Review Article :

Occupational ultraviolet light exposure increases the risk for non-melanoma skin cancer: Systematic Review and Meta-Analysis

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Abstract

Background:

Ultraviolet light (UV) had been found to cause much acute and chronic health burdens on the skin where occupational exposure to sunlight as an outdoor worker and artificial UV is the most common cause of Cutaneous squamous cell carcinoma (SCC). Aims We aimed in this review, to analyse the relationship between occupational exposure to solar UV radiation and the development of cutaneous non melanoma skin cancer (NMSC).

Methods:

Comprehensive electronic search with time and language restrictions was conducted. Several known databases were included Ex: "PubMed, The Cochrane Library, Web of Science" from 2015 to 2020. Depending on PRISMA checklist we will remove duplicates, articles will be screened based on title, abstract, and full text.

Results:

After applying inclusion, exclusion criteria and applying PRISMA strategy, we had gathered 10 studies that had different study designs. The ten studies included 85,423 participants in which 77,896 were cases with a type of NMSC and 7527 participants as a control sample with a mean age of 58.15 years old and gender distribution of 65% were male. It seems that patients with any type of NMSC had been exposed to higher UV radiation than control. This was seen in the incidence of SCC and BCC were patients with high occupational UV exposure.

Conclusion:

We had found a significant positive association between occupational UV exposure and high incidence of NMSC. Moreover, we had found that the knowledge of outdoor workers about this effect and about the correct application of sun protective measures was low and insufficient.

Keyword:

Nmsc, Melanoma, Scc, Bcc, Occupational, Outdoor, Indoors, Knowledge, And Sun Protective Measures

Introduction:

Ultraviolet light (UV) had been found to cause §many acute and chronic health burdens on the eye, immune system and skin where sunburns and photo dermatitis are the most common acute effects while actinic keratosis and different skin cancers are the long-term effects of exposure of UV[1]. Skin cancers are classified into cutaneous malignant melanoma and non-melanoma skin cancer where the last one is considered the most common type of skin cancer and is responsible for one-third of all malignancies diagnosed each year around the world[2,3]. Basal cell carcinoma (BCC) is considered the first most common type of non-melanoma skin cancer. That is followed by Cutaneous squamous cell carcinoma (SCC) , which is considered the second common malignancy causing significant public health problems[4]. The main environmental risk factor for non-melanoma skin cancer is natural ultraviolet light after long-time exposure to sun or due to usage of tanning lamps[5,6]. This exposure includes exposure to the sun radiation due to occupational exposure to sunlight as an outdoor worker and artificial UV as arc welding[7,8]. The level of exposure to sunlight UV radiation is different among individuals due to different geographical locations, types of occupation, duration of outdoor activities, and personal protection against UV radiation. Considering outdoor occupation where workers have to work for long periods under sunlight making them potentially exposed to high levels of UV radiations including agricultural workers, greenkeepers, construction workers, fishermen, sailors, military and police officers, farmers and landscapers[9]. It is found that most of workers experience high levels of chronic work related exposure to solar UV radiation as for example in Germany there are two million individuals working in typical outdoor occupations[7]. Face and arm are the most common sites of having BCC and SCC because there are the most sun-exposed body sites[10,11], which can be protected using some sun protective measures [12]. Today, it is known that sunlight is considered a definite human carcinogen (group 1) where all type of UV radiation is considered as agents that are carcinogenic to human however these results depend on few studies[13].

The incidences of non-melanoma skin cancer have increased steeply during the past fifty years especially in populations with light-skin where the highest incidence had been found in Australia and New Zealand because of having fair skin, high level of UVR, both countries located close to the ozone hole, genetics, age and gender[14,15]. In the Middle East and Africa, there is little data on the incidence of SCC howev-

er, some studies tried to assess its study conducted in northern Jordan finding that the age-adjusted incidence was 14.24 for each 100,000 male population and 4.18 for each 100,000 female population between 1997 and 2001, considering that during the study the incidence decreased between female and increase in male during the period of the study16. In Saudi Arabia, there are no population-based studies conducted to assess the incidence of non-melanoma skin cancer. However, there are studies that showed that SCC is the second most common type of skin cancer with an incidence of 18 % to 42 %[17,18].

Besides the environmental risk factors of SCC, there are many individual risk factors including phenotypic and genotypic were men compared to women are about twice as frequently affected. Moreover, the incidence of SCC is higher in an older population where 80 % of cases occur in people over 60 years. Furthermore, populations with fair skin and light eye and hair colour are at higher risk for SCC and also for BCC[10].

While the biological foundations of the causal role of UV light exposure and the development of non-melanoma are well understood and epidemiological data from several sources provided indirect but considerable evidence that solar UV light exposure is undoubtedly the most common risk factor for both BCC and SCC on the population level, there is an ongoing argument about the relationship between occupational exposure to solar UV light and the risk of cutaneous BCC and SCC [17]. However, most of the conducted studies were old that conducted before 2000, and little systematic review had been conducted to ensure this relation between exposure to sunlight and having NMSC. Therefore, we aimed in this review, to analyse the relationship between occupational exposure to solar UV radiation and the development of cutaneous NMSC depending on newly conducted studies.

Materials and Methods:

This review was reported in the light of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.

Search methods for identification of studies:

A comprehensive electronic search with time and language restrictions was done. Several known databases included: "Google Scholar, PubMed, The Cochrane Library, Web of Science" from 2015 to 2020.

Eligibility criteria and study selection

Inclusion criteria:

- Participants: workers of outdoor occupations or indoor workers in comparison to outdoor ones.

- Studies that assess the level of UV exposure and its relation to non-melanoma skin cancer.
- Observational, retrospective and prospective studies were to be included.
- Published in English.
- Published in a year between 2015 to 2020

Exclusion criteria:

- Trials assess the effect of environmental factors other than UV radiation on the incidence of NMSC.
- Trials assess the effect of individual factors on the incidence of NMSC by exploring the effect of UV radiation.
- Animal studies.
- Reviews or systematic review, meta-analysis studies.
- Unsupported opinion of an expert.
- Replies to the author/editor.
- Books'/conferences' abstracts.
- Published in any language other than English
- Published papers before 2015.

Data analysis:

In Several known databases which were searched Ex: Google Scholar, PubMed, The Cochrane Library, Web of Science. We combined the search terms (non-melanoma, skin cancer, BCC, SCC, ultraviolet, incidence) and limited the study to the English language. Depending on PRISMA checklist we removed duplicates, articles were screened based on title, abstract, and full text. For meta-analysis, we had used software of Comprehensive Meta-Analysis version 3 for the required statistical analysis.

Results:

1.Study selection

The electronic search strategy conducted in this review ended in 115 hits which after removing duplicated reduced to 70 studies. These 70 studies were considered eligible for further evaluation, from which 60 studies were excluded for different reasons as 31 studies based on title and abstract, 17 studies do not relevant to the subject of this study, 3 consider replies of authors, 1 book, 4 systematic reviews and 5 were reviews. In the end, 10 articles were included in the qualitative and quantitative synthesis of the present review (Figure 1).

2.General results:

In table 1, we explore the general characteristics of the ten studies chosen for this review. The studies in this review varied according to their design where there was four population-based case-control studies19-22, two case control studies23,24, two cross-sectional studies25,26, one qualitative study27 and one retrospective28. These studies had been covered different countries as five studies had been

conducted in Germany19,22,25-27, one in France23, one study in Greece24, one in Italy20, one in Canada21, one in Poland28. All had been published as journal papers and/or dissertations in English between 2015 and 2020 (Table 1).

Table 1: General information about individual studies

No	Name of authors	Study design	Residency	Aims
1	J. Schmitt et.al 2018 (1)	population-based case-control study	Germany	To investigate the association between occupational and non-occupational UV-exposure with SCC
2	Savoye, I. et. Al. 2018 (2)	case-control study	France	To quantify the associations between various UV exposures and the risks of melanoma, BCC, and SCC
3	F. Gobba et.al 2019 (3)	population-based case-control study	Italy	To evaluate the incidence of skin cancers due to occupational exposure to UV
4	Cheryl E. Peters et.al. 2019 (4)	population-based case-control study	Canada	quantify the health burden of non-melanoma skin cancers among outdoor workers in Canada.
5	Marc Rocholl et. al. 2019 (5)	A qualitative study	Germany	To investigate outdoor workers' perceptions and attitudes toward the effect of UV
6	Jochen Schmitt et,al 2018 (6)	population-based case-control study	Germany	To investigate to role of occupational and non-occupational UV-exposure concerning the development of basal cell carcinoma
7	Mateusz Szewczyk et.al 2018 (7)	Retrospective	Poland	To assess occupation as a risk factor for the development of high-grade cSCC
8	L. Tizek et.al 2020 (8)	cross-sectional study	Germany	to compare the unique sun exposure patterns and sun protection behaviour of foresters with those of other outdoor workers and their relation to the KC risk
9	Linda Ruppert et. al 2016 (9)	cross-sectional study	German	assess the provision of sun protection measures by the employers in vocational school students for outdoor professions.
10	M. Trakatelli et. al 2016 (10)	case–control study	Greece	To compare outdoor with indoor workers in terms of: (i) skin cancer risk factors, and (ii) risk of developing skin cancer.

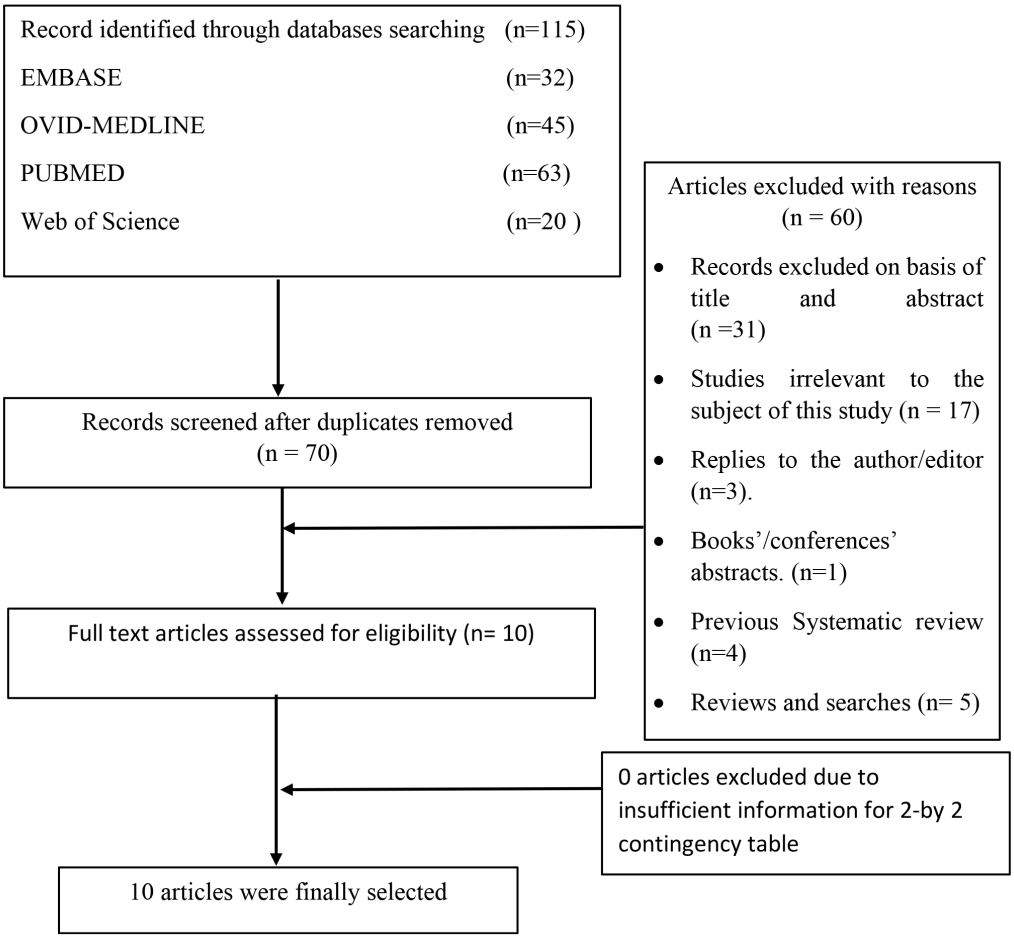


Figure 1The PRISMA figures showing the steps to choose the studies for systematic review.

3.Results of individual studies and synthesis of result:

In Table 2, showed the individual characteristics of each study. In this review, we concluded ten studies that included 85,423 participants of which 77,896 were cases with a type of NMSC and 7527 participants as a control sample. The mean age of all populations in the studies indicated the age was 58.15 years old as the mean age of participants in cases population was 56.6 with a standard deviation of 19.05 while the mean age of control cases was 59.62 with a standard deviation of 11.9 years. Male represent 65 % of a total sample where they represent 71.8 % of cases and 60.3 % of control. Four studies study the effect of occupational UV exposure on developing NMSC1-4, three studies study the effect on SCC1,5-7, two studies dealing with BCC1,8, two studies deal with KC1,9 and two studies studied the perception of workers and students about the effect of occupational UV exposure and risk for NMSC and the useful of usage of sun protective measure7,10. The mean lifetime

occupational UV radiation exposure of cases was 2209.361 with a standard deviation of 413.23 compared to 1518.85 with a standard deviation of 78.559 in control participants. Moreover, the prevalence of exposure to natural UV-radiation was 8.9 %: 13.8 % in cases compared to 11.3 % in control and the prevalence of exposure to artificial UV-radiation was 6.6 % in cases compared to 7.7 % in control. The prevalence of SCC was higher in the cases group than in the controls group when comparing those exposed to the highest UV-exposure5, and the same was found in BCC risk when comparing individuals who had high occupational UV exposure to those with low or moderate exposure8. Moreover, it is was found that patients with high occupational UV exposure or those who have more than 90 % of their occupational time in the exposure of UV radiation more than 18,000 SED had 2 fold increase risk for both SCC and BCC compared to those exposed to low level of UV-exposure5,8. Furthermore, it was noticed that outdoors workers had more signs of simple photodamage (78.7 % compared to 65.5 % in indoors workers), and 37.7 % of outdoor workers had more than two skin cancers during their life compared to 28.6 %.

1: Characteristics of each study

No	Authors	Sample characteristics		Control		Variable	Type of cancer	Results
		N (Age)	lifetime occupation	N (Age)	lifetime occupation			
1	J. Schmitt et.al 2018 (5)	632 (71.2)	Average lifetime occupational UV-exposure = 2,520.8 SED	996 (69.7)	Average lifetime occupational UV-exposure =1,576.4 SED	Total solar UV-exposure (occupational and non-occupational UV-exposure)	SCC	1. The incidence of SCC was higher in cases than control group 2. The risk of SCC in patients with high occupational UV- exposure was twice
2	Savoye, I. et. al 2018 (1)	1558 (68)		3,647		direct comparison of exposure profiles associated with different types of NMSC	Melanoma, BCC and SCC	1.A history of severe sunburns <25 years was associated with increased risks of all skin cancers 2.high-sun protection factor sunscreen use before age 25 was associated with lower BCC risk 3.There were positive linear associations between total UV score and risks of BCC and SCC not melanoma
3	F. Gobba et.al 2019 (2)	295				compared the number of reported skin cancers for outdoor workers with the expected numbers, obtained from currently available NMSC incidence rates	NMSC and AK	1.The incidence of NMSC increased from 25 cases in 2012 to 47 in 2017 and the conditions of these patients were linked to their occupational UV-exposure
4	Cheryl E. Peters et.al. 2019 (3)	72245	exposure prevalence of 8.9%			Exposure levels occupation, sex	NMSC	1.6.31% (4556 cases) of non-melanoma skin cancer cases were estimated to be attributable to occupational exposure to solar ultraviolet radiation.

No	Authors	Sample characteristics		Control		Variable	Type of cancer	Results
		N (Age)	lifetime occupation	N (Age)	lifetime occupation			
5	Marc Rocholl et. al. 2019 (10)	7 (39 year)	Mean hours working outdoor per week during summer (44.7 h)					1.underestimation of the perceived skin cancer risk in the seven outdoor workers and heterogeneous attitudes toward the usage of sun-protective measures.
6	Jochen Schmitt et,al 2018 (8)	836 (66 y)	lifetime occupational UV-exposure was 1,936.4 SED	836 (66 y)	lifetime occupational UV-exposure was 1,463.3 SED	occupational and non-occupational UV-exposure dosages	BCC	1.Individuals with high levels of occupational UV-exposure were at significantly increased BCC-risk compared to individuals with low 2.Non-occupational UV exposure was not independently associated with BCC.
7	Mateusz Szewczyk et.al 2018 (6)	256 (75 y)				Indoor working / out door working Age Gender	cSCC	Outdoor workers were significantly more likely to have a G3 tumour than a G1 tumour. By contrast, there were no G3 tumors within the indoor workers subset
8	L. Tizek et.al 2020 (9)	406 (46.8 y)		185 (42.8 y)		Foresters compared to other professionals	KC	1.Having an outdoor profession or spending hours outside for leisure was negatively associated with sun protection. 2.Skin examination revealed an overall KC prevalence of 16.7%, with 16.5% of foresters being affected.
9	Linda Ruppert et. al 2016 (7)	245 (21 y)				Sun screen measures	cSCC	Overall, 37.3 % (n = 91) of the participants regarded their current protection against solar UVR as insufficient, whereas 32.0 % (n = 78) did not know whether their sun protection measures were adequate.
10	M. Trakatelli et. al 2016 (4)	1416 (66.5 y)		1863 (60 y)			NMSC	1.Outdoor workers had more signs of photodamage (78.1% vs. 65.5%) and among the skin cancer patients, 37.7% of outdoor workers vs. 28.6% of indoor workers had ≥2 skin cancers diagnosed during their lifetime.

of indoor workers4. Moreover, it is found the outdoor workers were significantly more likely to have an advanced type of tumours than those with indoor works where patients working outdoors had 4 times greater risk of developing G2 or G 3 tumour compared with no cases of G3 in indoor workers6. However, it noticed that the risk depends on the duration of UV-radiation exposure or accumulation of sun exposure as only exposure of 5 or more years of work outdoors showed a significantly increased risk for all skin cancer4. Moreover, a study had found that a

history of severe sunburn for less than 25 years of sun exposure was associated with increased risk for all types of skin cancer. For example, 2.7 times increase in melanoma, 1.7 times increase in BCC and 2 times increase in SCC. However, sunburn more than 25 years of sun exposure was associated with increasing in the risk for only BCC and SCC[1]. Moreover, no studies had found a correlation between non-occupational UV exposure and BCC or NMSC other8. While age was significantly associated with developing advanced G3 tumour as the risk increased by 1.06 per year after 72 years, however gender had no effect6. Farmers, construction laborers and landscapers are the typical jobs in the high exposure category, while operators of heavy equipment, couriers and carpenters are in the moderately exposed and drivers, educators and other jobs are classified as low exposure category. Therefore, industries were the most common carriers in which the number of cases increase followed by agriculture, construction and transportation9. In the study of J. Schmitt et. al. individuals who had high levels of occupational UV exposure had a significantly higher risk of BCC than those who had low occupational UV exposure with OR equal to 1.84 with 95 percent -CI 1.19-2.83. However, in the same study, BCC was not found to be linked to non-occupational UV exposure. Furthermore, in the study of Peters et. al. in Canada found that occupational exposure to solar UV radiation was attributed to being responsible for 6.31 percent (4556 cases) of non-melanoma skin cancer cases with Most of them being involved in outdoor occupations such as agriculture or construction3,8. Therefore, we could find that having outdoor work or spending outsides for a long time has an adverse effect on sun protection and increase the rate of NMSC9. Moreover, the reported cases of NMSC have been in an increasing rate as found that the reported cases of NMSC in Italy increased from 25 cases in 2012 to 47 in 2017 which mean that the increase in cases was by 31 % every year[2]. Considering knowledge of outdoors workers about the effect of sun exposure on developing NMSC, we found that most cases underestimate this risk therefore we most of them did not use sun-protective measures and almost a third of them did not know how to apply the proper sun protection measures[7,10]. However, it was found that high-sun protection factor sunscreen uses before age 25 was associated with lower BCC risk[1]. This came with the finding that sun protective behaviours were less applied among outdoor workers compared with indoor workers[9].

Discussion:

In this review, we aimed to analyse the

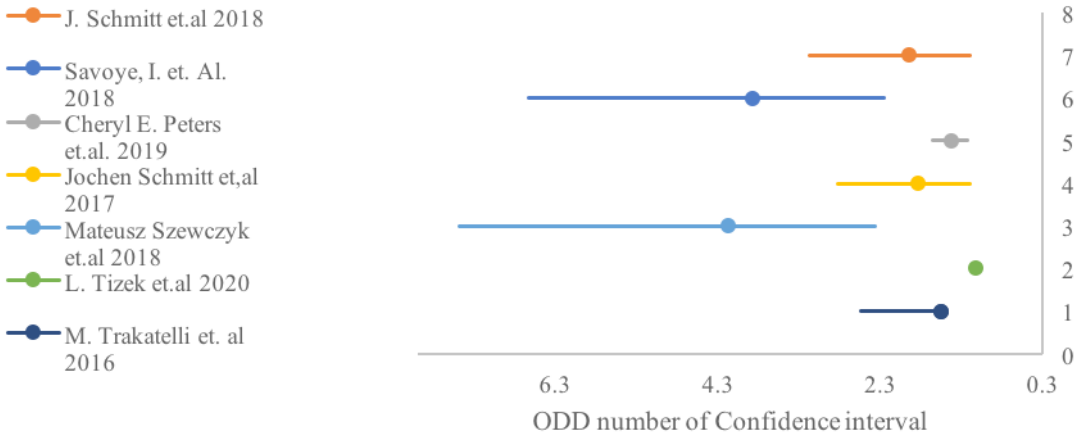
relationship between occupational exposure to solar UV radiation and the development of cutaneous NMSC depending on new studies. After applying inclusion and exclusion criteria and applying PRISMA strategy to choose the studies we had gathering 10 studies that had different study designs and were conducted in 6 different countries in the last five years. The ten studies included 85,423 participants of which 77,896 were cases with a type of NMSC and 7527 participants as a control sample with a mean age of 58.[15] years old and gender distribution of 65 % were male. The high incidence of males in this type of study was because most of the workers outdoor were male as reported by many studies11. Different studies describe occupational UV exposure in different terms while some describe them as standard erythema dosages (SED) and others by the prevalence of exposure. However, the term used in describing the exposure of subjects to UV radiation, it seems that patients with any type of NMSC had been exposed to higher UV radiation than control[12]. It seems that patients with any type of NMSC had been exposed to higher UV radiation than control. This was seen in the incidence of SCC and BCC where patients with high occupational UV exposure or those who have more than 90 % of their occupational time in the exposure of UV radiation more than 18,000 SED had a 2-fold increase risk for both SCC and BCC compared to those exposed to low level of UV-exposure. It noticed that the risk depends on the duration of UV-radiation exposure or accumulation of sun exposure as only exposure to sun radiation for at least five years during outdoor work showed a significantly increased risk for all skin cancer. Industries were the most common carriers in which the number of cases increase followed by agriculture, construction and transportation. Considering the knowledge of outdoors workers about the effect of sun exposure on developing NMSC, we found that the most common reason for not using sun-protective measures is that workers underestimate the importance of it and the risk of exposure to solar radiation.

Many studies are conducted to assess the association between occupational UV radiation and risk for NMSC in outdoor patients however, most of these studies were conducted before the years of 2005. Therefore, in this study we aimed to depend on new studies however, it was few. In similar to our finding, a review conducted by English et. Al 1997, had reported that NMSC risk was higher in outdoor patients[13]. Moreover, one review conducted in 2011 showed a significant correlation between SCC and BCC with occupational UV-exposure (OR of 1.77, 95 % confidence inter-

val 1.4 – 2.22 IN SCC) and (OR 1.43, 95 % confidence interval 1.23-1.66 in BCC)[14]. In another systematic review study conducted in 2011, they raise that most of studies found an increase in the risk of SCC in individuals with occupational UV light compared with those with no occupational exposure to UV radiation[15].

Some studies conducted in Australia, Europe and south and north America showed similar results where some showed a non-significant increase in BCC risk in occupational exposure population while other studies found that this increase is significant with a population who exposed to high UV exposure during their occupation had 1.3 to 4.7 higher risk of BCC[11,12,14,16,17]. Considering the finding that outdoor workers underestimated the effect of UV radiation exposure on the incidence of NMSC, other studies found similar findings as a study of Zink et al among a sample of outdoor workers found that a low-risk perception of skin cancer is associated with insufficient use of protective measures[18].

Figure 2: Odd nmber of relation between the occupational UV exposure and incidence of NMSC



This review has the great advantage of conducting a systematic review among new studies conducted over the last five years to study the effect of occupational UV exposure on the incidence of NMSC. We have discovered that there was a lack of knowledge and practice of sun protection tools, therefore will cause an increase in cases of NMSC among outdoors workers who were exposed to a high levels of UV radiation during their work. We recommend that companies as the industrial, construction and petroleum industries should provide their outdoor workers with

the knowledge and sun protective tools and how to apply them in order to reduce the incidence of NMSC among outdoors workers. The mentioned industries are not the only one to apply this recommendation but they are the most common occupation found in Saudi Arabia.

On the other hand, this review has some limitations, first is that few studies had been included however, this is because of our desire to include only new studies conducted in the last five years. Moreover, all of the studies had been conducted in European countries with no Arabian or Middle East studies therefore, we recommend further investigation to conduct a study to assess the incidence of NMSC among outdoor workers in Saudi Arabia and Arabic countries especially that these countries characteristic with high UV exposure.

Conclusion

We had found a significant positive association between occupational UV exposure and high incidence of NMSC especially SCC and BCC. Moreover, we had found that the knowledge of outdoor workers about this effect and the correct application of sun protective measures was low and insufficient.

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