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Research Article

UV-Related Melanoma Cancer and Its Association with the Human Development Index (HDI): GLOBOCAN Sources and Methods

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Abstract

Background: Exposure to radiation is a major risk factor for skin cancer so that 65 to 90% of skin cancers can be attributed to the exposure with sunlight.
Objectives: The current study aimed to investigate the association between the human development index and the incidence of UV-related melanoma.
Methods: This is an ecological study. Data on the incidence of UV-induced melanoma were extracted from the GLOBOCAN estimates (GLOBOCAN 2012), and data on the human development index were extracted from the World Health Organization (WHO) database. Data analysis was conducted by Stata software (Ver. 14). The descriptive analysis involved mean and standard deviation. The correlation method was used to evaluate the association between the population attributable fraction (PAF) of melanoma for ultraviolet (UV) and the HDI components. A P value < 0.005 was considered as statistically significant.
Results: The results revealed a significant positive association between UV-attributable melanoma cancer and HDI in women (r = 0.401, P < 0.0001), men (r = 0.488, P < 0.0001), and both sexes (r = 0.455, P < 0.0001). In Americas (r = 0.452, P < 0.05) and Europe (r = 0.740, P < 0.05), a significant positive correlation was observed between UV-induced melanoma and HDI, but this association was not significant in Asia (P > 0.05). In Africa, a negative correlation was observed, though it was not statistically significant (r = -0.301, P > 0.05). The results of the analysis of variance (ANOVA) showed a significant statistical relationship between the incidence of UV-related melanoma and the levels of development (F = 25.1, P < 0.0001) so that the higher the score of HDI, the higher the incidence of this cancer.
Conclusions: Since there is a positive correlation between UV-related melanoma and HDI, further attention should be paid to this risk factor, especially in countries with a high HDI to reduce the UV-induced melanoma cancer.

Keywords: Melanoma Cancer, UV Radiation, Human Development Index, Population Attributable Fraction

1. Background

According to the predictions, cancer would be the major burden of diseases, so that it is expected that the incidence of various types of cancer increases by 15 million by 2020 (1-3). Skin cancer is one of the most prevalent cancers in the world (4), that its incidence has been on the rise in recent decades due to the consequences of climate changes, such as ozone depletion and altered individual and social habits. Skin cancer has two main types: Melanoma skin cancer (MSC) and non-melanoma skin cancer (NMSC) subgroups (4-6).

Malignant melanoma accounts for 1% of all skin tumors and 60% of all deaths due to skin cancer. The incidence of melanoma has been growing worldwide over the past four decades (7). According to the US Academy of Dermatology, melanoma is particularly common in Australia, New Zealand, Asia, Africa, and Latin America. In the United States, Europe, and Australia skin cancer constitutes 25, 20, and 45% of all new cases of cancer each year, respectively (8).

Environmental studies have shown that the incidence of melanoma is associated with geographical variations all around the world. Besides, these studies reported that the melanoma incidence is higher in low-latitude regions near the equator and higher-altitude areas (9). Ultraviolet (UV) radiation is a risk factor for approximately 65% of melanoma and 90% non-melanoma skin cancers, and sunburn doubles the risk of melanoma. Therefore, environmental changes that increase UV radiation transmission have a direct impact on human health. Hence, a history of sunburn and extensive sun exposure is directly related to the relative risk of melanoma during life (10, 11).

One of the most important factors associated with cancer is the human development index (HDI), which reflects the social and economic status of individuals in different countries (12, 13). HDI is a globally-verified indicator that demonstrates the level of economic and social well-being of communities. Comprising three dimensions of health, education, and income, this index shows the quality of life (14). Melanoma cancer is more common in people with high socioeconomic status, but its mortality rate is higher in individuals from lower socioeconomic status (15).

2. Objectives

The current study aimed to investigate the association between HDI and the incidence of UV-related melanoma.

3. Methods

3.1. Cancer incidence and HDI Grouping

National estimates of the new cases of cutaneous melanoma, herein referred to as melanoma, were obtained from GLOBOCAN 2012. In this study, only countries/territories with at least 10 melanoma cases (in both sexes) were included (n = 153 countries/territories), which accounted for 96% of the estimated global melanoma burden.

The results are classified by several factors, including HDI, which is a composite indicator of life expectancy, education, and gross domestic product (GDP) per person. 153 countries/territories that had inclusion criteria were assigned to four categories according to their 2012 UN-defined HDI groups: very high, high, medium, and low HDI (UNDP 2013 Human Development Report).

3.2. Exposure Assessment

It is difficult to quantify the intensity of UV radiation exposure in the population. Given that all populations to somehow are exposed to the sunlight, the traditional approach to quantifying population attributable fractions (PAF) (i.e., using population prevalence of exposure and the corresponding relative risks of cancer) was not applicable. Hence, we compared the observed melanoma incidence rates with those of a minimally exposed reference population (1). By doing so, differences in the number of new cases could be attributed to corresponding differences in UV radiation exposure between the reference and study populations.

PAFs were calculated as the difference between the estimated number of new cases in 2012 (by country/territory in 5-year age groups (ages $\geq$ 30 years) and sex) and the expected number of cases based on incidence rates of the reference population (1).

The following formula was used to calculate country/territory-, age, and sex-specific PAFs:

$PAF = (I_p - I_u)/I_p$

Where I_p is the incidence of melanoma in the study population in 2012 and I_u is its incidence in the reference population. The number of cancer cases attributable to UV radiation exposure was also expressed as the percentage of the total number of all new cancer cases in 2012, except for non-melanoma skin cancers.

The variance estimate of PAF obtained from the delta method was used to achieve 95% uncertainty estimates.

3.3. Human Development Index

HDI, which ranges from zero to one, exhibits the extent of the progress in achieving the highest value (HDI = 1), which allows comparisons across countries. In other words, HDI is a summary measure that combines the mean achievements of a country/territory in three dimensions of human development, including long and healthy life, education, and decent living. As a geometric mean of normalized indices for each of these dimensions, HDI measures the degree of progress and success in each dimension. Life expectancy is measured by life expectancy at birth, education by mean years of schooling (elementary, secondary, and higher education), and standards of living by gross national income (GNI) per capita (16, 17).

3.4. Statistical Analysis

Data were analyzed using Stata software (Ver. 14). The descriptive analysis included mean and standard deviation. The correlation method was used to evaluate the association between PAF of melanoma for UV and HDI components. A P value of $P < 0.05$ was considered as statistically significant.

4. Results

The highest proportion of UV-related cancers was among those aged 30-49-years in South-Central Asia, followed by those aged 50-69-year olds in East Asia and those aged 70-year olds in the Australia and New Zealand (Table 1).

UV-induced melanoma cancers separated by men and women and for both sex are shown in Table 2. As shown in the table, the highest incidence of UV-related melanoma cancers in both sexes in Asia belongs to in Israel (88.2%) and Timor-Leste (87%), the United States (90.5%) and Canada (85.4%) in Americas, Norway (92.5%) and Switzerland (92%) in Europe, and South Africa (72.4%) and Uganda (72%) in Africa (Table 2 and Figure 1).

According to the results, the higher the incidence of UV-induced melanoma cancers in men and women of all age groups, the higher the HDI (Figure 2).

According to the results, there is a significant positive correlation between UV-induced melanoma and HDI in women ($r = 0.401$, $P < 0.0001$), men ($r = 0.488$, $P < 0.0001$), and for both sex ($r = 0.455$, $P < 0.0001$) (Figure 3).

Concerning the relationship between HDI and UV-related melanoma in each continent, the results suggested a positive and significant correlation between the ratio of UV-related melanoma and HDI in the Americas ($r = 0.452$, $P < 0.05$) and Europe ($r = 0.740$, $P < 0.05$), though this relationship was not significant in Asia ($P > 0.05$). In Africa, a negative correlation was found, which was not statistically significant ($r = 0.301$, $P > 0.05$) (

According to the results of the analysis of variance (ANOVA) the highest mean of UV-related melanoma was for women (60.4 ± 32.3), men (73.8 ± 29.5), and both sexes (68.0 ± 29.8) in regions with very high human development, while the lowest mean was for women (15.0 ± 20.3), men (26.1 ± 25.1), and both sexes (20.21 ± 22.1) in regions with a medium human development (Table 3).

5. Discussion

In 2012, there were nearly 168,000 cases of UV-related cancers worldwide. Studies estimated that each year there occur 23,000,000 new cases and 55,000 deaths due to melanoma globally (18). Various studies have shown that exposure to radiation is a major risk factor for skin cancer so that 65% to 90% of skin cancers are caused by exposure to UV radiation. Hence, skin protection is of paramount importance in this regard (19). It has been shown that 86% of all melanoma cases are induced by sun exposure, so increased exposure to sunlight raises the risk of melanoma up to two-fold (20).

According to the results of the current study, the highest incidence of UV-related melanoma in both sexes was in Israel (88.2%) in Asia, the United States (90.5%) in Americas, (92.5%) Norway in Europe, and South Africa (72.4%) in Africa. In Americas ($r = 0.452$, $P < 0.05$) and Europe ($r = 0.740$, $P < 0.05$), there was a significant positive association between UV-related melanoma ratio and HDI, but it was not significant in Asia ($P > 0.05$). In Africa, there was a negative correlation, which was not statistically significant ($r = -0.301$, $P > 0.05$).

One reason for variations in melanoma incidence worldwide is the disparity in UV exposure in different regions of the world. In the Southern Hemisphere, due to higher exposure with UV radiation, the incidence of this cancer is higher. Although the rate of melanoma is higher among Caucasians, people known as non-white are also at risk for melanoma. Lack of awareness may also increase the risk (21).

Sun is the major source of UV radiation, and the degree of exposure to this radiation depends on latitude and location, time of day and year, cloud cover, air pollution, and ozone depletion in the stratosphere (22). Therefore, outdoor activities and exposure to sunlight can be considered as the major causes of melanoma proliferation over the past 5 decades (23).

The highest incidence of melanoma in New Zealand, Australia, and Europe has been registered in the elderly, with UV being a major cause of the disease in these countries (24, 25). Other reasons include genetics, lifestyles, the habit of living in open areas, and tanning by sunlight. Epidemiological studies revealed that UV is a risk factor for melanoma in genetically vulnerable populations. The presence of cancer markers is associated with a significant rise in the risk of melanoma. New Zealand's population is at an increased risk of melanoma due to these cancer markers. In recent decades, the population distribution in New Zealand has changed dramatically, which may lead to a lower incidence of the disease in the future (26).

Given that middle-aged and older men are more prone to sun cancer than younger men and women, they are more susceptible to skin cancer. In a study conducted in Colombia, 62 and 19% of all melanoma cases in men in women were related to UVR exposure, respectively (27).

Table 1. Relative Proportions (by Age Group) of Cancer Cases Attributable to UV Radiation Exposure in Men and Women of All Ages (30+ years) Separated by Region in 2012 (source: GLOBOCAN 2012)

Region	Age Group, y						Total
	Number	Relative, %	Number	Relative, %	Number	Relative, %	
Western Europe	7580	25.0	13100	43.0	10000	33.0	30700
Sub-Saharan Africa	433	16.0	1630	59.0	700	25.0	2760
Southern Europe	4920	35.0	5970	42.0	3270	23.0	14200
South-East Asia	27	41.0	39	59.0	0	0.00	67
South-Central Asia	139	42.0	159	48.0	34	10.0	333
South America and Caribbean	1620	26.0	2440	39.0	2210	35.0	6280
Northern Europe	4730	24.0	8360	42.0	6780	34.0	19900
North America	12100	19.0	30100	46.0	22600	35.0	64900
Middle East and Northern Africa	473	28.0	787	46.0	443	26.0	1710
Eastern Europe	3160	24.0	7060	53.0	3070	23.0	13300
East Asia	31	30.0	71	68.0	2	2.0	104
Australia and New Zealand	2650	19.0	6230	45.0	4990	36.0	13900

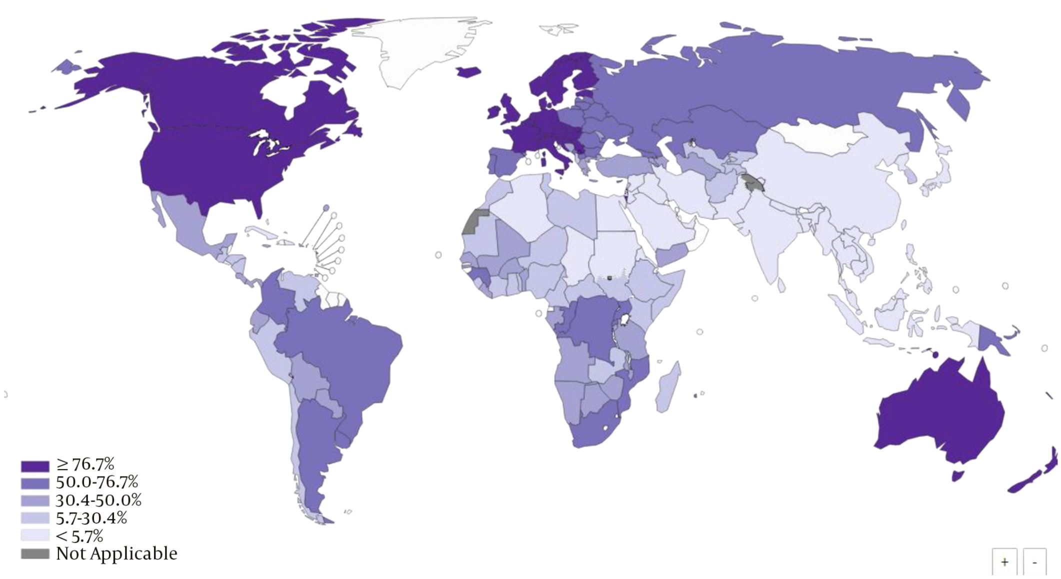

Figure 1. Global map presenting PAF of melanoma cases attributable to UV radiation exposure worldwide among men and women of all ages (30+ years) by country in 2012 (source: GLOBOCAN 2012).

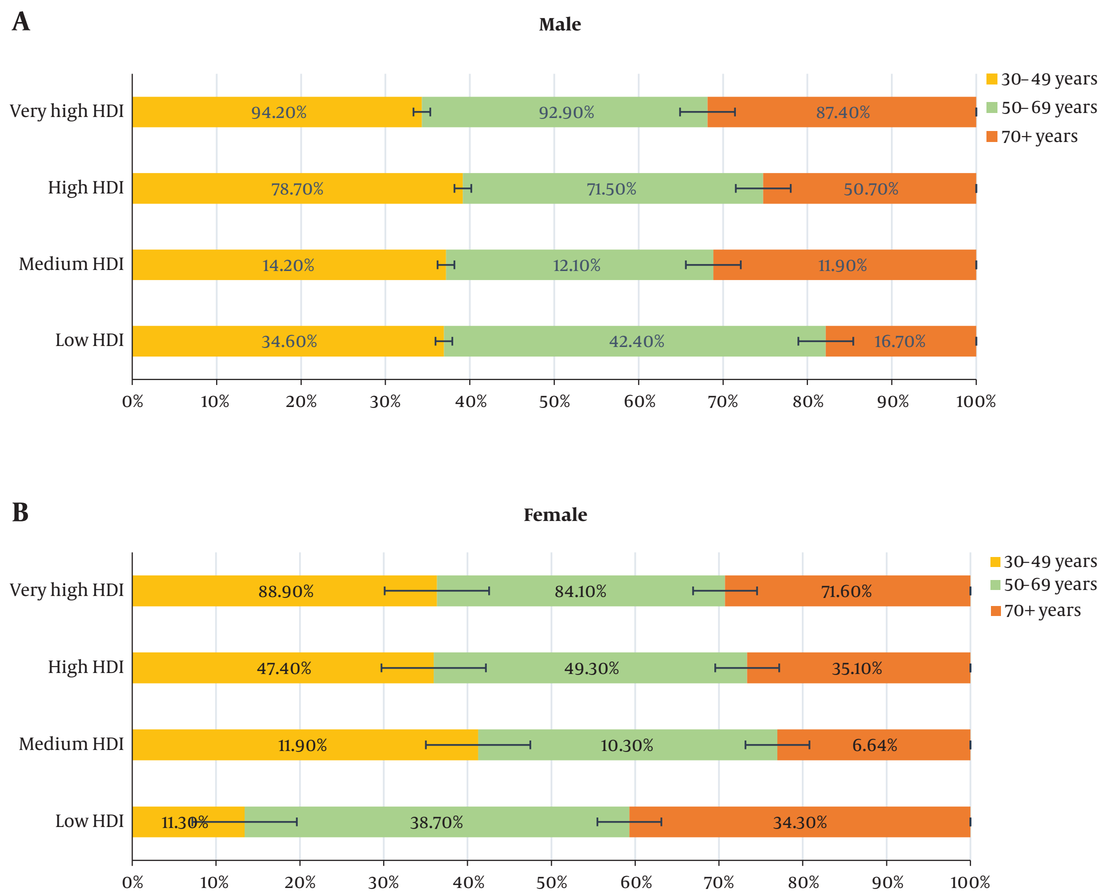

Figure 2. Bar charts show the distribution of UV-related melanoma in terms of HDI components for a: Male and b: Female in 2012 (source: GLOBOCAN 2012).

Table 3. Mean Fraction of Melanoma Attributable to UV in Different HDI Regions in 2012[a, b]

HDI Components	Fraction of Melanoma Attributable to Ultraviolet (UV)		
	Female	Both	Male
Very high human development	60.4 ± 32.3	68.0 ± 29.8	73.8 ± 29.5
High human development	20.4 ± 21.4	32.58 ± 24.6	42.9 ± 29.8
Medium human development	15.0 ± 20.3	20.21 ± 22.1	26.1 ± 25.1
Low human development	26.0 ± 21.7	29.4 ± 19.3	30.0 ± 22.6
F-test	23.7	25.1	21.61
P value	< 0.0001	< 0.0001	< 0.0001

[a] Values are expressed as mean ± SD.
[b] Statistical method: analysis of variance (ANOVA).

Avoiding UVR, especially during childhood and adoles-

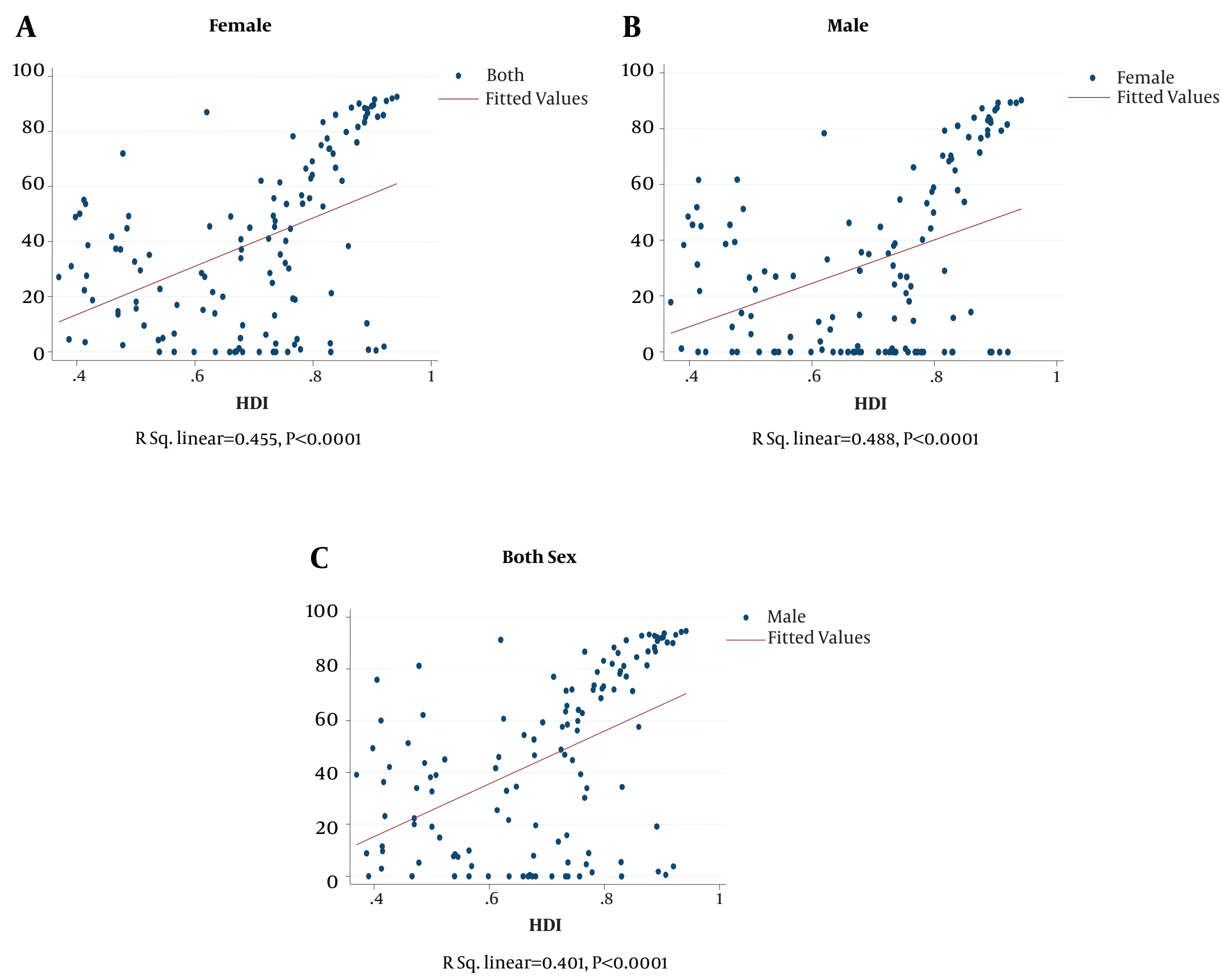

Figure 3. The correlation between HDI and the fraction of melanoma attributable to ultraviolet (UV) worldwide in 2012.

cence, which is a sensitive age for UV carcinogenesis, and UVR protection using appropriate garment and cover can reduce the risk of cancer at the old ages (28, 29). The incidence of skin cancer rises significantly with age, which is probably due to long-term exposure to environmental carcinogens and cancer development (30). Studies have shown that protecting individuals against the harmful effects of UVR during outdoor activities can lead to a dramatic drop in melanoma (31).

5.1. Conclusions

Melanoma is one of the most common cancers in the world, and UV radiation is its major risk factor. Since our study exhibited a positive correlation between the ratio of UV-related melanoma and HDI, further attention should be paid to this risk factor, particularly in countries with high HDI scores. Accordingly, restricting the level of exposure to UV radiation can effectively reduce UV-related melanoma cancer.

Footnotes

Authors' Contribution: None declared by authors.

Conflict of Interests: The authors declare no conflict of interest.

Ethical Approval: Code of ethics this article was IR.KMU.REC.1398.276.

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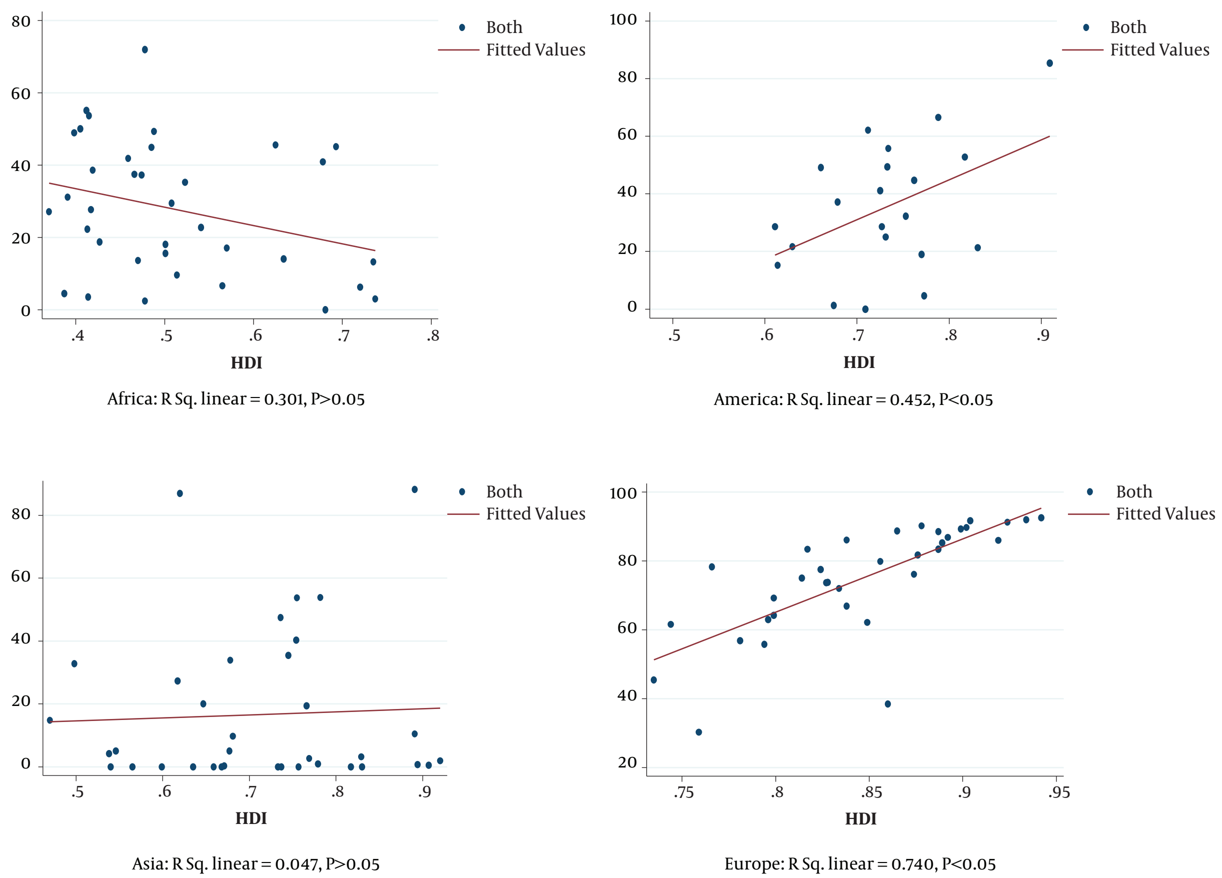

Figure 4. Correlation between HDI and the fraction of melanoma attributable to ultraviolet (UV) in each continent in 2012.

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Table 2. Fraction of Melanoma Attributable to UV Radiation Exposure Among Men and Women of All Ages (30+ Years) by Country in 2012 (source: GLOBOCAN 2012)

Country	Fraction of Melanoma Attributable to Ultraviolet (UV)		
	Male	Female	Both
Asia	-	-	-
Kuwait	-	0.0	0.0
Jordan	0.0	0.0	13.2
United Arab Emirates	5.45	0.0	72.4
Saudi Arabia	0.0	0.0	6.2
Israel	92.4	83.3	14.0
Qatar	-	-	-
Bahrain	-	-	2.97
West Bank and Gaza Strip	95.2	70.7	-
Syrian Arab Republic	0.0	0.0	40.9
Lebanon	30.2	11.1	18.1
Iraq	0.0	0.0	15.6
Turkey	59.9	21.0	-
Kazakhstan	73.7	0.0	-
Oman	-	-	49.3
Uzbekistan	19.6	35.7	45.1
Georgia	64.2	26.9	45.6
Azerbaijan	44.8	27.3	-
Iran	4.66	0.0	-
Armenia	58.6	38.9	9.56
Turkmenistan	52.9	13.2	17.0
Kyrgyzstan	34.5	0.0	29.8
Mongolia	-	-	37.4
Malaysia	1.51	0.0	22.3
Yemen	38.1	26.7	37.2
Darussalam Brunei	-	-	53.7
Singapore	3.82	0.0	27.6
Republic of Korea	19.2	0.0	44.8
Japan	1.75	0.0	38.6
Tajikistan	46.1	0.816	2.35
China	0.53	0.0	-
Maldives	-	-	55.1
Thailand	0.0	0.0	72.0
Philippines	0.42	0.0	6.28
Bhutan	-	-	50.1
Democratic People's Republic of Korea	0.0	0.0	35.2

Pakistan	7.58	0.0	-
Sri Lanka	0.0	0.0	22.8
Indonesia	7.89	0.0	13.6
India	0.0	0.0	41.8
Lao People's Democratic Republic	1.85	0.0	-
Nepal	0.0	0.0	67.4
Myanmar	0.0	0.0	44.9
Timor-Leste	91.3	78.4	48.9
Afghanistan	22.4	0.0	4.45
Cambodia	7.34	0.0	6.57
Viet Nam	0.0	0.0	27.1
Bangladesh	0.0	0.0	27.6
Europe			29.5
Czech Republic	92.9	84.0	31.1
Malta	79.2	69.1	3.46
Spain	81.5	71.5	53.5
Cyprus	71.5	53.8	18.7
Luxembourg	90.9	82.3	
Germany	90.1	81.6	38.4
Ireland	92.2	87.5	90.5
Hungary	86.3	68.4	52.8
Slovenia	93.3	87.3	85.4
Poland	77.2	58.0	32.3
United Kingdom	92.0	86.7	-
Portugal	78.1	70.4	-
Serbia	86.8	66.2	21.2
Lithuania	81.3	65.1	
Belgium	86.9	84.1	19.0
Slovakia	91.2	81.1	45.4
Finland	92.8	83.0	66.5
Bosnia and Herzegovina	65.8	24.1	44.7
Austria	88.5	77.9	49.4
Iceland	88.0	84.6	-
Croatia	88.3	79.3	21.6
Switzerland	94.4	89.4	1.31
Italy	86.9	76.7	37.2
Greece	57.6	14.3	41.1
Bulgaria	72.0	40.3	55.7
Montenegro	83.2	50.0	62.1
Latvia	82.1	70.4	25.0
France	88.0	79.4	28.6

Russian Federation	73.4	59.0	0.0
Netherlands	93.4	89.9	15.1
The former Yugoslav Republic of Macedonia	81.8	63.0	4.6
Norway	94.8	90.3	49.2
Albania	39.4	18.1	-
Sweden	93.8	89.4	28.6
Belarus	72.5	57.4	-
Africa	-	-	-
Egypt	0.0	0.0	-
Libya	15.8	11.9	0.0
South Africa	83.4	61.6	3.12
Tunisia	13.3	0.0	0.0
Morocco	21.6	12.4	88.2
Mauritius	-	-	-
Algeria	5.37	0.0	-
Swaziland	-	-	77.9
Gabon	52.6	29.2	0.0
Cameroon	32.8	6.34	19.4
Mauritania	19.1	12.7	0.0
Djibouti	-	-	40.3
Cabo Verde	-	-	53.8
Zimbabwe	43.7	51.2	-
Botswana	59.5	35.0	9.68
Namibia	60.8	33.1	53.7
Equatorial Guinea	-	-	35.4
Lesotho	-	-	2.59
Nigeria	14.9	0.0	47.5
Ghana	3.89	27.3	33.9
Cote d’Ivoire	48.7	7.94	20.0
Benin	0.0	45.6	-
Sierra Leone	2.84	31.3	0.87
Senegal	33.9	39.3	32.8
Guinea	9.67	61.6	-
South Sudan	36.3	21.8	1.86
United Republic of Tanzania	46.9	43.8	10.4
Liberia	23.2	45.1	0.73
Sudan	5.19	0.0	27.3
Comoros	-	-	0.53
Congo	60.0	51.8	-
Uganda	81.3	61.7	0.0
Somalia	14.7	3.68	0.23

Mozambique	75.8	45.6	-
Angola	45.1	28.8	0.0
America			86.8
Puerto Rico	58.8	14.9	86.0
United States of America	94.3	84.8	89.7
Argentina	72.1	29.0	77.5
Canada	90.4	79.3	90.2
Mexico	56.2	1.1	66.9
Bahamas	-	-	89.3
Belize	-	-	73.7
Chile	34.4	12.1	78.3
Barbados			72.0
Venezuela (Bolivarian Republic of)	34.0	0.0	85.3
Trinidad and Tobago	65.2	15.7	86.1
Uruguay	78.8	53.4	88.5
Costa Rica	63.0	23.5	45.4
Panama	63.6	31.0	83.3
Suriname	-	-	86.1
Nicaragua	33.0	7.95	83.4
El Salvador	0.0	2.04	92.0
Paraguay	46.6	29.1	81.7
Ecuador	48.9	35.3	38.4
Brazil	71.7	38.0	56.8
Colombia	77.0	44.9	69.2
Peru	46.9	1.2	75.0
Guatemala	41.7	10.7	83.5
Dominican Republic	0.0	0.0	64.2
Honduras	25.5	3.68	91.5
Cuba	8.99	0.0	72.8
Bolivia (Plurinational State of)	54.5	46.3	92.6
Guyana	-	-	30.2
Jamaica	57.7	0.0	91.7
Haiti	-	-	63.0
Onia			55.8
Australia	97.5		79.8
New Zealand	97.5		91.2
			61.5
			45.7