Impact of Climate Change on Skin Cancer

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1. Introduction

Climate change, characterized by rising global temperatures and increased ultraviolet radiation (UV), is a dynamic phenomenon that is anticipated to be the greatest threat to public health in the 21st Century. (Climate-ADAPT, 2024) A growing area of concern is the potential link between the environmental changes and the substantial increase in incidence rates of skin cancer. (Parker, 2020) Skin cancer, encompassing both melanoma and non-melanoma, is one of the most common cancers afflicting the population worldwide. (PubMed Central, 2010) In 2022 alone, there were 332,000 cases of melanoma with 59,000 deaths while 1.2 million cases of non-melanoma with over 69,000 deaths. (PubMed Central, 2024). Understanding climate change's potential influence on skin cancer rates could be crucial for stakeholders to develop effective management strategies to mitigate the impact as many of these cases are found to be preventable with the right measures. (Cancer Research UK, 2024) Furthermore, the finding of a connection between climate change and skin cancer can supply further evidence for the negative impact of climate change and strengthen advocacy for policies to tackle climate change.

This report explores this relationship between climate change and skin cancer, with the following exploratory questions serving as a guideline:

1. How have skin cancer rates changed over time, and do these correlate with rising global temperatures and UV exposure?
2. Are certain occupations (e.g., agriculture, construction) experiencing a disproportionate rise in skin cancer rates due to prolonged sun exposure in warming climates?
3. Do regions with higher temperature increases due to climate change also show higher skin cancer incidence rates?

Analysis of this issue concludes that temperature and UV radiation are key determinants of skin cancer, and those working outdoors are approximately 60% more likely to be diagnosed with skin cancer compared to those working indoors, thus highlighting the potential damage of higher temperatures induced by global warming. Additionally, after evaluating the interaction between region and temperature with skin cancer rates, a conclusive link between different global regions and skin cancer rates could not be established.

2. Exploratory Questions and Findings

Skin cancers predominantly develop in the sun-exposed areas of humans, such as the head and neck. They can be generally classified into two main types: cutaneous melanomas (CM) and keratinocyte carcinoma (KC). (Wright et al, 2019) Non-melanoma cancers form in the upper layers of the skin beyond the melanocyte cells that produce skin pigment. As melanomas are more likely to spread and cause serious illness and death, there is a general perception that non-melanoma cancer is of less concern. However, the latter is more common.

2.1 Skin Cancer vs Climate Change Trends

Climate change is hypothesized to contribute to skin cancer through multiple mechanisms, mainly rising ambient temperatures, increased UV exposure and increased tumorigenesis from air pollution. (Watson et al, 2024) Research has consistently demonstrated a positive correlation between skin cancers and UV radiation, where 65% to 90% of CMs are attributed to UV radiation (Armstrong, 2004). Emerging evidence has also suggested that air pollution is detrimental to skin integrity due to direct exposure to harmful airborne pollutants such as particulate matter, volatile organic compounds, ozone, nitrogen dioxide and sulphur dioxide. (Krutmann J et al, 2014) Beyond UV radiation, an independent relationship between increasing ambient temperature and KC incidence rates has also been discovered (Van der Leun et al, 2008), and studies have even indicated that a 2°C increase in ambient temperature might result in a 10% annual increase in skin cancer cases. (Kaffenberger et al, 2017)

Supporting these findings, all skin cancers have shown an increase in incidence worldwide over the past decades (Lee et al, 2018), with the most significant increases observed in fair-skinned populations (Garbe & Leiter, 2009; Lomas et al., 2012). A study done by calculating the incidence of KC together with the ambient UV dose and average daily maximum temperature in the summer of ten regions of the USA has shown a correlation between higher temperatures and incidence rates of skin cancer. (Van der Leun, 2002) Temporal trends have also illustrated non-melanoma skin cancer (NMSC) incidence rates rising at an alarming rate in the US. Similarly, NMSC incidence rates have more than doubled in Scandinavia since 1960 while Australia has seen a fourfold increase in cases over the same period. (Lomas et al., 2012).

Overall, there is evidence to suggest a positive correlation between rising global temperatures and increased skin cancer rates. The notable increase in skin cancer rates globally over the past few decades aligns with the rising global temperatures and increased UV exposure.

2.2 Rising Skin Cancer Rates in High-Exposure Occupations

A joint report by the World Health Organization (WHO) and the International Labour Organization (ILO) found that nearly one in three deaths from non-melanoma skin cancer is caused by working under the sun. (WHO & ILO, 2023). Evidence suggests that outdoor workers have a 60% higher chance of developing non-melanoma skin cancer as compared to indoor workers. 28% of all working-age people were exposed to solar radiation while working outdoors in 2019. These studies done by the WHO and ILO were quite detrimental, suggesting that the sun is the third most hazardous occupational carcinogen, after asbestos fibres and silica dusts. (PubMed Central, 2024)

Low income labourers in particular tend to work more outdoors in the sun, which makes them more vulnerable to skin cancer. Their lower socioeconomic status is associated with thicker melanoma and later detection, putting them at a disadvantage for receiving the right treatment. (AJMC, 2024) Although there are numerous organizations making these workers aware of the occupational hazards of working under the sun - like Australia's Slip-Slop-Slap campaign and the USA's SPOT Skin Cancer - the fact of the matter is that skin concerns often take a backseat as compared to struggling for survival. These workers are exposed to the sun's ultraviolet rays for long periods of time, despite doing their best in covering up. Even though a farmer might wear a hat, the ultraviolet rays can be reflected back from the watered fields.

Occupations such as agriculture, construction and maritime industries have workers at elevated risk due to repeated exposure to environmental carcinogens. In agriculture, exposure to pesticides combined with sun exposure are known to increase the risk of sun cancer. This is the same for gardening, groundskeeping and certain service-related occupations. Maritime workers experience intensified ultraviolet radiation due to water reflection which can exceed the recommended daily limits and increase the risk of melanoma. (Parikh & Tan, 2024)

It was also found that more men died from non-melanoma skin cancer from being exposed to solar ultraviolet radiation than women. (WHO, 2023) This disparity is likely due to the overrepresentation of men in outdoor occupations like agriculture and construction. Sociocultural norms such as men traditionally serving as the primary earners in the households may lead to the higher likelihood of being hired in occupations where they spend a significant time outdoors. While these trends are observable, more research would be necessary to establish a direct causal link between gender roles and occupational exposure to the sun.

In summary, skin cancer remains a significant occupational hazard, especially for workers in agriculture, construction and maritime industries as they have prolonged exposure to the sun. Despite campaigns to raise awareness, the socioeconomic status of these workers plays a pivotal role in limiting the efficacies of these initiatives. With rising temperatures and UV radiation, this already vulnerable group is at the risk of being more susceptible to skin cancer and other related ailments.

2.3 Regional Skin Cancer Trends

As skin cancer can be linked to environmental factors such as sun exposure, an area of potential investigation is to find out if regional trends are different in terms of skin cancer rate and temperature changes due to climate change. Sources have found differences in UV exposure across varying latitudes and altitudes, suggesting that there is potential for differential impact of climate change globally and across regions on skin cancer rates (Watson et al, 2024).

To study this impact, the effect of temperature changes on melanoma and non-melanoma cancer rates were evaluated between 1990 and 2019. On average, while temperature increased by 4% globally during this period, melanoma and non-melanoma cancer rates surged by 156% and 74%, respectively. This leads to the question of whether temperature shifts have an outsized impact on skin cancer rates. Analysis of per-country temperature and skin cancer rate data showed a moderate correlation of 0.4 between the change in temperature and the change in skin cancer rates during this period. This figure indicates that changes to skin cancer rates are positively associated with temperature changes, yet are likely also influenced by additional factors. While an aggregate snapshot of temperature change against skin cancer incidence offers moderate alignment, it remains to be seen if different regions of the world display varied skin cancer increases in response to temperature hikes.

When taken collectively, both melanoma and non-melanoma cancer rates grow in response to a rise in temperature of 1 degree Celsius. However, the below table, separated for melanoma and non-melanoma cancers, demonstrates that there are varying effects in responses to changes in temperature.

Table 1: Cancer rate percent changes with temperature increase

Region	Melanoma	Non-Melanoma
	Average Change in Cancer Rate for 1ºC Increase	Average Change in Cancer Rate for 1ºC Increase
	%	%
South Asia	-0.30%	-0.37%
Europe and Central Asia	-1.07%	-0.36%
Middle East and North Africa	-0.38%	-0.11%
Sub-Saharan Africa	-0.13%	0.20%
Latin America and Caribbean	-0.39%	-0.30%
East Asia and Pacific	0.93%	0.75%
North America	-1.24%	0.18%

Of the results shown above, only four offer a positive association between temperature change and skin cancer rates. Moreover, when aggregated, East Asia and the Pacific is the only region consistently experiencing rising skin cancer rates in response to temperature increases. The findings from other regions, which display negative associations, suggest that temperature change plays a limited role in influencing skin cancer rates, and additional factors serve to impact skin cancer rates.

Additional or extraneous factors that could contribute to the surge in skin cancer rates seen from the analysis could be non-environmental related. For example, increase in reporting and detection of skin cancer might contribute to the inflation of skin cancer rates, as promotion of early screening has increased. (Loud et al, 2017) Additionally, an increase in the prevalence of tanning beds and voluntary sun exposure, especially in western countries (Reed et al, 2012), has also been linked to rising skin cancer rates. This could explain the negative correlation seen between region-specific skin cancer rates and temperature change, especially in North America and Europe, as it supports the notion that temperature increases in fact did not significantly increase melanoma and non-melanoma skin cancer rates. Thus, these additional factors point to the fact that changes in skin cancer rates cannot be attributed solely to climate and environmental factors and that more analysis might be required to either isolate temperature as a main effect or investigate interactions between climate and other variables.

Moreover, due to the lack of positive correlations between most regions' temperature and skin cancer rate changes, a potential future direction to explore could be classification by latitude rather than region, especially as the regions included in analysis were not assigned by geography or temperature but by the WHO. For example, stratification by distance to the equator or climate zones could reveal greater differences or patterns than region as some regions included in the current analysis extend across various climate zones (NASA, 2020) and temperatures (Abraham et al, 2023).

Overall, regional differences did not appear to have a significant or consistent impact on skin cancer rates when interacted with temperature. However, exploration into more climate-based delineations for geographical regions might yield different results.

3. Discussion and Recommendations

Given skin cancer has surged worldwide over the last thirty years, it is imperative that efforts be exhaustive to combat this growing epidemic. Based on the findings of this report, the impact on skin cancer rates from temperature and UV radiation increases brought about by climate change further strengthen the argument for policies to combat anthropogenically-induced climate change. Statistics concerning incidence, prevalence, and mortality associated with skin cancer can be voiced to governing bodies to illustrate the impact to human lives caused by climate change, and to advocate for policies to reduce emissions associated with ozone depletion, which cause temperature increases.

While this approach is oriented toward the long-term, immediate steps can be taken to prioritize the dermatological health of populations in response to rising temperatures. This includes the adoption of sunscreen, which must be encouraged to reduce the impact of increased ultraviolet radiation. Given outdoor workers have a 60% higher chance of developing non-melanoma skin cancer when compared to indoor workers, sunscreen use must increase through education and incentives. Examples of worldwide policy to incentivize sunscreen adoption include public awareness campaigns, subsidies, and workplace safety policies. Future briefs will examine the potential impact of sunscreen adoption on skin cancer rates to identify the potential of such policies.

4. Conclusion

Overall, there is robust evidence to suggest that skin cancer rates and climate change are linked across variable dimensions, including occupation and potentially region or climate zones.

Positive correlations between rising global temperatures and increased skin cancer rates over the past few decades along with increased UV exposure support this conclusion. Additionally, skin cancer seems to be a significant hazard for occupations with prolonged sun exposure which further highlights the environmental impacts on skin cancer rates. In terms of region and temperature, more investigation can be done to stratify areas of the world to understand correlations between region, temperature changes, and skin cancer rates.

In the future, exploring causal relationships with skin cancer could be imperative to understanding and changing skin cancer trends. Whether climate change is an underlying cause for the increase in skin cancer over the past few decades can better inform where to target policy decisions and solutions to reduce skin cancer rates.

5. Appendix

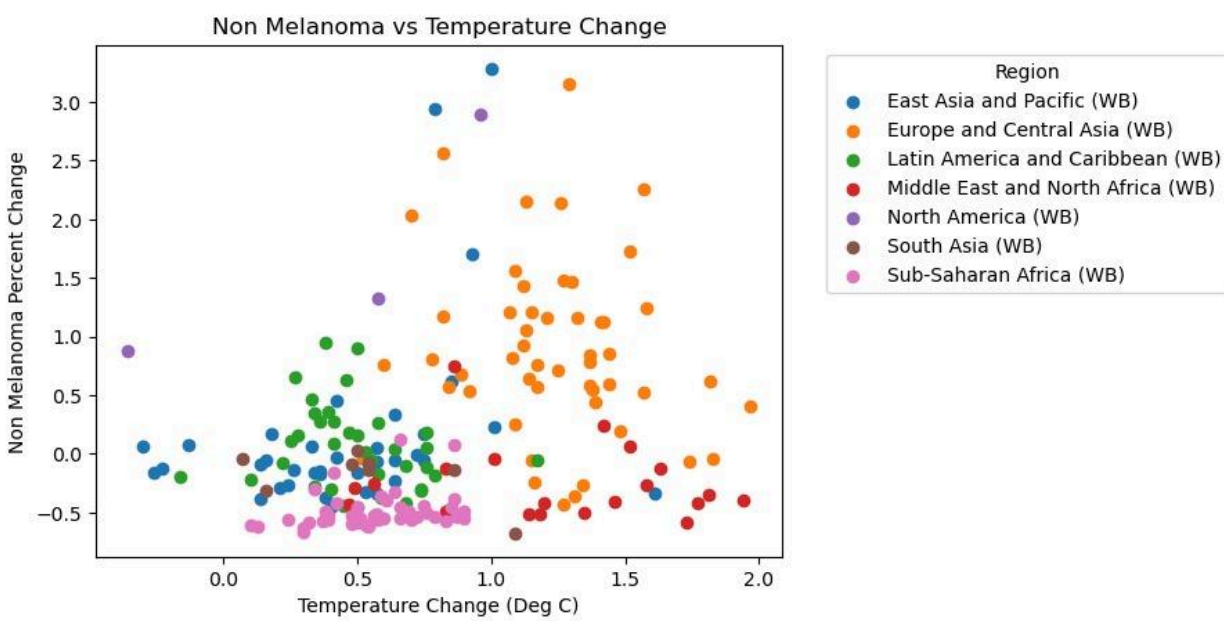

Figure 1: Percent Change in Non Melanoma Rate (y-axis) and Temperature Change (Degrees C) by region

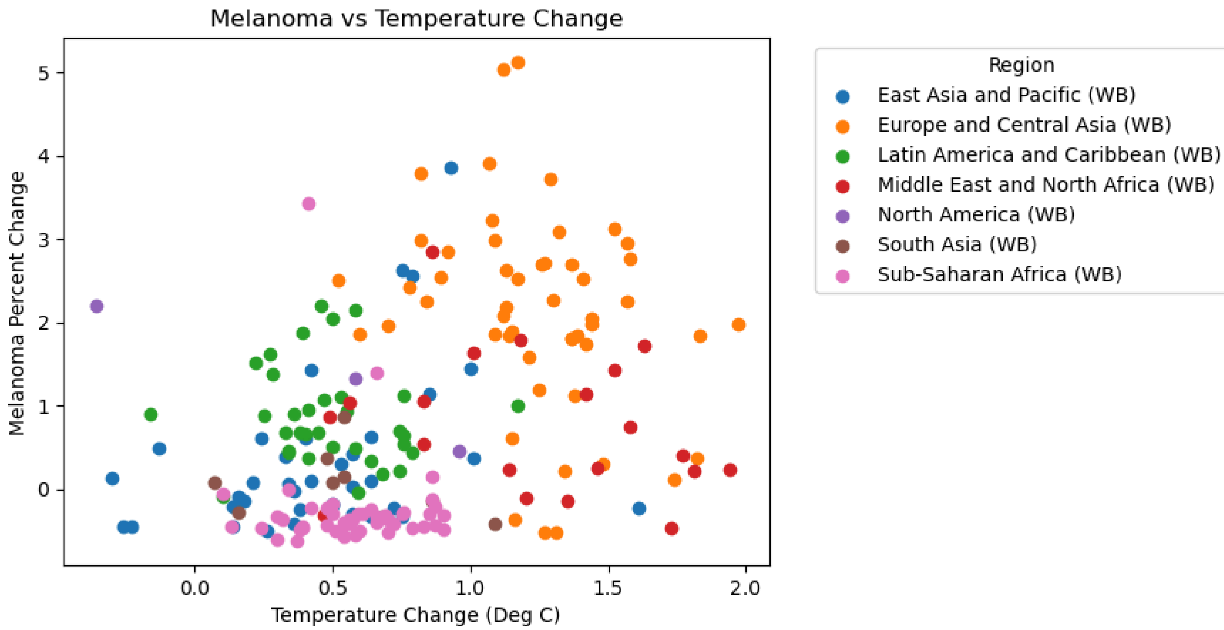

Figure 2: Percent Change in Melanoma Rate (y-axis) and Temperature Change (Degrees C) by region

Table 1: Non-Melanoma Percent Change with Temperature*Region Regression

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.2013	0.143	-1.407	0.161	-0.483	0.081
Region[T.Europe and Central Asia (WB)]	1.5306	0.359	4.260	0.000	0.822	2.239
Region[T.Latin America and Caribbean (WB)]	0.4194	0.259	1.618	0.107	-0.092	0.931
Region[T.Middle East and North Africa (WB)]	0.0810	0.393	0.206	0.837	-0.695	0.857
Region[T.North America (WB)]	1.3822	0.417	3.318	0.001	0.560	2.204
Region[T.South Asia (WB)]	0.2151	0.412	0.522	0.602	-0.597	1.027
Region[T.Sub-Saharan Africa (WB)]	-0.4024	0.280	-1.435	0.153	-0.956	0.151
Temp_Number_Change	0.7485	0.240	3.112	0.002	0.274	1.223
Temp_Number_Change:Region[T.Europe and Central Asia (WB)]	-1.1042	0.353	-3.126	0.002	-1.801	-0.407
Temp_Number_Change:Region[T.Latin America and Caribbean (WB)]	-1.0452	0.463	-2.258	0.025	-1.958	-0.132
Temp_Number_Change:Region[T.Middle East and North Africa (WB)]	-0.8556	0.368	-2.325	0.021	-1.581	-0.130
Temp_Number_Change:Region[T.North America (WB)]	0.5731	0.624	0.919	0.359	-0.657	1.803
Temp_Number_Change:Region[T.South Asia (WB)]	-1.1176	0.673	-1.662	0.098	-2.445	0.209
Temp_Number_Change:Region[T.Sub-Saharan Africa (WB)]	-0.5464	0.464	-1.177	0.241	-1.462	0.369

Table 2: Melanoma Percent Change with Temperature*Region Regression

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.0897	0.225	-0.398	0.691	-0.534	0.355
Region[T.Europe and Central Asia (WB)]	3.5391	0.566	6.253	0.000	2.423	4.656
Region[T.Latin America and Caribbean (WB)]	1.1126	0.408	2.725	0.007	0.307	1.918
Region[T.Middle East and North Africa (WB)]	1.3194	0.620	2.129	0.035	0.097	2.542
Region[T.North America (WB)]	1.9048	0.656	2.903	0.004	0.610	3.199
Region[T.South Asia (WB)]	0.3325	0.648	0.513	0.609	-0.947	1.612
Region[T.Sub-Saharan Africa (WB)]	-0.0795	0.442	-0.180	0.857	-0.951	0.792
Temp_Number_Change	0.9306	0.379	2.457	0.015	0.183	1.678
Temp_Number_Change:Region[T.Europe and Central Asia (WB)]	-2.0017	0.556	-3.597	0.000	-3.099	-0.904
Temp_Number_Change:Region[T.Latin America and Caribbean (WB)]	-1.3186	0.729	-1.808	0.072	-2.757	0.120
Temp_Number_Change:Region[T.Middle East and North Africa (WB)]	-1.3142	0.580	-2.267	0.025	-2.457	-0.171
Temp_Number_Change:Region[T.North America (WB)]	-2.1710	0.982	-2.210	0.028	-4.109	-0.233
Temp_Number_Change:Region[T.South Asia (WB)]	-1.2272	1.059	-1.158	0.248	-3.317	0.863
Temp_Number_Change:Region[T.Sub-Saharan Africa (WB)]	-1.0652	0.731	-1.457	0.147	-2.508	0.377

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