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Sunscreen Science

Formulations, Efficacy and Best Practices

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CHAPTER 3

Role of Ozone Layer and Climate Effects on Skin

Rohit Batra, Sanjeev Gupta, Aditi Dabhra

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CHAPTER AT A GLANCE

- The Sun's energy drives life on Earth, but 5% of sunlight is ultraviolet (UV) radiation, particularly UVB (280–320 nm), which can harm human health if unfiltered by the ozone layer.
- The ozone layer (10–50 km altitude) absorbs 97–99% of harmful UVB and UVC rays, protecting against skin cancer, cataracts, and ecosystem damage.
- Ozone depletion, mainly from human-made substances like chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons—has led to seasonal ozone holes, notably over Antarctica, but global efforts like the Montreal Protocol (1987) have shown promising signs of recovery.
- Climate change and ozone depletion are interlinked, as greenhouse gases alter stratospheric temperatures, affecting ozone formation and destruction cycles.
- Increased UV exposure from ozone thinning can cause sunburn, tanning, photoaging, and all types of skin cancer [basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma]; UVB is the most carcinogenic.
- Behavioral factors, such as outdoor activity, vacations, clothing choices, and sun protection habits, heavily influence personal UV exposure especially in children and during warmer months.
- Climate change raises temperatures, leading to longer outdoor exposure, increasing the risk of sunburn and skin cancer, especially in moderate temperature ranges (19–27°C), as people seek sun without sufficient protection.
- Studies project a temporary mid-century rise in skin cancer rates, even with ozone recovery, due to past UV exposure latency and climate-driven behavioral changes.
- Tools like the Global Solar UV Index and public health education on sunscreen use, protective clothing, and sun avoidance are essential to mitigate future UV-related skin health risks.

INTRODUCTION

The sun is fundamental to the origin and sustenance of life on Earth. Its infrared radiation provides warmth, while our eyes perceive the visible portion of its spectrum, enabling sight. More importantly, visible light is indispensable for photosynthesis, which is the process that allows plants—an essential part of the food chain—to generate energy. Beyond serving as the primary source of food and energy, sunlight plays a crucial role in regulating human biochemical processes, influencing growth rates, and maintaining biological rhythms. However, a small but significant fraction of sunlight, approximately 5%, consists of ultraviolet (UV) radiation, which may pose risks to human health if exposed for long. The shorter wavelengths in the UVB range (280–320 nm) are particularly harmful. The extent to which these rays reach the Earth's surface depends largely on the presence of stratospheric ozone, which acts as a protective barrier. In recent years, concerns have grown regarding the interplay between ozone depletion and climate change, as both factors could influence human exposure to terrestrial UV radiation.

OZONE LAYER

The ozone layer is a region of Earth's stratosphere (about 10–50 kilometers above the surface) that contains a high concentration of ozone (O_3) molecules. Although ozone is present in small amounts, it plays a vital role in absorbing the majority of the Sun's harmful UV (UV-B and UV-C) radiation.

Functions of Ozone Layer

- *UV radiation absorption:* Blocks 97–99% of harmful UV rays, preventing skin cancer, cataracts, and immune suppression in humans
- *Climate regulation:* Indirectly affects climate by influencing stratospheric temperature and wind patterns
- *Protecting ecosystems:* Shields terrestrial and marine ecosystems from harmful UV rays, enabling normal biological processes

While ozone depletion and climate change are different issues, they are somehow interconnected. Ozone-depleting substances (ODS) such as chlorofluorocarbons (CFCs) are also greenhouse gases, contributing to global warming. Climate change affects stratospheric temperatures, influencing ozone formation and destruction. Recovery of the ozone layer is influenced by changing climate dynamics. The Antarctic ozone hole is the most prominent sign of ozone depletion, appearing every southern hemisphere spring (August–October). Extreme cold temperatures in the Antarctic stratosphere allow for the formation of polar stratospheric clouds (PSCs). These clouds facilitate chemical reactions that activate chlorine and bromine compounds, which rapidly destroy ozone when sunlight returns. This seasonal hole has been monitored since the 1980s and is slowly healing due to global interventions.

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OZONE LAYER BALANCE

The ozone layer maintains a balance through the natural ozone-oxygen cycle. However, this balance is disrupted by man-made chemicals and a few natural causes **(Box 1)**.

- *Formation:* UV radiation splits oxygen (O_2) into individual oxygen atoms, which then combine with other O_2 molecules to form ozone (O_3).
- *Destruction:* Ozone naturally breaks down into O_2 and an oxygen atom when struck by UV light, releasing heat in the process.

EFFECTS OF OZONE LAYER DEPLETION

The effects of ozone layer depletion are as follows:

- *On humans:* Increased *UV radiation exposure* can lead to:
  - Skin cancers (especially melanoma)
  - Cataracts and eye damage
  - Immune system suppression
- *On plants:*
  - Reduces photosynthesis and stunts growth
  - Affects crop yields
  - Alters plant physiology and reproduction
- *On marine life:*
  - UV radiation penetrates surface waters, damaging phytoplankton, the base of aquatic food webs
  - Affects larval stages of fish, shrimp, and other marine organisms
  - Disrupts nutrient cycling in oceans

ENVIRONMENTAL FACTORS

Ozone depletion increases UV radiation, while climate change influences exposure through changes in cloud cover, aerosols, and human behavior. These alterations

BOX 1 Causes of ozone depletion.

Human-made causes:

- Chlorofluorocarbons (CFCs) emissions
- Emission of hydrochlorofluorocarbons (HCFCs)
- Halons
- Rocket launches
- Chlorine monoxide (ClO) reaction
- Additional chemicals contribution

Natural causes:

- Volcanic eruptions
- Sunspots and solar activity
- Natural atmospheric chemistry

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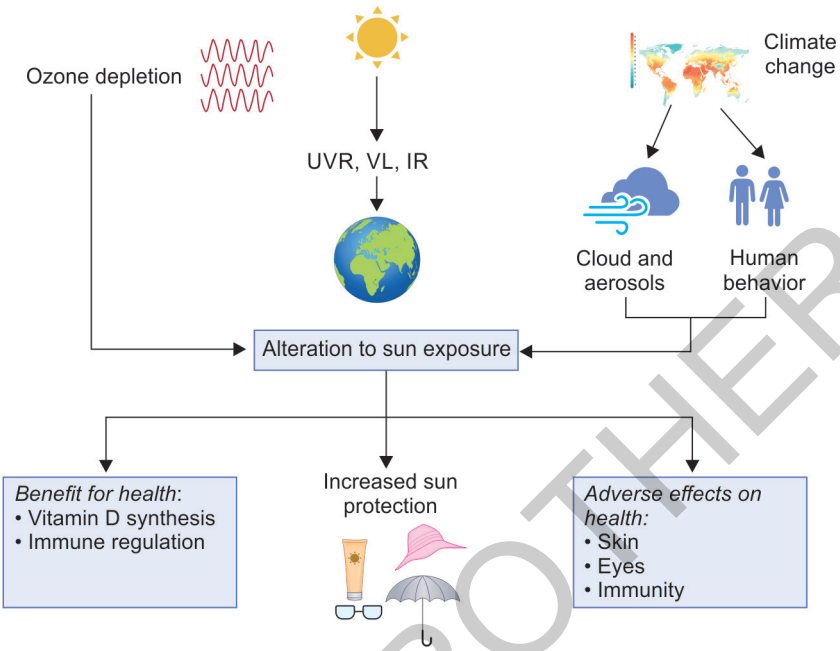

FIG. 1: Environmental factors influencing ultraviolet exposure to human skin.
(IR: infrared; UVR: ultraviolet radiation; VL: visible light)

have both positive and negative consequences. On the beneficial side, sun exposure supports vitamin D synthesis and immune regulation. However, excessive exposure poses risks to the skin, eyes, and immune system, leading to increased sun protection measures such as sunscreen, hats, sunglasses, and umbrellas **(Fig. 1)**.

OZONE DEPLETION

Since the late 1970s, significant decreases in atmospheric ozone levels have been observed globally. In the northern hemisphere, during the 1990s, ozone depletion was particularly prominent, with a loss rate of approximately 6% per decade in winter and early spring at the mid-latitudes (30–50°N). In contrast, the rate of loss during the summer months, when UV radiation levels are higher and people are more exposed to the sun, was lower, around 3% per decade. By the early 2000s, ozone loss in mid-latitudes appeared to stabilize, with a reduction of approximately 4% in winter/spring and 2% in summer/autumn. Recent data suggests that the rate of ozone depletion in the upper stratosphere has slowed, with evidence supporting this trend emerging throughout the early 2000s. This has been attributed to various factors, including the success of international agreements like the Montreal Protocol, aimed at phasing out ozone-depleting chemicals. As a result, ozone levels in certain regions are showing signs of recovery.

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Biogeochemical Cycles and Ozone Depletion

Ozone depletion indirectly impacts:

- *Carbon cycle:* Less phytoplankton means reduced carbon fixation
- *Nitrogen cycle:* UV affects microbial activity in soils and oceans
- *Oxygen cycle:* Reduced plant growth impacts oxygen release

Greenhouse gases trap heat in the troposphere but cool the stratosphere, enhancing ozone destruction. Changes in wind and temperature patterns due to global warming can alter ozone distribution and recovery rates.

MONTREAL PROTOCOL

Signed in 1987, it is a global agreement to phase out the production and use of ozone-depleting substances. The Montreal Protocol has led to a 93–99% reduction in the consumption of controlled ozone-depleting substances. It has resulted in early signs of ozone recovery, including the shrinking of the Antarctic ozone hole.

Amendments and Adjustments

- *Kigali Amendment (2016):* Phases down hydrofluorocarbons (HFCs) and potent greenhouse gases (though not ozone-depleting)
- Recognized as one of the most successful international environmental agreements

AIR POLLUTION: EFFECTS ON OZONE LAYER AND GLOBAL TEMPERATURE

Air pollution contributes to both the degradation of the ozone layer and changes in temperature. Certain chemicals—such as chlorofluorocarbons (CFCs) and halons—released by industrial activities, were historically major culprits in depleting the stratospheric ozone, which normally shields Earth from harmful UV radiation. Although many of these substances have been phased out under international agreements, some pollutants continue to affect ozone recovery.

At the same time, pollutants such as greenhouse gases (e.g., carbon dioxide and methane) and black carbon from incomplete combustion enhance the greenhouse effect, trapping heat in the atmosphere and leading to global warming. Additionally, particulate matter can influence cloud formation and reflect or absorb sunlight, which further contributes to regional temperature changes.

ULTRAVIOLET RADIATION-TRENDS AND DISCREPANCIES

Despite the observable decrease in ozone, predictions for the increase in terrestrial erythemal-effective UV radiation, particularly in the UVB wavelength, were not fully supported by ground-based monitoring programs. Calculations for the

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period from 1979 to 1992 suggested that UV radiation would increase by <1% per decade near the equator, and by 5% per decade at higher latitudes (50–60°N). However, these projections have not always aligned with UV monitoring data.

Several factors may explain the discrepancies in the predicted and observed UV radiation trends, including the relatively short duration of most UV monitoring networks, the impact of fluctuating cloud cover, and instrument calibration issues. Additionally, the accumulation of ozone and aerosols in the lower atmosphere because of pollution could obscure the effects of ozone depletion on UV radiation. Ongoing improvements in data quality, such as through international intercomparisons of instrumentation, are gradually reducing these uncertainties.

Long-term Ultraviolet Measurements and Confounding Factors

Ground-based measurements of erythemal UV radiation from 1989 to 2002, conducted by the United Kingdom National Radiological Protection Board (NRPB), indicated an upward trend of about 12% per decade in UV radiation. However, this result was subject to considerable uncertainty, with a confidence interval ranging from 3 to 20%. This trend may not directly reflect the effects of ozone depletion, as it was also influenced by confounding factors such as cloud cover. The number of hours of bright sunshine during the same period was weakly correlated with the measured UV levels, suggesting that variations in cloud cover might play a role in explaining the observed increase in UV radiation.

Future Projections of Ultraviolet Radiation and Ozone Recovery

Looking ahead, projections indicate that UV radiation will change little over the next decade, with levels expected to return to those of 1980 by the mid-21st century, assuming all other factors remain constant. However, this assumption is not guaranteed. Various influences, such as interactions between ozone depletion and global warming, noncompliance with the Montreal Protocol, and potential future volcanic eruptions, could affect the rate at which ozone levels recover and, by extension, influence future UV radiation trends.

EFFECTS OF ULTRAVIOLET RADIATION ON SKIN

Ultraviolet radiation from the sun has a range of effects on the skin, some beneficial and others harmful. While skin responses to UV radiation are predominantly detrimental to health, there are some notable benefits, particularly in relation to vitamin D production.

Production of Vitamin D

The primary beneficial effect of solar UV exposure is the synthesis of vitamin D3, which is crucial for maintaining skeletal health. UVB radiation in sunlight is

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absorbed by the skin and converts sterol precursors, such as 7-dehydrocholesterol, into vitamin D3. This compound is further metabolized in the kidney and liver to produce 1,25-hydroxyvitamin D, the active form of vitamin D. This active form enhances calcium absorption in the intestines, supporting bone health. Additionally, there is some evidence suggesting that vitamin D3 may play a role in reducing the risk of certain cancers (e.g., colon, breast, and prostate) and may also help in preventing conditions like acute myocardial infarction, hypertension, and multiple sclerosis.

Tanning and Epidermal Hyperplasia

Tanning, or the delayed pigmentation of the skin, is a common consequence of UV exposure and is often regarded as desirable in many cultures. In addition to tanning, the skin has a protective adaptive response to limit any further UV damage, i.e., epidermal thickening or hyperplasia. This process, which begins about 72 hours after the exposure, is triggered by increased cell division in the lower epidermis. Over time, this leads to thickening of the epidermis. Unlike tanning, this adaptive response does not rely on genetics and is a significant protective factor, especially for those who tan poorly.

Sunburn

Sunburn, characterized by erythema caused by the dilation of blood vessels in the dermis, is the most immediate and obvious harmful effect of UV exposure. Erythema typically develops 2–4 hours after sun exposure, reaching its peak intensity between 8 and 24 hours. In more severe cases, sunburn can result in pain, swelling, and blistering. The skin may take several days to fully recover from sunburn.

Skin Cancer

Exposure to UV radiation is a major risk factor for the development of skin cancer. Approximately, 90% of skin cancer cases are nonmelanoma [basal cell carcinoma (BCC) and squamous cell carcinoma (SCC)], with BCC being about four times as common as SCC. UV radiation, both UVA and UVB, is recognized as a significant cause for all types of skin cancer. However, the specific wavelengths and exposure patterns that contribute to skin cancer risk remain under investigation, particularly for BCC and melanoma.

- *SCC:* SCCs primarily develop on sun-exposed skin areas (e.g., face, neck, and arms) and are closely linked to cumulative UV exposure. Incidence rates correlate with geographical latitude, with higher rates seen in sunnier regions. Studies suggest that sun exposure is a key risk factor.
- *BCC:* The connection between BCC and sun exposure is weaker than for SCC, but still significant. Unlike SCC, which is strongly related to lifetime sun exposure, childhood and adolescent sun exposure may play a more critical role in BCC development.
- *Malignant melanoma:* Melanoma incidence has risen in white populations over the past 50 years. An inverse relationship exists between latitude and

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melanoma incidence, suggesting that sunlight exposure may contribute to the disease. However, this pattern varies, as higher rates are observed in Scandinavian countries despite their lower sun exposure. Intermittent sun exposure, especially from recreational activities, has been linked to a higher risk of melanoma, with sunburn history being a significant risk factor.

Photoaging

Chronic UV exposure accelerates skin aging, a process known as photoaging. The clinical signs of photoaged skin include deep wrinkles, dryness, sagging, loss of elasticity, and uneven pigmentation. Photoaging is distinct from intrinsic aging, which occurs naturally over time (see Chapter 2 for details). UV radiation, particularly UVB and UVA wavelengths, is a major contributor to photoaging. UVB radiation, which is more strongly associated with skin cancer, also plays a significant role in the development of photoaged skin. The depletion of ozone may increase UVB exposure, potentially accelerating the photoaging process.

RISK ESTIMATES OF HUMAN SKIN CANCER ASSOCIATED WITH OZONE DEPLETION

The impact of ozone depletion on skin cancer incidence has been the subject of various studies, with one of the most sophisticated attempts to estimate this risk being provided by Slaper et al. and later discussed in the 1998 UNEP assessment. These estimates highlight the relationship between ozone depletion and skin cancer, specifically in terms of its potential effects on human health.

Impact of Ozone Depletion on Skin Cancer Incidence

According to a study done by Slaper et al. in 1996 and the 1998 UNEP report, the increased risk of skin cancer due to ozone depletion could not have been fully mitigated by the initial implementation of the Montreal Protocol. However, the subsequent amendments to the protocol are expected to provide effective control over this risk. Under the Montreal Amendments, the incidence of skin cancer in north-western (NW) Europe is predicted to peak around the middle of the 21st century, with an additional 90 cases per million people.

For a population such as the United Kingdom (UK), which is around 60 million, this translates to approximately 5,000 additional cases of skin cancer per year. This represents an 8% relative increase compared to the present incidence, which is around 60,000 cases annually. After this peak, the increase in skin cancer rates due to ozone depletion is also expected to nearly return to baseline by the end of the 21st century. This delayed response is due to the long latency period between UV exposure and the development of skin cancer, which can take several decades.

It is crucial to note that these risk estimates are based on the assumption of full global compliance with the Montreal Protocol and its amendments. If compliance with these restrictions were to decline in the future, the damage

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to the ozone layer could exceed current expectations, leading to more severe biological consequences, including a higher incidence of skin cancer.

Role of Human Behavior in Skin Cancer Risk

Additionally, skin cancer risk estimates are predicated on the idea that human behavior does not change. This is quite unlikely, though, considering skin cancer incidence doubles every 16 years in the UK, and rates have gradually increased during the 1980s and 1990s. It is believed that changes in outdoor exposure and fashion over the past 50 years have played a major role in this rise in skin cancer. Given the uncertainties surrounding both atmospheric changes and human behavior, it is unlikely that we will be able to definitively determine the exact contribution of ozone depletion to global skin cancer incidence by the end of this century. While modeling provides valuable insights, the real-world outcomes may be influenced by a variety of factors, including changes in exposure patterns and public health measures, making it difficult to isolate the specific impact of ozone depletion on skin cancer rates.

- Skin cancer incidence may peak mid-21st century in NW Europe due to past ozone depletion.
- Approximately, 90 additional cases/million people/year predicted are at peak.
- Delayed impact due to long latency (decades) between UV exposure and cancer onset.
- Montreal Protocol and Amendments are expected to reduce risk in long-term.
- Full global compliance is crucial—noncompliance could worsen ozone damage.
- Changes in lifestyle, fashion, and sun exposure have also raised skin cancer risk.
- It is difficult to isolate ozone's impact due to behavioral and environmental factors.
- Continuous monitoring, modeling, and public health efforts remain essential.

CLIMATE CHANGE AND ULTRAVIOLET EXPOSURE

The relationship between climate change and UV exposure is complex, with most attention traditionally focusing on the direct effects of stratospheric ozone depletion on terrestrial UV radiation. However, the influence of climate change, particularly greenhouse gas-induced warming, on ambient UV exposure is also significant. This can occur through both indirect effects on ozone levels and changes in other environmental factors such as cloud cover and aerosols, all of which can modify UV radiation levels reaching the Earth's surface.

Influence of Climate Change on Ultraviolet Radiation

Climate change influences ambient UV radiation in several ways. As global temperatures rise due to greenhouse gas emissions, changes in the stratosphere

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can affect total ozone levels, which in turn impact the amount of UV radiation reaching the ground. Furthermore, variations in climate factors such as aerosols and clouds can alter UV levels.

Changes in Ambient Temperature and Outdoor Behavior

More notably, the warming of global temperatures is likely to influence human behavior, specifically the time people spend outdoors. For instance, a 2002 study by Hulme et al. predicts that by the 2080s, average annual temperature increase in the UK will range from 2°C to 3.5°C. These temperature changes will be accompanied by more frequent extreme weather events, such as the high summer temperatures seen in 2003. Additionally, rainfall patterns are expected to shift, with wetter winters and drier summers. Such climatic shifts may encourage more outdoor activity, particularly during warmer periods, leading to increased exposure to sunlight and associated health risks, including skin damage from UV radiation. As temperatures will rise, people may spend more time outdoors, often without adequate sun protection, which could increase their risk of sunburn and skin cancer.

Influence of Climate on Ultraviolet Exposure Behavior

Studies have shown that climate conditions influence people's UV exposure behavior. For instance, a study on school children found that personal UV exposure varied more by geographic location and local climate than by ambient UV levels alone. In a study conducted by Diffey et al. in 1996, children in the south-west of England, where the climate is warmer, tended to receive higher UV exposure during recreational activities compared to children in the cooler north-east of England. This suggests that local climate conditions, such as temperature, play a significant role in determining behavior and, consequently, UV exposure. Additionally, research from Australia done by Hill and Boulter in the year 1996 demonstrated a direct correlation between temperature and the likelihood of sunburn. When temperatures ranged from 19°C to 27°C, the likelihood of sunburn approximately doubled compared to temperatures below 18°C. This increase in sunburn risk is likely due to people spending more time outdoors in warmer temperatures, thereby increasing their exposure to UV radiation. Interestingly at temperatures above 27°C, the likelihood of sunburn decreased as people looked for shade, indicating that at extremely high temperatures, individuals may take measures to avoid prolonged exposure to the sun.

CLIMATE CHANGE AND SKIN CANCER

Research in experimental animals has demonstrated that elevated temperatures can exacerbate UV-induced skin cancer, with higher temperatures resulting in more severe carcinogenic effects compared to room temperature. In a notable study by van der Leun in 2002, it was hypothesized that if ambient temperatures in humans rise by 2°C due to climate change, the carcinogenic impact of solar

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UV radiation could increase by approximately 10%. This increase in temperature would amplify the incidence of skin cancer because the relationship between UV exposure and skin cancer is approximately quadratic, i.e., skin cancer rates rise faster as UV exposure increases. As a result, the combined effect of ozone depletion and global warming could lead to an additional 20% increase in skin cancer cases. Although the authors admit that their calculations made a number of assumptions, they contend that, as temperatures continue to rise, the effect of rising temperatures on the incidence of skin cancer may soon outweigh that of ozone depletion. Given this possible change, it is more important than ever to implement international programs like the Montreal Protocol that try to lessen the damaging impacts of climate change on human skin. Reducing the total burden of skin cancer in the future will require addressing both the effects of global warming and ozone depletion.

BEHAVIORAL INFLUENCES ON EXPOSURE TO SOLAR ULTRAVIOLET RADIATION

The amount of solar UV radiation an individual is exposed to depends on various factors, including ambient solar UV levels, personal behavior, the amount of time spent outdoors, and the use of protective agents such as sunscreens. Studies have shown that adult indoor workers receive approximately 200 standard erythemal doses (SEDs) annually, mostly from weekend and holiday exposure, particularly to the hands, forearms, and face. The breakdown of this exposure is as follows:

- 30% from sun-seeking holidays
- 40% from summer weekends
- 20% from casual weekday exposure during April to September
- 10% from exposure during the colder months (October to March)

For children, who generally spend more time outdoors, dosimetric studies indicate an average annual exposure of around 300 SED. As a result, approximately one-third of lifetime exposure to the sun occurs before the age of 18 years. Higher discretionary incomes, earlier retirement, and longer life expectancies may cause this ratio to change, with later-life sun exposure accounting for a greater share of lifetime UV exposure.

Sun Exposure Trends

While climatological factors influence UV radiation levels, individual behavior plays a significant role in determining personal UV exposure. Over recent decades, lifestyle changes have led to increased sun exposure and higher risks associated with it. For example, the total number of overseas holidays taken by humans has increased sevenfold between 1971 and 1998, with many choosing destinations closer to the equator where UV levels are typically higher. Similarly, participation in outdoor leisure activities has grown, leading to higher UV exposure. The impact of ozone depletion on skin cancer rates may be lessened by public health campaigns that seek to minimize sun exposure through avoidance techniques and the application of protective gear such as clothes, sunscreen, and

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shade. Such programs might lessen the UVB exposure of the general population and counteract the detrimental effects of ozone layer loss.

Global Solar Ultraviolet Index

To help the public understand UV levels, the Global Solar UV Index was introduced. This index measures the average maximum solar UV at the Earth's surface, with values indicating the potential for skin damage. The index takes into account variations in UV intensity over a short period, usually 10–30 minutes, and helps estimate the UV exposure at solar noon. The scale of the UV index ranges from zero upward, with higher numbers indicating a greater likelihood of skin damage and shorter time frames for damage to occur.

- *Low exposure:* 1 and 2
- *Moderate exposure:* 3 and 4
- *High exposure:* 5 and 6
- *Very high exposure:* 7 and 8
- *Extreme exposure:* Greater than 9

CONCLUSION

The relationship among UV exposure, ozone depletion, climate change, and skin cancer risk is complex and multifaceted. As the ozone layer continues to recover due to the implementation of international agreements like the Montreal Protocol, the threat posed by ozone depletion on skin cancer incidence is expected to diminish. However, climate change, particularly rising temperatures, introduces a new layer of risk, potentially exacerbating the carcinogenic effects of solar UV radiation. While individual behavior, such as increased outdoor activities and holidays to high-UV regions, significantly contributes to overall UV exposure, public health initiatives focused on sun protection can help mitigate these risks. The growing awareness of UV indices and the promotion of photoprotective measures such as sunscreens, clothing, and shades are crucial in reducing the likelihood of skin cancer.

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Salient Features

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- **User-centered design:** Designed with clinical photographs, illustrations, bullet points, and flowcharts to facilitate easy understanding and quick reference for readers
- **Patient education strategies:** Tips for counseling patients on proper sunscreen application, dispelling myths, and promoting adherence to sun protection
- **Comparison of global regulations:** Analysis of sunscreen regulations, SPF labeling, and approved ingredients across different countries
- **Safety and efficacy:** Includes a dedicated section on evaluating the safety of sunscreen ingredients and their impact on skin and systemic health, with emphasis on photostability, allergenicity, and absorption concerns.
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Sanjeev Gupta MD DNB MNAMS is working as Professor and Head, Department of Dermatology, MM Institute of Medical Sciences and Research MM(DU), Mullana, Ambala, Haryana, India. He is a member of most of national and international academic societies. He has around 170 publications, 6 books and 17 book chapters to his credit. He has invented many dermatological techniques and instruments to simplify the procedures and reduce the cost. Twenty-six of such inventions have been published in one of the most prestigious journals of dermatology—Journal of the American Academy of Dermatology USA. He was awarded with "Making a Difference" award by the American Academy of Dermatology, USA. He is the first Indian to be honoured with this prestigious award. He has served his professional association [Indian Association of Dermatologists, Venereologists, and Leprologists (IADVL)] as Executive Committee Member at the state level as Treasurer, Secretary, Vice President, and President and also at the National level as Joint Secretary and Vice President IADVL. He was honoured with the LN Sinha Award by IADVL in 2013 and the ACSI Innovation Award 2021 by the Association of Cutaneous Surgeons of India (ACSI). He is the recipient of Dr BM Ambady Oration awarded at DERMACON 2025 Jaipur.



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