Original Article

Unraveling the Connection between Occupation, Sun Exposure, and Basal Cell Carcinoma: A Cross-Sectional, Single Center Study

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Abstract

Background: Prolonged sun exposure is a major risk factor for basal cell carcinoma (BCC) due to cumulative UV-induced DNA damage. Studies have shown that outdoor workers face a significantly higher likelihood of developing BCC, with the risk further amplified by inadequate protective measures.

Objective: This study investigates the impact of sun exposure duration and occupational risk on BCC at Dr. Moewardi General Hospital.

Methods: A cross-sectional study was conducted from September to December 2024 involving 78 subjects meeting the inclusion criteria. They were allocated study into two groups, BCC and non-BCC groups. Occupational risk was assessed by type of work, length of work, use of protective equipment, and duration of sun exposure. Sun exposure was expressed in hours/day, p value <0.05 was statistically significant.

Results: There were 32 subjects with BCC and 46 subjects non-BCC. Our analysis obtained that occupational risk in the form of outdoor work type (p = 0.001; OR = 4.85), length of work > 20 years (p = 0.005; OR = 3.81), and use of protective equipment (p = 0.032; OR = 2.74) were associated with the incidence of BCC. The duration of sunlight exposure in the BCC group was found to be longer, at 5.31 hours/day than the non-BCC group, 2.78 hours/day (p <0.001). The ROC curve obtained the cutoff point of sun exposure duration of 3.5 hours / day (p <0.001; OR = 10.12).

Conclusion: Daily sun exposure of 3.5 hours or more, outdoor work, and length of work >20 years, and not using protective equipment during work effect on the development of BCC.

Keywords: BCC, Risk factors, Sun exposure, Occupational risk.

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Introduction

Basal cell carcinoma (BCC) is the most common skin malignancy, typically occurring in sun-exposed areas.[1] It represents 75% of all skin cancers[2] and arises from basal cells in the hair follicle and dermis, leading to local invasion.[3] The global incidence ranges from 4–8%, with higher rates in men and regions with intense sun exposure. In Indonesia, BCC is the most common skin cancer, with a prevalence of 3.8–5.2%.[4] At Dr. Moewardi General Hospital, 182 cases were recorded from 2016–2021, with a prevalence of 0.0091%.[5] Chronic sun exposure, with a latency of 15–20 years, is a key risk factor.[6] Other factors include genetic predisposition and occupational exposure.[7] Indonesia's high Ultraviolet Index (UVI) increases the risk for outdoor workers.[8] The pathogenesis of BCC is multifactorial, with the Hedgehog signaling pathway playing a central role.[4] Clinically, BCC presents in various forms, such as nodular, superficial, and infiltrative, and is diagnosed via dermoscopy and histopathology.[9] Histopathology is ess-

ential for subtype classification. Surgical excision is the first-line treatment.[9] Due to the significant role of sun exposure, protective measures for outdoor workers are vital. This study explores the impact of occupational risks and sun exposure duration on BCC incidence at Dr. Moewardi General Hospital, offering insights for prevention.

Methods

This study is a retrospective cross-sectional study conducted on patients with BCC at the visiting dermatology outpatient clinic of Dr. Moewardi Hospital, Surakarta, Indonesia between September and December 2024. The inclusion criteria were patients aged >18 years and diagnosed with BCC based on clinical and histopathological examinations. Exclusion criteria included patients with incomplete medical records or a history of other skin malignancies.

Demographic data and medical history were obtained from medical records, while information on occupation, protective equipment use, work duration, and sun exposure duration was collected through direct interviews. Data analysis was performed using IBM SPSS version 20, with bivariate analysis conducted using the Chi-square and Fisher's exact tests to assess the significance of risk factors for BCC, along with odds ratio (OR) calculations. The study also employed a Receiver Operating Characteristic (ROC) curve analysis to determine the cut-off value for sun exposure duration based on the highest sensitivity and specificity. A p-value < 0.05 was considered statistically significant.

Results

This study included 32 BCC and 46 non-BCC subjects. Females were more prevalent in both groups, with a male-to-female ratio of 1:1.67 in the BCC group and 1:1.19 in the non-BCC group. The average age was higher in the BCC group (64.03 years) compared to the non-BCC group (46.47 years). Education levels differed, with most BCC patients having only primary school education (43.8%) and the non-BCC group mainly high school graduates (43.5%). Outdoor workers accounted for 65.6% of the BCC group and 28.3% of the non-BCC group.

Table 1: *Characteristics of Study Subjects: This table summarizes the demographic and clinical characteristics of the study participants.*

Characteristic	BCC (n = 32)		Non BCC (n = 46)	
Gender				
Male	13	40.6%	20	43.5%
Female	19	59.4%	26	56.5%
Age (years)	64.03 ± 12.57		46.47 ± 15.86	
Education				
No schooling	5	15.6%	3	6.5%
Primary school	14	43.8%	8	17.4%
Junior high school	6	18.8%	5	10.9%
Senior high school	5	15.6%	20	43.5%
Tertiary education	2	6.3%	10	21.7%
Occupation				
Outdoor work	21	65.6%	13	28.3%
Laborer	10	47.6%	7	53.8%
Farmer	10	47.6%	3	23.1%
Professional worker	1	4.8%	0	0.0%
Employee	0	0.0%	1	7.7%
Motorcycle taxi driver	0	0.0%	1	7.7%
Student	0	0.0%	1	7.7%
Indoor work	11	34.4%	33	71.7%
Merchant	5	45.5%	3	9.1%
Housewife	3	27.3%	7	21.2%
Employee	2	18.2%	14	42.4%
Retired	1	9.1%	2	6.1%
Healthcare worker	0	0.0%	1	3.0%
Teacher	0	0.0%	3	9.1%
Student	0	0.0%	1	3.0%
Unemployed	0	0.0%	2	6.1%
Employment duration				
>20 years	20	62.5%	14	30.4%
<20 years	12	37.5%	32	69.6%
Protective gear use				
Yes	13	40.6%	30	65.2%
No	19	59.4%	16	34.8%
Sunscreen use				
Yes	4	12.5%	18	39.13%
No	28	87,5%	28	60.86%

Among outdoor workers, laborers and farmers represented 47.6% and 47.6%, respectively, in the BCC group, while in the non-BCC group, they

were 53.8% and 23.1%. Indoor workers made up 34.4% of the BCC group and 71.7% of the non-BCC group, with merchants (45.5%) and housewives (27.3%) being the most common in the BCC group. Longer employment duration (>20 years) was more common in the BCC group (62.5%) compared to the non-BCC group (30.4%). Protective gear usage (e.g. hats, sleeves) was reported in 40.6% of the BCC group and 65.2% of the non-BCC group. Sunscreen use was notably lower in the BCC group (12.5%) compared to the non-BCC group (39.13%) **(Table 1).**

The majority of BCC patients had skin type 4 (62.5%) followed by skin type V (31.25%) and 1 patient with type III (6.25). The most common BCC lesion locations being nasal (31.25%) and orbital (21.87%) **(Table 2).** Outdoor occupations increased the risk of BCC by 4.85 times (p = 0.001; OR = 4.85), while not using protective gear raised the risk by 2.74 times (p = 0.032; OR = 2.74), and not using sunscreen increased the risk of developing BCC by 4.89 times (p = 0.0206; OR = 4.89). The average sun exposure was 5.31 hours/day for the BCC group and 2.78 hours/day for the non-BCC group, with a significant difference (p < 0.001), highlighting the strong link between sun exposure and BCC **(Table 3).** Additionally, working in outdoor jobs for 20 years or more increased the risk of BCC by 5.63 times (p = 0.020; OR = 5.63) **(Table 4).**

A receiver operating characteristics (ROC) curve test was then conducted to determine the cutoff

Table 2: *Skin Type and Location of BCC Lesion: This table presents the skin types and anatomical locations where Basal Cell Carcinoma (BCC) lesions were observed among study participants.*

Characteristic	BCC (n = 32)	
Skin Type		
III	2	6.25%
IV	20	62.5%
V	10	31.25%
BCC lesion location		
Nasal	10	31.25%
Frontal	6	18.75%
Orbital	7	21.87%
Buccal	2	6.25%
Zygomaticus	2	6.25%
Infraorbital	2	6.25%
Temporal	1	3.12%
Oral	1	3.12%
Mental	1	3.12%

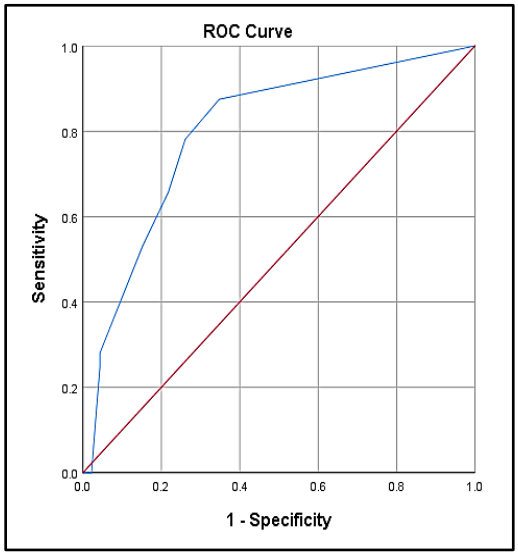

Figure 1: *ROC Curve Test Results: The receiver operating characteristic (ROC) curve illustrates the diagnostic performance of the model used in the study, showing sensitivity, specificity, and accuracy at different thresholds.*

Table 3: *Occupation-Related Risk for the Occurrence of BCC: This table outlines the occupational factors contributing to the risk of developing BCC, including job type, exposure levels, and related risk factors.*

Characteristic	BCC (n = 32)		Non BCC (n = 46)		OR	p-value
Occupation					4.85	0.001*
Outdoor work	21	65.6%	13	28.3%		
Indoor work	11	34.4%	33	71.7%		
Protective gear use					2.74	0.032*
No	19	59.4%	16	34.8%		
Yes	13	40.6%	30	65.2%		
Sunscreen use					4.5	0.0206*
No	28	87.5%	28	60.86%		
Yes	4	12.5%	18	39.13%		
UV exposure duration	5.31 ± 2.17		2.78 ± 2.13			<0.001*

point for sun exposure duration that could lead to BCC. The ROC curve analysis revealed a cutoff point of 3.5 hours/day with a sensitivity of 78.1% and specificity of 73.9% **(Figure 1).**

The cutoff point of 3.5 hours/day was then analyzed to assess its impact on the risk of BCC occurrence **(Figure 2).**

Table 4: *Risk of Prolonged Work Duration and Outdoor Work in the Development of BCC: This table examines the relationship between extended work duration, outdoor occupations, and the incidence of BCC among the study population.*

Characteristic	Outdoor				OR	p-value
	BCC (n = 21)		Non BCC (n = 13)			
Employment duration					5.63	0.020*
>20 years	15	71.4%	4	30.8%		
≤20 years	6	28.6%	9	69.2%		

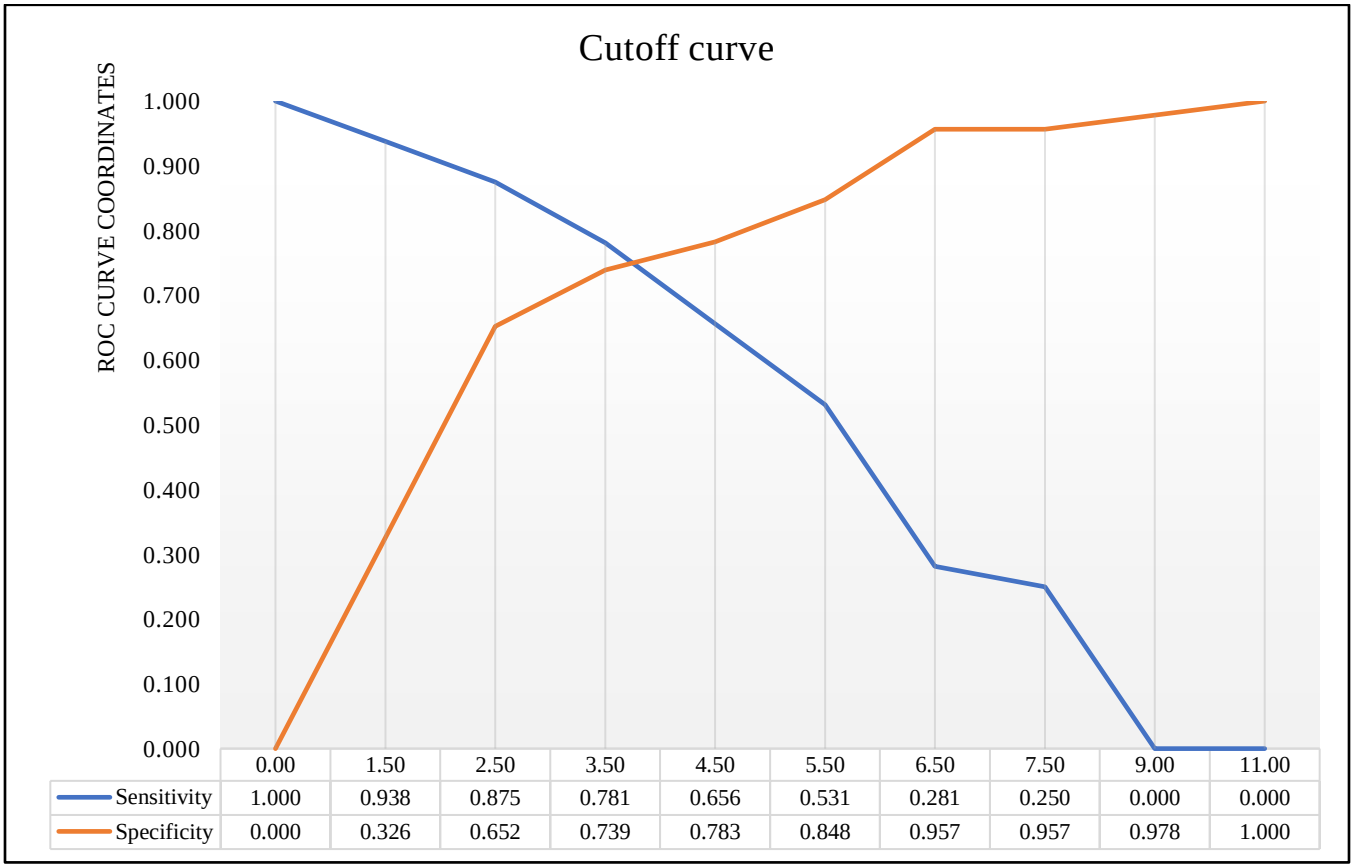

Figure 2: *Cutoff Point Curve Results: This figure presents the cutoff points derived from the data, indicating the optimal thresholds for predicting the occurrence of BCC.*

The data analysis revealed that a duration of sun exposure of 3.5 hours/day or more significantly affects the occurrence of BCC, increasing the risk of BCC by up to 10 times (p = <0.001; OR = 10.12) **(Table 5).**

Table 5: *Sunlight Exposure Duration and BCC Occurrence: This table details the correlation between the duration of sunlight exposure and the occurrence of BCC in the study subjects.*

Parameter	BCC (n = 32)		Non BCC (n = 46)		OR	p-value
Sunlight exposure duration					10.12	<0.001*
<3,5 hours/day	7	21.9%	34	73.9%		
3,5 hours/day or more	25	78.1%	12	26.1%		

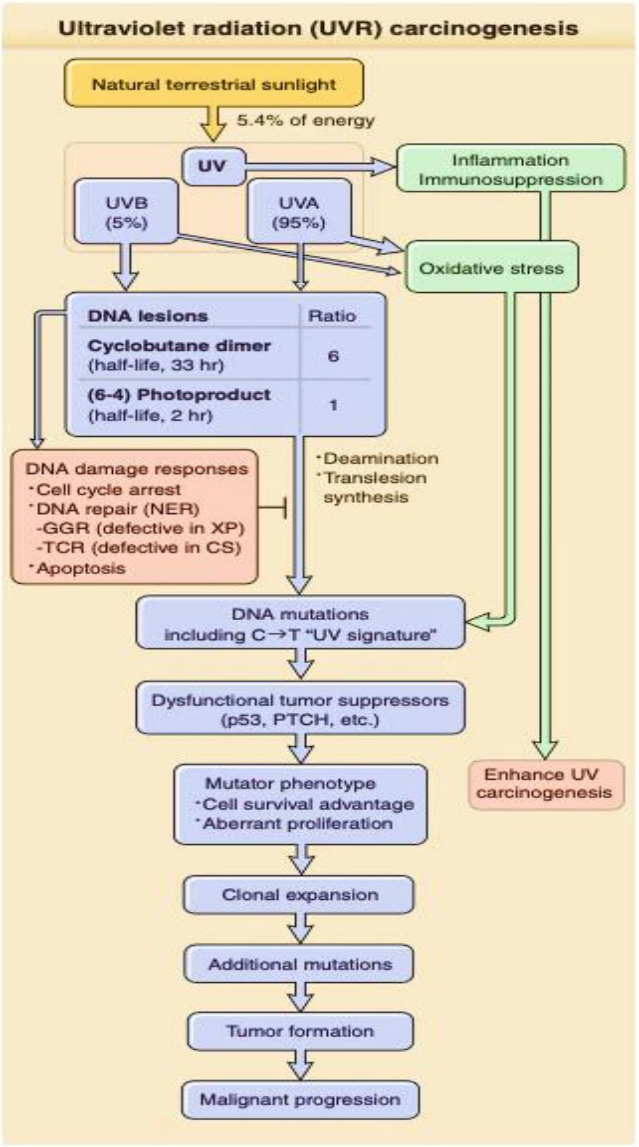

Figure 3: *Ultraviolet Radiation (UVR) Carcinogenesis: This figure depicts the pathway of UV radiation-induced carcinogenesis, illustrating the biological mechanisms leading to BCC development.*[19]

Discussion

Basal cell carcinoma (BCC), the most common skin malignancy and a non-melanoma skin cancer originating from the epidermal basal layer, typically occurs in sun-exposed areas and was first identified in the 1820s.[1,10] In 2019, there were 4 million BCC cases globally, with a 10% annual increase.[11] BCC incidence varies, with rates of 224 per 100,000 in Europe and 16 per 100,000 in Asia.[12] In Jakarta, BCC accounted for 66% of skin cancers in 2019, while a study in Surakarta found 19 cases, predominantly in females.[10,13] In this study, the average age of BCC patients was 64.03 years, with females (59.4%) outnumbering males. Aging reduces DNA repair,[14] but susceptibility to ultraviolet (UV) damage also depends on skin type. While the Fitzpatrick scale suggests that darker skin types (IV–VI) are less prone to skin cancer, it can still occur in these skin types.[15] In this study, most BCC patients had skin type IV (62.5%), followed by type V (31.25%), with one patient having type III.

Ultraviolet B (UVB) radiation from sunlight is the primary cause of BCC by directly damaging DNA in keratinocytes, leading to gene expression alterations that promote cancer. Ultraviolet A (UVA) radiation also produces reactive oxygen species (ROS), which can damage DNA.[16] Sun exposure-induced genetic mutations disrupt the Hedgehog signaling pathway, vital for stem cell maintenance and tissue repair. In BCC, this pathway is aberrantly activated, contributing to tumor formation.[17] UV exposure also likely inactivates the TP53 tumor suppressor gene and activates the RAS proto-oncogene, further promoting carcinogenesis.[18] The pathogenesis of UV radiation carcinogenesis is illustrated in **(Figure 3).**

Indonesia's National Report (April 2024) highlights UV measurements in Bandung and Watukosek, with UV-B irradiance at 280–315 nm. Data from the Automatic Weather Station and Ozone Monitoring Instrument on Aura show UVI ranges from 9 to 13.[8] The Standard Erythemal Dose (SED), measuring erythemally-weighted UV exposure, equals 100 J/m² and is independent of skin type. Minimal Erythema Dose (MED) represents the threshold for skin damage. People with skin types IV or V, common in Indonesia, have a higher MED, tolerating more UV exposure before erythema occurs.[20] However, the high UVI in Java Island, ranging from 7.8 to 13.6 (peaking in October), may exceed the average Indonesian MED.[21] According to the WHO UVI scale, levels 1–2 require minimal protection, while levels 3–7 necessitate shade, protective clothing, and SPF 15+ sunscreen. At levels 8+, extra precautions are needed.[22] Sunscreens include either chemical or physical ingredients that

shield the skin from UV radiation, including UVA, UVB, and UVC rays.[23] Consistent with earlier studies, this study found that not using sunscreen raised the likelihood of developing BCC by 4.89 times ($p = 0.0206$; OR = 4.89).

A 2023 study by Yu et al, in the U.S. and a 2020 study by Cai et al, in Japan both found that outdoor workers have an increased risk of developing BCC, with the latter reporting a 2.18 times higher likelihood.[23] Outdoor jobs involve greater exposure to sunlight compared to indoor jobs, which, combined with lifestyle and genetic factors, increases the risk of BCC.[16,24] This study found that outdoor work increases BCC risk by 4.85 times, and lack of protective measures raises the risk by 2.74 times.

Chronic sun exposure can lead to BCC lesions after years or decades of cumulative cell degeneration.[25] A 2023 study by Lashway et al, found sun exposure increases BCC risk by 1.4 times, while Bauer et al, (2020) reported moderate to high exposure doubles the risk, with chronic exposure over 15 years potentially causing epidermal damage and triggering BCC lesions.[26] This study found that sun exposure of 3.5 hours per day or more increases the risk of BCC by up to 10 times. Additionally, working for more than 20 years was associated with a 5.63 times higher risk of developing BCC. These findings underscore the critical role of prolonged, unprotected sun exposure in the development of BCC, emphasizing the importance of protective measures, particularly for outdoor workers with long-term exposure.

Conclusion

Daily sun exposure of 3.5 hours or more significantly increases the risk of developing basal cell carcinoma (BCC). Engaging in outdoor work, particularly for extended periods exceeding 20 years, further elevates this risk due to prolonged exposure to harmful UV radiation. Not using protective equipment during work hours exacerbates the situation, as it leaves the skin more vulnerable to the damaging effects of sunlight, thereby contributing to the development of BCC.

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Author's Contribution

ND: Conception & design, acquisition of data, drafting of article, analysis & interpretation, critical revision of the article, final approval of the version to be published.

OEP: Conception & design, acquisition of data, analysis & interpretation, final approval of the version to be published.

References

1. Basset-Seguin N, Herms F. Update in the Management of Basal Cell Carcinoma. Acta Derm Venereol. 2020;100(11):adv00140.Doi:10.2340/00015555-3495.
2. Peris K, Fargnoli MC, Garbe C, Kaufmann R, Bastholt L, Seguin NB, et al. Diagnosis and treatment of basal cell carcinoma: European consensus-based interdisciplinary guidelines. Eur J Cancer. 2019; 118:10–34.
3. Lang BM, Balermpas P, Bauer A, Blum A, Brölsch GF, Dirschka T, et al. S2k Guidelines for Cutaneous Basal Cell Carcinoma - Part 1: Epidemiology, Genetics and Diagnosis. J Dtsch Dermatol Ges. 2019;17(1):94–103. Doi: 10.1111/ddg.13733.
4. Kim DP, Kus KJB, Ruiz E. Basal Cell Carcinoma Review. Hematol Oncol Clin North Am. 2019; 33(1):13–24. Doi: 10.1016/j.hoc.2018.09.004
5. Octarica S, Dharmawan N. Profil pasien karsinoma sel basal pasien rawat jalan RSUD dr. moewardi surakarta periode januari 2016 – desember 2021. 2022;1–8.
6. Hasan A, Kandil AM, Al-Ghamdi HS, Alghamdi

MA, Nasr M, Naeem SA, et al. Sun-Exposed versus Sun-Protected Cutaneous Basal Cell Carcinoma: Clinico-Pathological Profile and p16 Immunostaining. Diagnostics (Basel). 2023;13(7). Doi: 10.3390/diagnostics13071271
7. Schierbeck J, Vestergaard T, Bygum A. Skin Cancer Associated Genodermatoses: A Literature Review. Acta Derm Venereol. 2019;99(4):360–9. Doi: 10.2340/00015555-3123
8. Indonesia National Report for the 12 WMO / UNEP Ozone Research Managers Meeting. 2024.
9. Cameron MC, Lee E, Hibler BP, Barker CA, Mori S, Cordova M, et al. Basal cell carcinoma: Epidemiology; pathophysiology; clinical and histological subtypes; and disease associations. J Am Acad Dermatol. 2019;80(2):303–17.
10. Toha SS, Rahman A, Mochtar M, Julianto I, Dharmawan N, Mawardi P, et al. Kejadian Karsinoma Sel Basal di RSUD Dr. Moewardi Surakarta Berdasarkan Subtipe Histopatologi menurut Jenis Kelamin, Usia, Lokasi Anatomi, dan Diameter Tumor. Cermin Dunia Kedokteran [Internet]. 2019 Apr 1;46(4 SE-Articles):256–60. Available from: https://cdkjournal.com/index.php/cdk/article/view/478
11. Zhang W, Zeng W, Jiang A, He Z, Shen X, Dong X, et al. Global, regional and national incidence, mortality and disability-adjusted life-years of skin cancers and trend analysis from 1990 to 2019: An analysis of the Global Burden of Disease Study 2019. Cancer Med. 2021;10(14):4905-4922. Doi: 10.1002/cam4.4046
12. Ibrahim N, Jovic M, Ali S, Williams N, Gibson JAG, Griffiths R, et al. The epidemiology, healthcare and societal burden of basal cell carcinoma in Wales 2000-2018: a retrospective nationwide analysis. Br J Dermatol. 2023 Feb;188(3):380–9. Doi: 10.1093/bjd/ljac090.
13. Wibawa LP, Andardewi MF, Ade Krisanti I, Arisanty R. The epidemiology of skin cancer at Dr. Cipto Mangunkusumo National Central General Hospital from 2014 to 2017. Journal of General-Procedural Dermatology & Venereology Indonesia. 2019; 4(1):11–6.
14. Petr MA, Tulika T, Carmona-Marin LM, Scheibye-Knudsen M. Protecting the Aging Genome. Trends Cell Biol. 2020;30(2):117–32.
15. Goon P, Banfield C, Bello O, Levell NJ. Skin cancers in skin types IV-VI: Does the Fitzpatrick scale give a false sense of security? Skin health and disease. 2021;1(3):e40.
16. Fan W, Rokohl AC, Guo Y, Chen H, Gao T, Kakkassery V, et al. Narrative review: mechanism of ultraviolet radiation-induced basal cell carcinoma. Frontiers of Oral and Maxillofacial Medicine; Vol 5 (March 10, 2023): Frontiers of Oral and Maxillofacial Medicine [Internet]. 2021; Available from: https://fomm.amegroups.org/article/view/55995
17. Patel TN, Dhanyamraju PK. Role of aberrant Sonic hedgehog signaling pathway in cancers and developmental anomalies. J Biomed Res. 2021;36(1): 1–9. Doi: 10.7555/JBR.35.20210139
18. Oh ST, Stark A, Reichrath J. The p53 Signalling Pathway in Cutaneous Basal Cell Carcinoma: An Immunohistochemical Description. Acta Derm Venereol. 2020 Mar;100(6):adv00098. Doi: 10.2340/00015555-3420
19. Kawasumi M, Nghiem P. Ultraviolet Radiation Carcinogenesis. In: Goldsmith LA, Katz SI, Gilchrest BA, et al., eds. Fitzpatrick's Dermatology in Gen-eral Medicine. 8th ed. New York, NY: McGraw-Hill; 2012:1251-1260.
20. Gilaberte Y, Trullàs C, Granger C, de Troya-Martín M. Photoprotection in Outdoor Sports: A Review of the Literature and Recommendations to Reduce Risk Among Athletes. Dermatol Ther (Heidelb). 2022;12(2):329–43.
21. Komala, Ninong. Analysis of Java Island's ozone layer and ultra violet index variability based on satellite data. E3S Web Conf [Internet]. 2019;76: 4001. Available from: https://doi.org/10.1051/e3sconf/20197604001
22. U.S. Environmental Protection Agency. UV Index Scale [Internet]. 2025 [cited 2025 Feb 7]. Available from: https://www.epa.gov/sunsafety/uv-index-scale-0
23. Sander M, Sander M, Burbidge T, Beecker J. The efficacy and safety of sunscreen use for the prevention of skin cancer. CMAJ. 2020 ;192(50):E1802–8.
24. Cai H, Sobue T, Kitamura T, Sawada N, Iwasaki M, Shimazu T, et al. Epidemiology of nonmelanoma skin cancer in Japan: Occupational type, lifestyle, and family history of cancer. Cancer Sci. 2020; 111(11):4257–65. Doi: 10.1111/cas.14619
25. Kasumagic-Halilovic E, Hasic M, Ovcina-Kurtovic N. A Clinical Study of Basal Cell Carcinoma. Med Arch. 2019;73(6):394–8. Doi: 10.5455/medarh.2019.73.394-398
26. Lashway SG, Worthen ADM, Abuasbeh JN, Harris RB, Farland LV, O'Rourke MK, et al. A meta-analysis of sunburn and basal cell carcinoma risk. Cancer Epidemiol. 2023;85:102379. Doi: 10.1016/j.canep.2023.102379.