Skin Cancer due to UV Radiation Worldwide and its Identification

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Abstract— The objective of this work is to study the effect of UV radiation on human skin causing skin cancer. This is a review-type article that gives information on the phenomena of damaging the DNA of skin cells by UV rays and the result is skin cancer. Mainly there are two types of skin cancer melanoma and non-melanoma caused by UV radiation. After initiating the skin cancer by damaging the DNA the infection or cancer cell grows slow and increases the cancer cell quantity. The increase leads to serious or fatal if they are not cured in time. Skin cancer is rapidly growing day by day and one in five (lifetime) has skin cancer in the USA and one in three (not lifetime) has skin cancer in Australia. Therefore, one should have aware of skin cancer protection and prevention that would decrease skin cancer among people.

Index Terms— UV radiation, Skin Cancer, USA and Australia, Fatal, DNA, melanoma, non-melanoma.

1 Introduction

1.1 Introduction to skin cancer

Skin cancer is abnormal cells that grow in the skin this is due to UV radiation damage. It is of three types mainly Basal cell carcinoma (BCC), Squamous cell carcinoma (SCC), and Melanoma. BCC is most common and least dangerous with slow growth in the head, neck, and upper torso region. BBC appears as a lump or dry, scaly area with red, pale, or pearly color. SCC is less common than BCCs in humankind but SCC spread to other parts of the body if treatment is not taken. The growth takes some months and appears on skin exposure to UV radiation. It is physical appearance is thicker, red, scaly spot, bleed easily, crust and ulcerate. Melanoma skin cancer is life-threatening it takes about six weeks to identify and spreads to different parts of the body when not treated in time.

A study by Gallagher in 2010 reported that about 90% of skin cancer cases are caused by UV radiation overexposure. Robbins reports in 2016 that non-melanoma cancer recorded 5.4 million cases in the United States and Katalinic in 2012 estimate malignant melanoma in Europe and the United States has almost tripled in the last 30 years. According to Robbins, it is estimated that one person will die from melanoma every hour and accounts for melanoma as the majority of deaths of skin cancer. About 86% of melanomas come due to over-exposure to UVR.

1.2 The skin layer and identification of Skin cancer

The skin is the largest organ of the body with sensitivities of hot and cold. It contains a three-layer Epidermis, Dermis, and Subcutis. The epidermis is a very thin and upper layer that protects the deeper layers from external factors or agents like sunlight, temperature changes, and infections. The Dermis is a thicker layer that contains hair follicles, nerves, blood, and lymph vessels. The Subcutis is a collagen-insulated layer with the deepest fat, abundant blood, and lymph vessels. Most skin cancers develop in the epidermis layer.

In the epidermis layer, new skin cells are developed and the layer is called basal cells. As cells age, they move upwards towards the surface and become thin called squamous cells. Basal cells are brown tan pigments that help to formation of melanocyte cells. The visualization is shown in Figure 1 below [1].

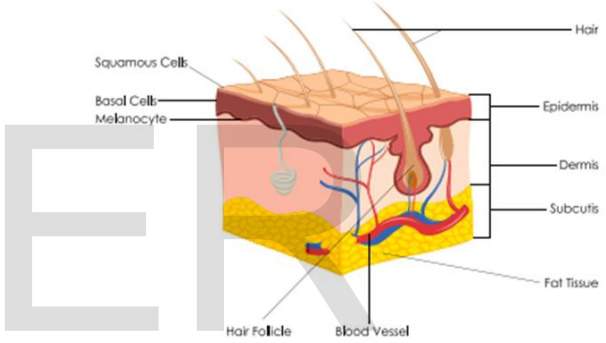

Figure 1: Different layers of human skin [1].

Mainly NMSCs are of two types BCC and SCC both derived from epidermal keratinocytes. NMSCs are less deadly than melanoma and found in the areas of skin (face and arm) most exposed to UV. Most of NMSCs are effectively treated by local control measures alone (resection, MOHS microsurgery, or cryosurgery). Epidemiologic and molecular data shows that skin cancer due to UV exposure cause nearly 65% of melanoma and 90% of non-melanoma skin cancers. UV-signature mutations are cancer-relevant genes such as the p53 tumor. The UV-induced DNA mutations for melanoma and other skin cancers [2],[3],[4].

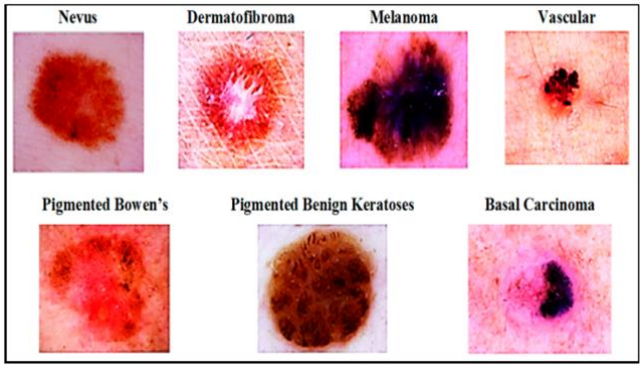

Figure 2: Skin disease categories from international skin imaging

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collaboration dataset [5].

1.3 UV radiation with Impacts on Humankind

Exposure of humans to solar ultraviolet radiation has well and band impacts on health. The over-exposure of human health with less or non-protective skin part to UV radiation cause skin cancer was observed by researchers and different organizations. The current report shows that the diseases caused by UV radiation is increasing globally. On another hand, moderate exposure to UV radiation to human skin produces a sufficient amount of vitamin D which is essential for bone. Therefore, knowledge about UV radiation and its exposure is very important to every humankind [6]. Second International Congress categories UVs Light in 1932 into three types UVA (400-315nm) UVB (315-280nm) and UVC (280-100nm). But for environmental and dermatological photobiologists divisions of UVs are different that is UVA (400-320nm), UVB (320-290nm), and UVC (290-200nm). Among these three UVs radiation, UVC is absorbed ozone present in the atmosphere while more than 90% of UVB is absorbed but UVA is little change. The penetration depth of UVA to human skin high than UVB. This is because UVB is absorbed by DNA– subsequent damage [7],[8],[9].

UV measure in purely physical units or weighted using an erythemal response function to give biologically effective and its unit is joules per square meter (Jm^{-2}). The minimal erythemal dose (MED) differs from the skin to skin (skin type) similarly standard erythemal dose (SED) is also dependent upon the type of skin. The SED has been developed as an erythemal weighted measure of radiant exposure, equivalent to 100 Jm^{-2}[10].

2 Literature Review

2.1 Worldwide status of Skin cancer

The most common skin cancer skinned populations around the world are melanoma, and nonmelanoma skin cancers (NMSCs). In addition, basal and squamous cell carcinomas (BCC and SCC, respectively) can't be neglected. Melanoma mainly leads to mortalities while NMSCs have locally aggressive features. A report shows about 132,000 new cases of melanoma occur worldwide each year. WHO estimates 65,161 people die worldwide per year from malignant skin cancer. American Academy of Dermatology (AAD) estimated 121,840 new melanoma case in 2009 with 8650 deaths [11],[12]. Skin cancer is the most common type of cancer in different parts of the world and morbidity and mortality rates of skin cancers are increasing. Ultraviolet radiation (UVR) is the major medicine agent that develops skin cancers by damaging DNA and genetic mutations which lead to skin cancer. Several factors influence the UVR reaching the earth's surface like the ozone layer, elevation, latitude, altitude, weather conditions, etc. The unnecessary exposure to sun and artificial UVR has attributable risks [13].

Skin cancers are the most common malignancies of humans, roughly 1 in 5 Americans will develop skin cancer in their lifetime and nearly 15,000 deaths. In addition, more than three billion dollars each year in medical costs in the United States alone [14],[15]. Melanoma accounts for about three-quarters of all deaths from skin cancers (ten thousand per year) in the U.S. Many melanomas can be managed by surgical excision alone but doctors also used different types of therapies. The increase of melanoma is dramatically over the past several decades without any scientific reason but assume that multifactorial, increased UV exposure, environmental, inherited cancer risk factors, better surveillance, etc. [16],[17],[18].

New Zealand has a relatively high peak UVI in earlier studies that are the UVI at Lauder of New Zealand is 40% greater than North America at the same latitude. The spectral irradiance measurements at sites in New Zealand, Australia, and the USA were based on NIWA-designed spectrometers. The daily doses in SED (1 SED =100 Jm^{-2} of UV_{Ery}) and people are recommended to use protection against sun damage when UVI exceeds 3. In addition, UV doses in Australia are greater than in New Zealand. The UV in New Zealand is relatively high in northern latitudes because of lower summer ozone, less Earth-Sun separation, unpolluted air, etc. [19].

2.2 Necessary dose of UV for better human health

World Health Organization (WHO), the United Nations Environment Programme (UNEP), World Meteorological Organization, and International Commission on Non-Ionising Radiation Protection (ICNIRP), and is standardized by ISO/CIE are commonly effort to protect humankind for UVR. A UV index expresses the erythemal power of the sun as $40 \times E_{eff} W.m^{-2}$. The limit value of UV index was studied by the American Conference of Governmental Industrial Hygienists (ACGIH) and ICNIRP as the maximal daily dose about $30Jm^{-2}(eff)$, this is less than 1/3 of SED [20].

Table 1: UV index and Standard erythemal Dose [20]

UV index	Number of SED/hr	Power of Sun	Duration of Exposure equivalent to 1SED
1	1	Weak	2hr 20m
2	2	Weak	1hr 10m
3	2.5	Medium	45m
4	3.5	Medium	35m
5	4.15	Strong	30m
6	5	Strong	25m
7	6	Very strong	20m
8	7	Very strong	18m
9	8.5	Extreme	16m
10	9.5	Extreme	14m
11	10.5	Extreme	12m

The average time of tanning dose with UVB is less than 7.15 min while UVA is up to nearly five hours for longer wavelengths. As color plays an important role in the absorption of light, therefore, skin color also affects the absorption of UV. Nielsen et al. in 2004 studies that visible light has high reflectivity on light skin but reflectivity below 300 nm to 330 nm is greater in dark skin [21]. UVB also affects the immune system because part of the immune system is in the outer layers of skin and helps the body to fight the body was studied by many authors (De Gruijl, 1995; Longstreth et aI., 1998; Chapman, 1995).

2.3 Absorption of UVR by DNA molecules

The optimal absorption of UV light by DNA is 254nm and at this wavelength radiation has a high carcinogenic activity and causes skin cancer. The penetration of UVC to the skin is high and causes strongly mutagenic but does not reach to earth's surface. About 90-95% of UVA and about 5-10% UVB reach the earth's surface. UVA causes skin photoaging by dermal fiber deterioration, and it is far less carcinogenic compared to UVB radiation. UVB has a direct

mutagenic effect on DNA as it is maximally absorbed by this primary chromophore. UV radiation can give rise to cellular DNA damage by either direct excitation of DNA or by the indirect excitation of other endogenous non-DNA chromophores [22].

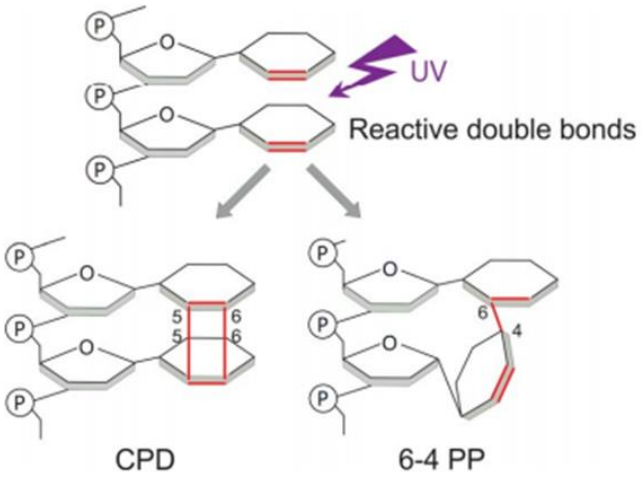

Figure 3: Absorption of UV by DNA and formation of cyclobutane-pyrimidine dimers (CPDs or 6-4PP) [22].

The mechanism of skin carcinogenesis is still not fully understood and multiple studies are going on the molecular pathways activating. Some authors show reactive oxygen species produced by ultraviolet radiation, oxidizers, or metabolic processes can damage cells and initiate pro-inflammatory cascades. Therefore, therapy is considered the best treatment of skin cancer [23].

2.4 Different Effect of UVR on humankind

UVR is classified as a carcinogen because it is both a mutagen and a non-specific damaging agent with tumor initiator and tumor promoter. UVR has complex and mixed effects on human health that is excessive exposure to UV has health risks [24]. UVR (245-290 nm) is absorbed by DNA and UVR can create mutagenic photoproducts in DNA between adjacent pyrimidines (collectively call dimers). The dimers are of two types (cyclobutane and pyrimidine dimers). The mutations lead to loss of cell cycle control and carcinogenesis UV radiation is a complete carcinogen. UVR also acts as a promoter with initiating events inside the cell (DNA mutations arising from DNA polymerase). UVA is a far less efficient carcinogen and acts as an initiator with UVB as a promoter in skin carcinogenesis. Mutations in genomic DNA can lead to carcinogenesis through changes in the function of genes that influence cell growth [25].

Carcinogenesis involves three stages and they are initiation, promotion, and progression. Mutations in the DNA may act as initiating events and dormant for several years for a promoting agent to occur. Promoter's later initiating events to cause progression into tumor development. It has been estimated that 3 to 7 mutational events take place to transform normal cells into cancer cells. Since skin contains protective mechanisms to prevent DNA damage from UV and one mechanism is arrest followed by DNA repair and the other is cell death by apoptosis. The failure of such a mechanism result in abnormal cell proliferation [26].

UVR has a positive and negative effects on the human system (positive synthesis of vitamin D and negative on the skin as sunburn, phototodermatosis, photoaging, precancerous, neoplastic skin lesions, etc.). UVA radiation causes erythema very quickly and is irritating to the conjunctiva and the cornea of the eye. It is recognized that UVA radiation is over 1000 times less mutagenic than UVB radiation but not no facts are found. In addition, UVB affects fibroblasts, dendritic cells of the skin, vascular endothelial cells, T-lymphocytes, mast cells, and granulocytes and UVA causes photoallergic and phototoxic reactions which form free radicals [27].

The cytotoxic effect of UVA radiation is less than UVB radiation. The genotoxic effect is mediated through an indirect mechanism. The skin exposed to UVA causes oxidative stress in keratinocytes and damage keratinocyte stem cells which are called daughter cells. The UVB radiation results, DNA is covering the aromatic rings and the result is 6,4-pyrimidone (6,4-PP) photoproduct and cyclobutanol pyrimidine dimers (CPDs). UVB breaks the bonds between the pyrimidine bases that formed cyclobutane pyrimidine or dipyrimidine dimers which is mutagenic properties [28],[29],[30].

2.5 Development and growth of skin cancer with gender

A report shows that gender also plays an important role to develop skin cancer. This is because IL-6 and TNF-α protein expressions are more elevated in males than females with UVR exposure, studies are based on animals (mouse). In addition, sex hormones show tumor development in the skin is different, estrogen could play a protective role in skin physiology.

2.6 The penetration depth of UVR in Human skin

The penetration of UVR depends upon wavelength and types of skin and Meinhardt et al. analyzed that phototype I: n=3; II: n=7; III: n=5; IV: n=5, revealing large variability between individuals [31]. Various types of laser with different energy and intensity are used in the industry and medicine field for the treatment of skin diseases. Therefore, the molecular effects of irradiation of different wavelengths of light on the dermal cells are equally important to studies. The penetration depth of different lasers is shown in figure 4 below. Figure 4 shows that the penetration depth is high as the wavelength increase.

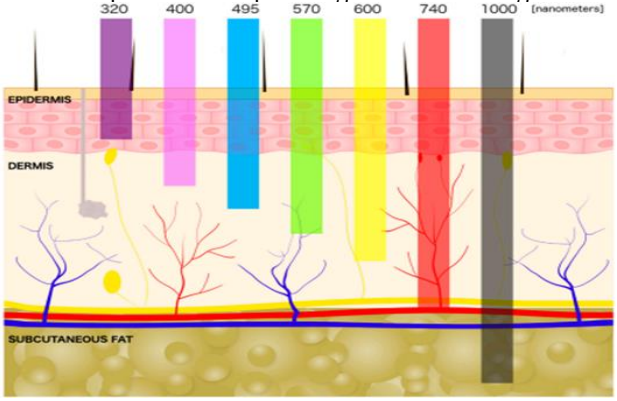

Figure 4: penetration depth of different wavelengths of light [32].

3 Conclusion

Studies show that several factors affect UVR coming from the sun. The UVR that reaches the earth's surface has both positive and negative impacts on humankind. Here the impact is skin cancer due to UVR. Review and literature show that skin cancer is increasing day by day. The increasing skin cancer among people increases the medi-

cal expenditure for the treatment of the disease. Numbers of research are going on to study the increasement of drastic skin cancer (a record) because it now it is unknown/unclear. Similarly, skin cancer studies are based on UVR but skin cancer due to other factors are not studied. Skin cancer is due to UVR because UVR can cause molecular phenomena damage and cause the abnormal growth of the cell.

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