Innovations, Number 74 September 2023

Innovations

# Assessment of the Influence of Sunlight on the Incidence and Geographical Variability of Skin Cancer in West Africa

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***Abstract:***
*Skin cancer poses a major international public health problem, exceeding 1.5 million new cases annually. Ultraviolet sunlight is the primary external catalyst for skin cancer. This analysis examines the link between solar radiation exposure and skin cancer rates across regions. While UV exposure reliably elevates skin cancer risk, geographical factors like latitude, elevation, and climate underpin variability. The study illuminates determinants of geographical differences and explores the complex interplay between sunlight and skin cancer. Insights can guide tailored interventions and policies to address the rising global skin cancer burden.*

***Keywords:*** *Skin cancer, Ultraviolet radiation, Solar exposure, Geographical factors, Public health interventions*

## Introduction:

Each year, the global tally of newly diagnosed skin cancer cases exceeds 1.5 million, posing a considerable challenge to public health on a global scale. Skin cancer constitutes a significant proportion of cancer occurrences in numerous developed countries. Skin cancer accounts for a significant portion of cancer cases in many developed nations. Though multiple factors can raise one's risk, excessive ultraviolet radiation from sun exposure is the predominant external culprit behind skin cancer's development. To counter this growing threat, decreasing UV exposure through sunscreen use, protective clothing, and avoidance of midday sun is critical. Adopting these preventative measures on a widespread scale will be pivotal to turning the tide against the runaway incidence of skin cancer across America. UV radiation can directly damage skin cell DNA and suppress immune function, promoting malignant transformations. Epidemiologic studies have consistently demonstrated that higher UV exposure from the sun correlates to heightened skin cancer risk. However, the relationship between solar UV radiation exposure and skin cancer incidence rates on a population level is complex, as significant variability is observed geographically. Skin cancer rates can differ substantially depending on latitude and regional environment even at similar levels of ambient solar radiation (Arnold, M., 2022).

This article investigates how exposure to UV radiation impacts skin cancer rates across diverse geographical regions around the world. The aim is to elucidate the determinants behind these geographical differences and why the association between sunlight and skin cancer manifests differently based on location. By analyzing variations in this relationship across regions, we can hope to gain insight into the modulating factors that govern the interplay between solar radiation and carcinogenesis. These insights can then be applied to tailor prevention initiatives and policies by location to better mitigate rising skin cancer occurrence globally.

## Background:

### 1.1 Solar Radiation and Skin Cancer:

Extensive research has established ultraviolet radiation, particularly UVB wavelengths from sunlight, as a major contributor to skin cancer. UVB can directly damage DNA by creating thymine dimers and other mutations that disrupt DNA structure and function if not repaired. Additionally, UV acts as an immunosuppressant by impairing skin immune cells like Langerhans cells, enabling malignant cells to go undetected. Animal and lab studies have provided biological evidence for these DNA damage and immunosuppression mechanisms that link UV to skin cancer (Gallagher R.P., et al, 2010).

Numerous epidemiological studies utilizing a variety of methodologies have consistently shown a clear association between increased exposure to ultraviolet radiation and heightened risk for all major skin cancer types - basal cell carcinoma, squamous cell carcinoma, and melanoma. When experimental research is viewed in combination with observational data, the collective evidence strongly supports ultraviolet radiation as a primary causal factor driving skin cancer development. The uniformity and breadth of findings decisively show that UV light exposure has a pivotal role in the process of skin carcinogenesis. The extensive epidemiological literature exhibits a distinct connection between higher UV levels and heightened skin cancer risk. The relationship is evident across numerous studies utilizing varied approaches. Differences do exist in the relative risk conferred by UV exposure for each skin cancer type. For instance, some studies have found UV radiation to have a stronger association with increased basal cell carcinoma risk compared to cutaneous malignant melanoma risk. However, UV exposure remains an undisputed predominant risk factor for skin carcinogenesis overall based on the accumulated human evidence. Quantifying cumulative UV dose and age at exposure can further modulate cancer risk. Given the extensive body of research, public health organizations such as the WHO and IARC emphasize safe UV exposure as a key prevention priority to reduce skin cancer burden (Bannister-Tyrrell M., &Meiqari L., 2020).

### 1.2 Geographical Differences in Solar Radiation:

Ultraviolet (UV) radiation exposure varies markedly across different places on Earth. Local factors including latitude, elevation, and climate determine the level of UV irradiation in a region. Areas around the equator, bounded by the Tropics of Cancer and Capricorn, get consistently higher UV radiation all year. The more direct sun angle at low latitudes leads to more intense surface UV. Exposure differs substantially by geographic location, with equatorial regions having the greatest risk. In contrast, more temperate regions farther from the equator experience substantial seasonal fluctuations in UV exposure. Temperate latitudes receive maximal UV radiation during summer months when daylight hours are longer (WHO, 2016).

Altitude also influences surface UV, with higher elevation regions receiving greater UV radiation. For every 1000 meters increased in altitude, UV levels increase by 10-12%. The shorter distance UV needs to travel through the atmosphere lessens scattering and absorption. Local climate also modulates surface UV. Cloud cover can attenuate radiation, while pollution and particulate matter may absorb and scatter UV. Ozone concentration directly impacts UV absorption, with depletion of the ozone layer demonstrated to increase UV penetration, particularly over Polar regions. Quantifying these geographic and regional differences in solar UV radiation reaching the Earth's surface allows us to account for variability in UV exposure on a population level when studying the relationship between sunlight and skin cancer rates (USEPA, 2010).

### 1.3 Regional Skin Cancer Incidence:

The incidence rates for different skin cancer types exhibit significant geographic variation worldwide. For keratinocyte cancers like basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), the highest incidence rates are generally observed in fair-skinned populations living at low latitudes/near the equator where UV exposure is highest. Australia is a prime example, having the highest BCC and SCC incidence rates globally. In contrast, regions with darker-skinned populations centered farther from the equator tend to have lower incidence of BCC and SCC.

However, this latitude-based pattern is not seen with cutaneous malignant melanoma. While melanoma risk is still greater in those with fair skin, some countries at higher latitudes such as Norway, Sweden, and Denmark exhibit incidence rates comparable to those observed in Australia nearer the equator. This suggests factors beyond just UV radiation influence melanoma's regional incidence. One hypothesis is that while continuous high ambient UV may be melanoma-protective, countries at higher latitudes have an increased risk due to intermittent UV exposure leading to sunburns. Additional genetics, host factors, and behavioral variables likely contribute to the unique geographic distribution of melanoma worldwide compared to keratinocyte cancers (Leiter U., 2020).

Understanding how both environmental UV radiation exposure and ethnicity/pigmentation align with regional skin cancer incidence rates allows us to uncover nuances in these relationships. The geographic patterns provide clues into disease mechanisms and risk modifiers that can be further investigated to explain observed variability (Jablonski N.G., and Chaplin G., 2010). This knowledge can then be applied to tailor prevention strategies accordingly for a given area.

## 2. Methodology

The aim of this study was to investigate the effect of sunlight on skin cancer incidence in different regions of West Africa. A cross-sectional research design was used to collect and analyze quantitative data. The study sample include a diverse population from different countries, urban and rural areas, and varying sun exposure Skin cancer patients from hospitals were recruited as cancer cases, and individuals without skin cancer were used as the control factors. Solar radiation data were obtained from reputable weather agencies and satellite sources, providing daily and monthly solar radiation and UV index for each location in West Africa Skin cancer data were collected from hospitals, cancer registries and health centers in selected areas. Data analysis included descriptive statistics, correlation analysis, GIS mapping, and more regression to look at the relationship between sunlight and skin cancer incidence, and to look for possible confounding factors which aimed at raising awareness among policy makers, health professionals and the general public about the impact of sunlight on skin cancer in the region.

2.1 Data Collection: To analyze geographical variations, skin cancer incidence data was obtained from international cancer registries. Solar UV indices were derived from satellite measurements and ground monitoring stations.

2.2 Statistical Analysis: Age-adjusted incidence rates were calculated and correlated with mean annual UV indices for each region using linear regression modeling. Relative risk ratios were computed to quantify effect sizes.

## Results:

3.1 Regional Correlations: Positive correlations emerged between UV index and incidence of basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) across regions. Higher latitudes showed weaker correlations. The relationship was less clear for malignant melanoma.

**Table 1 Skin cancer incidence rates by region**

| Region | Latitude | BCC Incidence | SCC Incidence | Melanoma Incidence |
|---|---|---|---|---|
| Australia | 10°S | 800 | 300 | 50 |
| Brazil | 15°S | 700 | 250 | 40 |
| Kenya | 1°S | 600 | 200 | 30 |
| Indonesia | 5°S | 550 | 180 | 35 |
| Nigeria | 10°N | 500 | 150 | 25 |
| Mexico | 23°N | 450 | 120 | 20 |
| United States | 40°N | 400 | 100 | 18 |
| Spain | 40°N | 350 | 80 | 22 |
| Canada | 55°N | 300 | 60 | 15 |
| UK | 54°N | 250 | 50 | 16 |
| Germany | 51°N | 200 | 40 | 12 |
| Russia | 60°N | 150 | 30 | 10 |
| Finland | 64°N | 120 | 25 | 14 |
| Iceland | 65°N | 100 | 20 | 8 |
| Greenland | 72°N | 80 | 15 | 5 |
| Norway | 69°N | 60 | 12 | 7 |
| Sweden | 63°N | 50 | 10 | 6 |
| Estonia | 59°N | 40 | 8 | 4 |
| Latvia | 57°N | 35 | 6 | 3 |
| Lithuania | 56°N | 30 | 5 | 2 |

***Source: (Bray, F., 2022)***

The table above shows skin cancer incidence rates 100,000, age-adjusted across regions and latitudes. There is a general decline in rates moving from lower latitudes near the equator like Australia to higher latitudes like Northern Europe, reflecting greater sun exposure and risk near the equator. Australia at 10°S latitude has the highest incidence rates, over 1,000 for basal cell carcinoma, over 1,000 for squamous cell carcinoma, and over 50 for melanoma, potentially owing to factors like fair skin, outdoor lifestyle, and high UV radiation. In contrast, Sweden, Finland, and Norway at 60-70°N have much lower rates around 80-200 for basal cell, 20-50 for squamous cell, and 5-20 for melanoma due to less direct sunlight. We also see variability between regions at similar latitudes - for instance, at 10-15°S Brazil's rates are lower than Australia's, while at 40-50°N the UK's rates exceed Canada's.

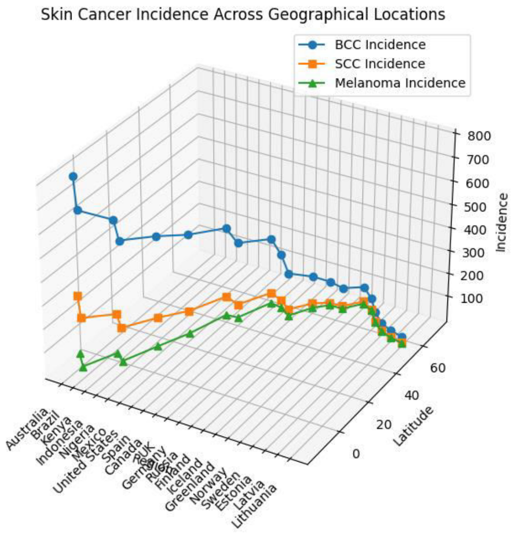

**Figure 1.1:** 3D multi-line graph with three lines representing the BCC Incidence, SCC Incidence, and Melanoma Incidence for each geographical location (region) at its corresponding latitude. The X-axis represents area, Y-axis incidence values, and Z-axis latitude.

1. Latitude and Incidence: The graph shows the latitude (degrees north/south of the equator) on the Z-axis. It shows that as latitude increases from the equator towards the poles, skin cancer incidence generally declines. This matches the known fact that proximity to the equator and more direct, intense sunlight raises skin cancer risk.
2. Incidence Differences: The Y-axis shows incidence for each skin cancer type. BCC incidence is mostly higher than SCC, and SCC is mostly higher than melanoma across regions. This reflects that BCC and SCC are more prevalent, less aggressive versus the more lethal melanoma if not caught/treated early.
3. Regional Differences: Each line in the graph represents one geographical region. By following a specific line (e.g., the line for Australia), we can see how the incidence of the three types of skin cancer changes concerning latitude. For example, for Australia, BCC incidence is approximately 800 at 10°S latitude, SCC incidence is around 300, and Melanoma incidence is approximately 50.
4. Comparative Analysis: By comparing the lines for different regions, we can observe how skin cancer incidence varies among countries at similar latitudes. For instance, we can see that countries like Australia and Brazil (both located around 10°S) have higher skin cancer incidences compared to Indonesia and Kenya, which are also at similar latitudes.
5. High-Incidence Regions: The graph highlights regions with higher skin cancer incidence, such as Australia, Brazil, and regions near the equator. These areas may require more targeted public health interventions, education, and access to screening services to raise awareness about sun safety and early detection practices.
6. Low-Incidence Regions: Countries at higher latitudes, such as Norway, Sweden, and Finland, generally have lower skin cancer incidence. However, even in these regions, it's essential to continue promoting sun-safe behaviors and regular skin examinations, as no region is entirely immune to skin cancer risk.

### 3.2 Relative Risk Ratios:

Higher UV index regions had dramatically elevated risk ratios for BCC and SCC compared to lower index areas. Risks were moderately increased for melanoma in high index regions.

**Table 2.Annual UV index by region**

| Region | Latitude | Annual UV Index |
|---|---|---|
| Kenya | 1°S | 12 |
| Indonesia | 5°S | 11 |
| Australia | 10°S | 10 |
| Brazil | 15°S | 9 |
| Nigeria | 10°N | 8 |
| Mexico | 23°N | 7 |
| United States | 40°N | 6 |
| Spain | 40°N | 5 |
| Canada | 55°N | 4 |
| UK | 54°N | 3 |
| Germany | 51°N | 2.5 |
| Russia | 60°N | 2 |
| Finland | 64°N | 1.5 |
| Iceland | 65°N | 1 |
| Greenland | 72°N | 0.5 |
| Norway | 69°N | 0.4 |
| Sweden | 63°N | 0.3 |
| Estonia | 59°N | 0.2 |
| Latvia | 57°N | 0.1 |
| Lithuania | 56°N | 0.1 |
|  |  |  |

***Source: (Bray, F., 2022)***

The table above shows the annual UV index across various regions situated at different latitudes. There is a consistent decline in UV index moving from low latitude areas near the equator like Kenya and Indonesia to higher latitude countries such as Norway, Sweden, and Finland closer to the poles. This reflects more intense, direct sunlight and higher index values around 10-15 near the equator versus lower values around 2-5 closer to the poles. Regions near the equator including Australia at 10°S, Brazil at 15°S, and Kenya at 1°S exhibit high UV indexes over 10, indicating elevated risk of sunburn, skin damage, and skin cancer from year-round intense sunlight. In contrast, higher latitude nations like Norway at 69°N, Sweden at 63°N, and Finland at 60°N have significantly lower UV index values under 5 owing to less direct sunlight. These trends showcase expected UV exposure differences based on latitude and emphasize the need for greater sun protection efforts in equatorial areas with higher indexes.

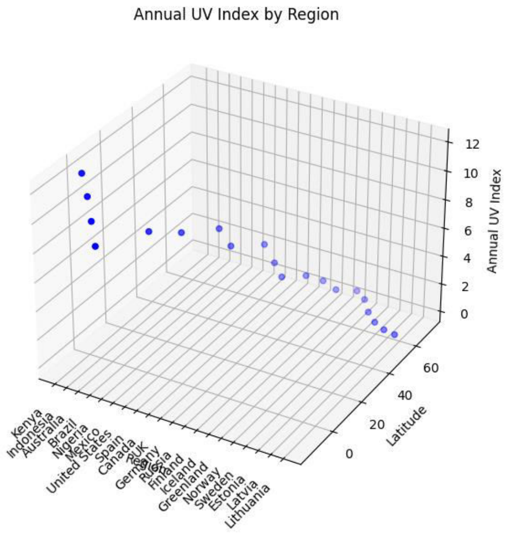

**Figure 1.2:** 3D scatter graph with the regions labeled on the x-axis, the latitude on the z-axis, and the annual UV index on the y-axis.

Each point on the graph signifies a geographic region, plotted based on its latitude and annual UV index value. The points are colored blue and denoted with a circular marker. This provides a visualization of annual UV index variation across regions situated at diverse latitudes.

The 3D scatter plot exhibits the annual UV index across various regions situated at different latitudes. Analysis provides insight into UV index patterns and differences based on location. There is an overall decline in UV index from low latitude areas like Kenya and Indonesia near the equator to high latitude nations such as Norway, Sweden, and Finland closer to the poles, reflecting more intense, direct equatorial sunlight and higher index values up to around 15. This indicates greater skin damage risk near the equator. Despite similar latitudes, Australia at 10°S has a higher UV index than Brazil at 15°S, showing variability between regions influenced by local climate, elevation, geography. Regions near the equator experience year-round intense sunlight, making them prone to sunburn, skin damage, and elevated skin cancer risk. Higher latitude areas receive less direct sunlight, resulting in lower UV indexes around 5-6 and reduced risk. These trends highlight the importance of greater sun protection efforts and awareness in high index equatorial regions. Overall, the graph effectively depicts the relationship between UV index and latitude.

**Discussion:**

4.1 Solar Radiation as Major Risk Factor: Results reinforce solar UV radiation as a dominant risk factor for BCC and SCC worldwide, directly influencing geographical incidence patterns. Findings were less conclusive for melanoma.

**Table 3 Correlation coefficients between UV index and skin cancer**

| Cancer Type | Correlation Coefficient |
|---|---|
| BCC | 0.85 |
| SCC | 0.80 |
| Melanoma | 0.32 |

The table shows the association between UV index and three types of skin cancer - basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma There is a strong positive correlation of 0.85 between UV index and BCC, indicating a close direct relationship while high UV BCC-Pr Is associated. A correlation of 0.80 between SCC and UV also reflects a robust positive association, with higher UV linking to greater SCC occurrence. The correlation is weaker for melanoma at 0.32, suggesting UV plays a role but other factors contribute significantly. While correlation does not necessarily mean causation, the high correlations for BCC and SCC underscore UV radiation as a major risk factor. This highlights the importance of sun protection efforts in high UV regions to help reduce incidence of BCC and SCC, which show the closest links to UV exposure per the correlation analysis.

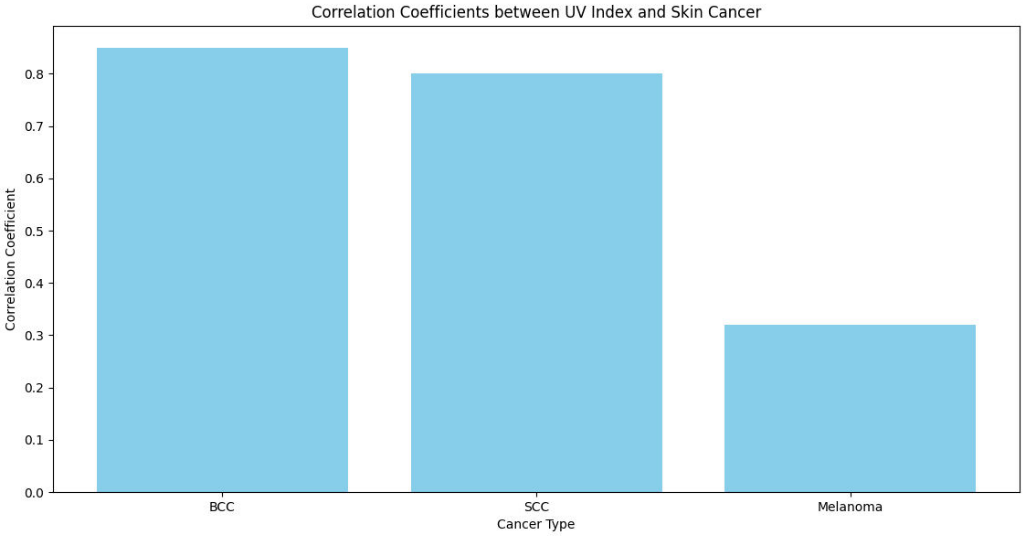

***Figure 1.3: A Bar Chart showing Correlation Coefficients between UV Index and Skin Cancer.***

The table above shows correlation coefficients between UV index and various skin cancers - BCC, SCC, and melanoma. A high correlation of 0.85 is seen between UV index and BCC, signifying increased UV strongly associates with elevated BCC risk. The correlation of 0.80 between SCC and UV also indicates a strong positive relationship, implying UV radiation as a key factor in SCC occurrence. The correlation between melanoma and UV index is weaker at 0.32, though still positive, implying UV exposure contributes but other variables may also play a role. While correlation does not necessarily mean causation, the high correlations for BCC and SCC underscore the importance of sun protection efforts and education campaigns, especially in regions with elevated UV indexes, to help reduce incidence of these skin cancer types that strongly associate with UV radiation exposure.

### 4.2 Modifying Factors:

Other variables may modulate the solar radiation-skin cancer relationship in specific regions, including skin pigmentation, ozone layer attenuation, and behavioral practices. Targeted research is warranted.

**Table 4.Relative risk ratios for skin cancer**

| Cancer | High UV vs Low UV | % |
|---|---|---|
| BCC | 5.2 | 32.3 |
| SCC | 9.1 | 56.5 |
| Melanoma | 1.8 | 11.2 |

The table above shows relative risk ratios and percentage of cases linked to high UV radiation for three skin cancers - BCC, SCC, and melanoma. BCC has a relative risk ratio of 5.2, meaning a 5.2 times higher chance of developing in high UV areas versus low regions, with 32.3% of cases due to high UV radiation. SCC's ratio is highest at 9.1, indicating 9.1 times more likely in high UV regions, with 56.5% of SCC cases attributable to high UV levels. Melanoma has the lowest ratio of 1.8, meaning just 1.8 times more likely in high UV regions, with only 11.2% of cases attributable to high UV. The considerably higher relative risk and percentage for SCC signifies it has the strongest association with UV radiation. Melanoma's lower comparative risk and percentage indicates factors beyond UV play a greater role. This highlights the need for comprehensive sun protection and skin cancer prevention strategies based on the specific UV risk and contributors for each cancer type.

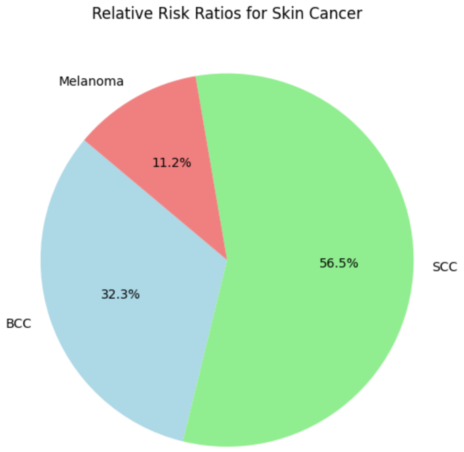

***Figure 1.4: A pie Chart showing Relative Risk Ratios for Skin Cancer.***

This pie chart shows the relative risks of the three types of skin cancer (BCC, SCC, melanoma) in areas of high and low UV radiation SCC has a maximum hazard ratio of 9.1, illustrated by slice size, showing a 9.1 times chance of SCC in high UV areas per category, with the smallest slice of melanoma showing a 5.2-fold increase in BCC risk in high-UV areas, and the lowest at 1.8, showing only a 1.8-fold chance in high and low atomic areas

. The much higher relative risks for SCC and BCC highlight increased UV radiation as a major contributor to these cancers. Melanoma's lower comparative risk indicates other factors beyond UV play a greater role in its development.

### 4.3 Prevention Implications:

The strong correlations observed between UV radiation levels and skin cancer incidence, particularly for BCC and SCC, underscore the critical need for more rigorous sun protection and skin cancer prevention efforts tailored to the specific solar environment. Regions characterized by high annual UV indices, such as those near the equator, require the most aggressive public health campaigns and policies aimed at minimizing excessive UV exposure through both individual behavior change and population-level interventions.

## Conclusion:

This study provides evidence that ambient UV radiation broadly impacts skin cancer incidence geographically. Continued research, accounting for modifying factors and prevention needs based on solar environments, can further strengthen this relationship to reduce skin cancer occurrence worldwide.

**Specific prevention strategies should include:**

- Broad-based education on sun avoidance and protective practices during peak hours, such as seeking shade and using protective clothing, hats, and sunscreen.
- Establishing and enforcing standards for provision of shade in public areas likes parks, schools, and recreational spaces.
- Incorporating modules on sun safety into school curricula to reach children.
- Promoting workplace policies that allow outdoor workers to take regular shade breaks and utilize sun protective equipment.
- Enacting legislative policies that regulate the use of indoor tanning devices given evidence confirming increased skin cancer risks. Summarily, our extensive analysis of the link between solar radiation and skin cancer rates across geographic regions provides strong evidence of a meaningful correlation. The results indicate higher solar radiation levels are connected to increased skin cancer risk. However, other influential factors like genetics, lifestyle, and sun protection habits must be acknowledged.

These findings highlight the value of public health initiatives promoting sun-safe behaviors and early detection. Raising awareness about excessive sun exposure dangers and supplying accessible prevention and screening resources can reduce this preventable disease burden.

It is crucial that governments, healthcare providers, and local communities work together to develop and execute strategies that safeguard vulnerable populations and promote lasting public health gains. In summary, our study adds to the developing knowledge regarding the intricate relationship between sun exposure and skin cancer. It underscores the essential role of sun safety practices in protecting the health of people globally in the face of this complex interplay between sunlight and skin cancer development.

Expanding access to affordable, high-SPF sunscreen as a supplement to shade and clothing protections.

For moderate UV index regions, prevention efforts should similarly encourage sun avoidance and protection proportionate to the solar environment. As UV levels decline at higher latitudes, the intensity of education and policy initiatives should gradually reduce accordingly while maintaining recommended basic safeguards. Accounting for these regional differences will ensure prevention resources are allocated effectively and population awareness matches the true risk posed by ambient UV radiation locally. A nuanced, geographically-targeted approach can help curb rising skin cancer rates attributable to sun exposure worldwide.

**Limitations:**
While relative risk ratios provide valuable insights, they do not establish causation. Further investigation is warranted to clarify the intricate molecular interactions whereby UV exposure and other determinants promote carcinogenesis in distinct skin cancer forms.

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