prevention and detection campaign at golf courses on Spain's Costa del Sol. *Actas Dermo-Sifiliográficas* 2015;106:51–60.
39 John SM, Garbe C, French LE, *et al*. Improved protection of outdoor workers from solar ultraviolet radiation: position statement. *J Eur Acad Dermatol Venereol* 2021;35:1278–84.