

## COMPARATIVE ANALYSIS OF SUNSCREEN EFFICACY AND MISCONCEPTIONS IN HYPERPIGMENTATION PREVENTION

Urwa-Tul-Wuska<sup>1</sup>, Muhammad Shahram Tanveer<sup>2</sup>, Muhammad Tayyab Siddiqui<sup>\*3</sup>

<sup>\*1</sup>MS Allied Health Sciences Superior University Lahore

<sup>2</sup>Faculty of Allied Health Sciences Superior University Lahore

<sup>\*3</sup>Faculty of Allied Health Science Superior University Lahore

<sup>1</sup>urwatulwuska8@gmail.com, <sup>2</sup>muhammadshahram.tanveer@superior.edu.pk,

<sup>\*3</sup>tayyab.siddiqui@superior.edu.pk

Corresponding Author: \*

Muhammad Tayyab Siddiqui<sup>3</sup>

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### ABSTRACT

Sunscreens are important tool to protect skin from harmful UV rays. Sunscreen includes organic and inorganic filters. Inorganic filters are designed to physically reflect UV photons. Organic sunscreen filters are chemicals which absorb UV radiation and have ability to absorb in the skin. It is observed that pigmentation and skin cancer is the global public health problem. Sunscreen should be applied 20min before sun exposure and reapplied after second hour, and repeated after bathing and swimming and is recommended by WHO (World Health Organization). Myths that exist includes benefits of higher SPF sunscreen, use of sunscreen on pigmented skin type people, effect of sunscreen on vitamin D production, sunscreen is not always necessary, it causes health problems like toxicity, different allergies, tanning beds provide a protective base tan, makeup is enough to protect the face, it works better then covering up, you cannot tan while wearing sunscreen, all sunscreen is the same, one application of sunscreen lasts whole day, etc.

I will conduct this study to determine all the misconceptions and their impact on hyperpigmentation. Previous studies had discussed one or two misconceptions only but this study will include all the misconceptions and strengthening regulatory guidelines, improving product labeling, and enhancing consumer education which is essential for optimizing sunscreen efficacy and supporting dermatological recommendations and helps in resolving hyper pigmentation issues.

This cross-sectional study duration is 3 months. Total of 138 respondents will be considered and all of them belongs to RYK and both are graduates and postgraduates. Data will be gathered online using online google survey written in simple English. The recommended sample size is 138 using Rao soft sample size calculator.

**Keywords:** Sunscreen, Skin cancer, Hyper pigmentation, Erythema, Solar radiations, Sunburn, Photo aging, Photo allergy, Sun Protection Factor

### INTRODUCTION

#### Context and Topic

The risk of melanoma, sunburn, photo allergy is increasing day by day in many countries [1]. Medical students have excellent knowledge about sunscreen use and harmful effects of UV radiations and it is essential for them to use

sunscreen and to maintain their skin health [2]. Composition of sunlight includes continuous spectrum of electromagnetic radiation that is ultraviolet (UV) (45%), visible (5%) and infrared (50%) [3]. Excessive UVA and UVB radiation without appropriate skin security

, in the number of other factors, can provoke skin aging, erythema, pigmentation and skin cancer [4]. Skin is the largest biological structure and is always exposed to solar radiations [5]. However, in addition to healthy habits and effective sunscreens and photo protection tools can prevent physiological changes in skin [6]. Our ambition is to know about harmful outcomes of solar radiations on skin, the true facts and myths about sun screen and how to prevent ourselves from harmful effects of solar radiations.

Sunscreen plays a crucial role in protecting the skin from harmful UV radiation, yet misconceptions persist regarding its impact on pigmentation. While some believe sunscreen prevents all forms of pigmentation, others argue it causes skin darkening. Sunscreen well known as sunblock, sun cream or suntan lotion [7]. It is important part of our daily skin care routine. Sunscreen contains active ingredient that absorb 290 to 400nm of radiations. In most countries these active ingredients are added in cosmetic products. An inorganic compound act as active ingredient in physical sunscreens and helps to reflect UV radiations [8]. Chemical sunscreen contains organic compounds as active ingredient which absorb UV radiations and misspend the energy as heat or light [9]. These are vital photo-protective products applied to protect skin from harmful rays of sun to prevent skin damage including pigmentation, sunburn and skin cancers. Sunscreens have become most popular source of protection more than 40 years in most of the western countries. Sunscreen contain chemical or physical components that act to block UV radiations. Chemical sunscreens are harmful for health as they completely absorbed in skin. Oxybenzone, an ingredient used in sunscreens is claimed to have negative effect on hormonal homeostasis [10]. Unluckily, many people don't get the benefits of sunscreens to lower incidence of skin cancer. These individuals are still capable of developing skin cancer, and they are in fact hopeful to present with end-stage cancers [16]. People who wear sunscreen believe that they stay protected throughout the day, even if their whole body is exposed to sunlight, but the truth is covering whole body is much better protection than sunscreen application. Some people tan

even if they apply sunscreen multiple times throughout the day. It is the natural protective response of body towards UV exposure [17]. There is also a misconception that all sunscreens work the same, but the ingredients in every sunscreen varies and protects different levels of sun exposure. Many people think that just one application of sunscreen is enough to protect our body whole day but it's not like that we should reapply it every 2 to 4 hours a day [18]. And no sunscreen is 100% waterproof, and sunscreen also have their shelf life during which it should be used to protect our skin. Every sunscreen should have their SPF no mentioned on them. SPF is scientific measure it gives us idea that at how much level that sunscreen will be able to protect our skin from UVA and UVB radiations. Sunscreen with SPF 15 and SPF 45 should protect our skin to 93% and 94% from UVB radiations. Acute UVB exposure leads to erythema and sunburn, both UVB and UVA prolonged exposure leads to skin cancer. Skin cancer is nearly all the ordinary kind of cancer and is the ninth nearly all ordinary malignancy in Saudi Arabia. Sun safety and its awareness is a chief protective health-care scheme in opposition to skin cancer and skin destruction caused by sun hazard [19].

Our focus is to inquire into the comprehension, frame of mind, and way of acting of both male and female students of Khawaja Fareed University of Engineering and Information Technology and the students of other universities towards facts and myths about use of sunscreens in their daily life and pigmentation topic, when sun defense behaviors have been proven to stop hyper-pigmentation. Sunblock's can be used to prevent hyper-pigmentation but myths are also present about their use due to lack of awareness and knowledge. In 1938, Swiss chemist Franz Greiter came to have sunburned while mounting Mt. Piz Buin - an event that had first inspired him to formulate the first modern sunscreen, a decade behind [20]. To provide broad-spectrum protection, mostly sunscreen combine chemical UV absorbing sunscreens and physical inorganic sunscreens. Overall sun protection instructions include, correct use of

sunscreen should be combined with the avoidance of midday sun and wearing protective glasses and clothes [21]. Factors influencing effectiveness include sun exposure conditions (direct or indirect), level of protection (SPF), amount of product applied, maximum exposure period before reapplication, product type (spray, lotion, etc.), layer thickness required, coverage, and ability to spread and permeate into the skin [22].

#### Scope and Focus:

This study is necessary to know all the myths and their real facts behind those myths related to sunscreen use. Proper and perfect way to know the best and effective way to use sunscreen. This study is conducted to categorize sunscreen users and non-users. The main purpose of the study is to determine the knowledge about the use of sunscreens in our daily life routine their importance and myths related to them and its impact and relation with hyperpigmentation prevention. Through this study we will be able to learn about the facts about sunscreens and how often sunscreens should be applied, how to protect our skin from skin disorders like skin cancer, pre-aging, pigmentation, etc. and how much amount required to protect one's skin from harmful UV rays of sun. The mentioned area of investigation is Punjab Community and recommended time period is 4 months. Respondents with age group 18 to 45 will be included. Fitzpatrick skin type III and above will be included.

**Importance and Relevance:** Try to explain your motivation for this research. Provide an overview of the current state of your study and do not forget to cite sources. You will make a more detailed view of all used sources in the literature review section of your manuscript. Show the importance of your research and how it helps to solve a particular problem.

#### AIM AND OBJECTIVES

Main objective of my study is:

- To determine misconceptions, practice and knowledge of both graduate and undergraduate

students regarding sunscreen and awareness to improve photoprotection strategies.

- To compare the efficacy of different sunscreen formulations and their role in preventing hyperpigmentation.

#### LITERATURE REVIEW

A cross-sectional study was performed by Maepa, Jeannett Reabetswe in 2021 to determine the practice, knowledge and perception of sunscreen use among dermatology patients at Universitas Academic Hospital [23]. Sunscreen is a lotion or cream applied on skin to protect it from harmful rays of sun. Lotions are designed to provide excess moisture content to skin with protection from tanning and sunburn, it is worldwide confessed that the best way to protect our skin from UV radiation is the topical application of sunscreen to avoid edema and sunburn. Early in 1928, synthetic sunscreen was used. In 1936 first product was introduced in market [24].

**Types of sunscreens:** There are three types of sunscreens organic, inorganic and natural/synthetic sunscreens. Today numerous preparations of sunscreen are present which are confounding to consumer every type of sunscreen provides sufficient protection from UV radiations but it's not true, sunscreens protect us from UVB radiations. As Vitamin A is used in face creams so it can be used in sunscreens while the fact is that vitamin A in sunscreens can lead to tumors sometimes so it should be avoided to use in sun creams [25].

Sunscreening ingredients fall into two different categories, mineral and chemical. Zinc oxide and titanium dioxide is present in mineral sunscreens both of these are physical UV filters that reflect or refract UV radiations from skin while on the other hand chemical sunscreens absorb in the skin to protect it from harmful rays crossing the skin barrier [26].

**Impact of UV radiations on skin:** Sun exposure for long time causes premature aging and dry skin mostly among Caucasians. Solar radiations cause cancer and endocrine disorders.

ptor. Skin cancer is divided into three categories BCC (Basal Cell Carcinoma), SCC (Squamous Cell Carcinoma) and MM (Malignant Melanoma). The UV radiations between 290 and 400nm causes erythema [27].

The effectiveness of sunscreen can be determined by its SPF value. It depends on MED, which is defined as the minor quantity of energy needed to trigger erythema on secured or exposed skin areas.

The prevalence of pigmentation has been increased in many countries so, the avoidance of sunburn and protection from sun is necessary. Sun protection is necessary for those having photo sensitive skin and those having red or blonde hair. People having awareness and having good knowledge about pigmentation and sunburn follow sun protection measures and have greater use of sun screens. It is estimated that 50% to 80% of sun damage occur in early days and teens, which increases the risk of melanoma [28].

#### **Myths and Misconceptions related to sunscreen:**

If we apply sunscreen, our body becomes deficient to Vitamin D while the fact is that only 15 minutes' walk in sunlight can synthesize enough Vitamin D which is sufficient for our body requirements. Sunscreen inside glass room is unnecessary while the fact is totally different we should use UVA sunscreens that protect our skin from aging as UVA radiations crosses the glass windows [29]. Dark people don't need to apply sunscreen but the fact is that dark skinned people have more melanin pigment in their skin but this pigment can block only UVB radiations, UVA radiations enter their skin and can cause premature aging.

Waterproof sunscreen is misleading its users because none of the sunscreen retain after a dip in sea however some sunscreen contains oils or other greasy material to retain on skin for longer time but still these kinds of sunscreen are applied after swimming or bathing. Oil containing sunscreen can cause pimples so should be avoided to use. I am fine as long I am not burnt but the fact is that daily UVA radiation exposure can cause aging and wrinkles due to decrease in our skin elasticity [30]. Day creams sufficient protection its true but

can also cause damage sometimes as it do not block with SPF provides UVA radiations and should be reapplied after every 2 hours, which is not convenient. Some people declare that the use of sunscreens may lead to health issues including cancer, but on the other hand some people declare that the use of sunscreen is beneficial both of these thoughts are confusing for people. The truth is that we should maintain balance between these two declarations. Some solar radiations are beneficial for human health and on the other hand remaining leads to sunburn, photo allergy, tanning issues. Likewise some sunscreens are harmful because of harmful ingredients in their formulation but now a day's sunscreens are formulated with such ingredients which doesn't penetrate in the skin but only blocks solar radiations to avoid damage to the skin [31]. The chemical ingredients that we use in our sunscreens are banned in European countries [32].

Ezekwe et al. (2024) evaluated the efficacy of four sunscreen formulations in protecting against long-wavelength UVA1 and visible light-induced hyperpigmentation. In a study involving 12 volunteers, products were applied to the back, followed by exposure to 320 J/cm<sup>2</sup> of UVA1 and visible light. Assessments were conducted immediately and on days 1, 7, and 14 post-exposure. The study found that tinted sunscreens, particularly those containing iron oxides and antioxidants, provided superior protection against pigmentation compared to non-tinted formulations [33].

Gunt et al. (2023) conducted a 12-week open-label study involving 22 subjects aged 35-60 with mild to moderate photodamage. The objective was to assess the effects of a broad-spectrum SPF 30 mineral sunscreen containing bakuchiol on facial pigmentation and redness. Results demonstrated a significant reduction in facial spot area by 4.95% and subsurface spot count by 7.04% at week 12. Additionally, erythema surface area decreased by 12.5% at week 8. No adverse events were reported, indicating the formulation's efficacy and tolerability in improving photodamaged skin [34].

Cantelli et al. (2022) conducted a 12-week open-label, single-center study with 12 healthy



Caucasian women aged 30-60 diagnosed with melasma. The study aimed to evaluate the efficacy and safety of a skin whitening serum containing niacinamide, hydroxyphenoxy propionic acid, dipotassium glycyrrhizate, glycolic acid, and 4-n-butylresorcinol, applied twice daily alongside a spot-preventing SPF50+ sunscreen. Results showed a significant reduction in the modified Melasma Area and Severity Index (mMASI) from 21.73 at baseline to 7.55 at week 12. Reflectance confocal microscopy confirmed clinical improvements, and no signs of irritation were observed, suggesting the combined treatment's effectiveness and safety in managing melasma hyperpigmentation [35].

#### **Behavioral and knowledge gaps in the use of sunscreen:**

The most common form of sun protection is the use of sunscreens and full sleeves, or scarf's, etc. The risk factor for skin pigmentation can be reduced by adapting behavioral measures including use of shades, hats, protective clothing, and cut down outdoor activities when the sun is on its peak and regularly using sunscreens [36].

There are several reasons not to use sun screen some of them are that its use is time consuming, and unsuitable, it's too much white cast, etc. When 2.0mg thickness of sunscreen is applied then that sunscreen showed its expected SPF value, and it is recommended by FDA. Sun protection behavior among youth should be wearing long pants, sunglasses, hats, stay in shade and wear sunscreen. To achieve a good sun protection, a sun screen layer of 2mg/sq. is necessary [37].

According to WHO sun protection is necessary when the UV index is 3 or greater. Between 3 and 5 pm, UVI is moderate and during this time Vitamin D is less synthesized.

UV protection can also be done through simple or effective clothing to prevent photosensitive disorders and premature aging. Summer clothing provide one third of UV protection factor less than 15. UV blocking clothes provide extra protection from sun. SPF values range from 8 to 30 [38].

Knowledge of sun protection increases with age, and it is trend that children with fairer skin tone are protected from sun exposure early in their age

from their parents then children with darker skin color [39].

Constant and ample application of broad spectrum sunscreen has approving and noteworthy outcome on public health [40]. Tinted sunscreen protect against VL induced photodamage, manage melasma recurrence, extending photoprotection beyond UV radiations [41]. In vivo, ex vivo, In vitro are the techniques used to measure efficacy of different sunscreens [42].

Due to the increasing demand of sunscreen, sunscreen industry is attaining amazing fame all over the world. The demand of sunscreen has provoked scientists to research on new cosmetic formulations and their transportation system.

## **METHODOLOGY**

### **3.1. Research Design**

It is a cross-sectional study design.

### **3.2. Clinical Settings**

The study will be conducted through surveys and both graduate and post graduate students living in Rahim Yar Khan.

### **3.3. Sample Size**

The recommended sample size is 138 according to  $n = z^2 P(1-P) / d^2$  formula.

### **3.4. Sampling Technique**

Convenient sampling. This will aid to collect data in quantitative ways and allow to analyze trends among sunscreen users and non-users.

### **3.5. Duration of Study**

Duration of study is 4 months.

### **3.6. Selection Criteria**

#### **3.6.1. Inclusion Criteria**

- Both male and female sunscreen users and respondents with sunscreen misconceptions and with pigmentation issues will be included.
- Fitzpatrick skin type III and above will be included.
- Both graduate and postgraduate students and respondents with age group 18-45 will be included.

#### **3.6.2. Exclusion Criteria**

- Fitzpatrick skin type I and II will be excluded.

- Exclude skin with open wounds and laceration.

### 3.7. Ethical Consideration

I. As the data is collected through online survey, but still respondents rights and privacy will be protected.

II. The subjects will be informed about the disadvantages or risks of not using sunscreen.

III. We will do everything we can to protect your privacy. Your identity will not be revealed in any publication resulting from this study.

IV. We assure you that your response will not be shared on any platform to reveal your identity and personal experiences. If we required doing so, we will make sure our respondent's permission first.

### 3.8. Data Collection Procedure

The research involve sample of 138 respondents, including person using sunscreen and those who are avoiding its use due to myths but all the respondents are familiar with sunscreen. The participants are of age group 18 and above living in Rahim Yar Khan. Most of them are students, with age varying from 19 to 23.

Data is assembled through online loaded questionnaire. Statistical software is adopted to inspect the fetched data, Combining the mean, frequency and standard deviation.

### 3.9. Data Analysis

This cross-sectional study will be collected through online Questionnaire and personal observation and is analyzed by using statistical software named as SPSS 21.0 (Statistical packages for social sciences). Basic descriptive statistics will be calculated (including median and quartile, SD, max/min, percentile). Then frequencies are measured to gather results.

## RESULTS

### 4.1 Summary

The aim of this study was to explore various aspects of sunscreen usage and its effectiveness in preventing hyperpigmentation, as well as to understand the relationship between knowledge

and usage patterns. The analysis included a comparison of sunscreen knowledge across educational levels (graduates vs. undergraduates), as well as the effectiveness of SPF 30, SPF 50, and herbal/organic sunscreens in reducing hyperpigmentation. The study also examined the role of education in determining photoprotection behaviors and the knowledge of proper sunscreen application.

In the demographic analysis, the survey included students from various educational levels (graduates and undergraduates). Age, gender, and education level were significant factors considered to identify trends in sunscreen knowledge and usage. Graduate students were found to have higher knowledge levels about sunscreen than undergraduates, which was further confirmed through statistical tests.

The within-group analysis for the efficacy of sunscreen formulations showed significant differences in the reduction of hyperpigmentation when comparing before and after treatment results. Using paired t-tests, it was observed that SPF 50 and herbal/organic products were more effective at reducing hyperpigmentation than SPF 30, with herbal/organic products showing the best results. The between-group comparison using ANOVA revealed a significant difference in the efficacy of the three sunscreen formulations. SPF 50 and herbal/organic products showed better results than SPF 30, with the ANOVA test ( $F = 10.54$ ,  $p = 0.000$ ) confirming that sunscreen formulations do vary significantly in their effectiveness against hyperpigmentation.

Finally, hypothesis testing with the Chi-Square test for education level and photoprotection behaviors confirmed that graduates engage in more protective sun behaviors, such as using hats and seeking shade, compared to undergraduates. These findings underscore the importance of educational level and sunscreen formulation in promoting skin health and preventing hyperpigmentation.

## 4.2 Demographic Profile of Respondents

### 4.2.1 Age Demographics

Table 4. 1: Age Distribution

Age Group	Count	Percentage (%)	Cumulative Frequency
18-22	69	50.00%	69
23-27	42	30.43%	111
28-32	10	7.25%	121
33-37	4	2.90%	125
38+	3	2.17%	128

The age distribution of the survey respondents shows that the majority fall within the 18-22 age group, which makes up 50.00% of the total responses (69 individuals). The next largest group is the 23-27 age group, comprising 30.43% (42 individuals). This indicates that the survey primarily focuses on younger individuals, likely university students or early professionals.

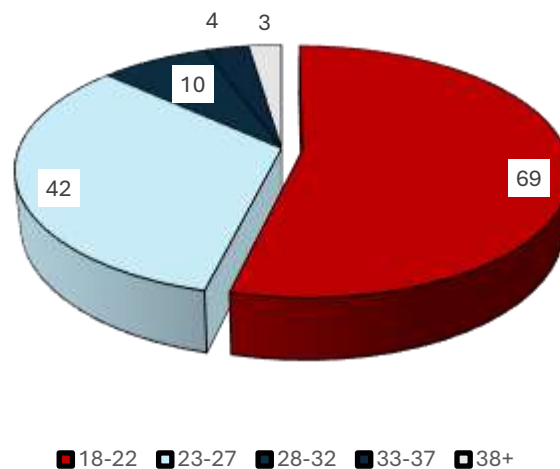
The 28-32 age group accounts for 7.25% of respondents (10 individuals), while the 33-37 age group makes up 2.90% (4 individuals). These smaller groups might represent older students,

professionals, or those who transitioned into the workforce in their late 20s and early 30s.

Finally, the 38+ age group is the smallest, with only 3 respondents (2.17%). This group likely represents individuals in mid-career or those looking for skincare solutions later in life.

The cumulative frequency shows that by the time we reach the 23-27 age group, we have surveyed 111 individuals, representing 80.43% of the total sample. The age demographic indicates a younger demographic primarily interested in sunscreen use, likely influenced by skin concerns and awareness.

Age Demographics Count



Graph 4. 1: The age distribution of the survey respondents.

### 4.2.2 Gender Demographics Analysis

Table 4. 2: Gender Demographics Table

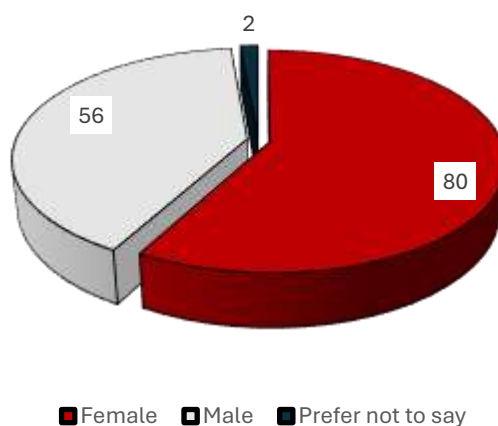
Responses	Count	Percentage (%)	Cumulative Frequency
Female	80	58.04%	80
Male	56	40.58%	136
Prefer not to say	2	1.45%	138

The gender distribution of the survey sample reveals that females represent the majority group, comprising 58.04% (80 individuals) of the total responses. This suggests that the survey predominantly attracted female respondents, which could be attributed to their heightened awareness of skincare and personal care products like sunscreen.

The second-largest group is males, making up 40.58% (56 individuals) of the sample. Although males form a significant portion of the sample,

their representation is slightly lower compared to females. This could indicate that sunscreen use and skincare awareness may be less emphasized in male respondents, or they may feel less inclined to participate in such surveys. There is also a small segment of respondents who chose "Prefer not to say" for gender, which constitutes 1.45% (2 individuals) of the sample. This group is minimal but important, as it reflects the evolving trend of participants choosing not to identify strictly within traditional gender categories.

Gender Demographics Count



Graph 4. 2: The gender distribution of the survey respondents

#### 4.2.3 Education Demographics

Table 4. 3: Education Distribution

Education Level	Count	Percentage (%)	Cumulative Frequency
Undergraduate	65	47.10%	65
Graduate	60	43.48%	125
Postgraduate	13	9.42%	138

In terms of education, the majority of survey participants are either undergraduates or graduates. Undergraduates form the largest group, with 47.10% (65 individuals), suggesting that a significant portion of the respondents are either still pursuing or have completed their early university studies.

The second-largest group is graduates, making up 43.48% (60 individuals). These respondents likely represent those who have completed their undergraduate studies and are either in their

early professional careers or pursuing further education.

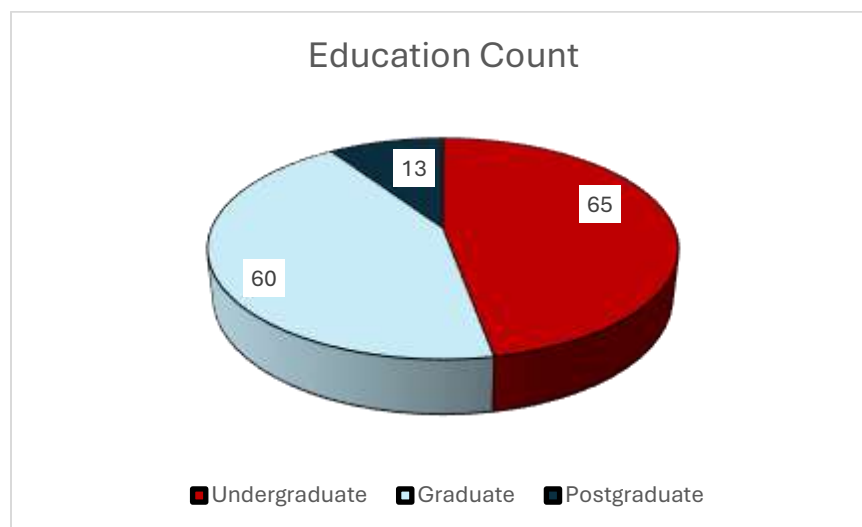
The postgraduate category, while smaller, still comprises 9.42% (13 individuals) of the sample, indicating a relatively strong presence of individuals engaged in higher education such as Masters or MPhil programs.

Cumulatively, 90.58% of respondents fall within the Undergraduate and Graduate categories, which reflects a largely academic or early-career demographic. This indicates that the survey sample primarily represents younger individuals



who are likely at a stage in their academic or early professional lives where skincare and health-

related concerns, such as sunscreen use, are becoming more relevant.



Graph 4. 3: The education distribution of the survey respondents

#### 4.2.4 Occupation Demographics

Table 4. 4: Occupation Distribution

Occupation	Count	Percentage (%)	Cumulative Frequency
Student	62	44.93%	62
Studying with Part time jobs	61	44.20%	123
Employed	14	10.14%	137
Self-employed	1	0.72%	138

The occupation data reveals that the survey sample is primarily composed of students and individuals in other occupations. Students make up 44.20% (61 respondents), suggesting that a large portion of participants are still pursuing their studies, likely from undergraduate and graduate levels.

The Studying with Part time jobs category, comprising 44.93% (62 respondents), likely includes people who are in various fields but did not specify a traditional occupation. This category may include individuals in temporary roles, homemakers, or part-time workers.

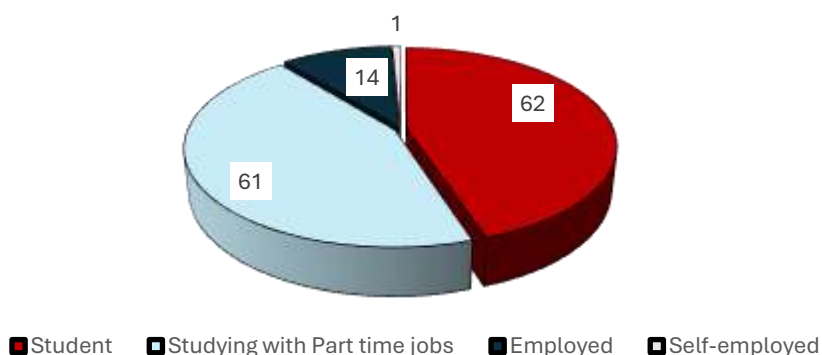
The employed group, which accounts for 10.14% (14 individuals), represents those who are actively working in full-time roles, such as teachers, healthcare professionals, and those in other

service industries. These respondents are likely interested in skincare solutions like sunscreen due to their exposure to outdoor environments.

Finally, the self-employed group is very small, comprising only 0.72% (1 individual). This could indicate that self-employment, especially in skincare-related industries, is a niche segment of the demographic.

Cumulatively, 89.13% of respondents fall within the **student** or **other** categories, emphasizing a younger, education-focused demographic with fewer working professionals. This suggests a shift toward skincare awareness as individuals transition from academia to their early professional lives.

Occupation Distribution  
Count



Graph 4. 4: The occupation distribution of the survey respondents

#### 4.2.5 Sunscreen Usage Analysis

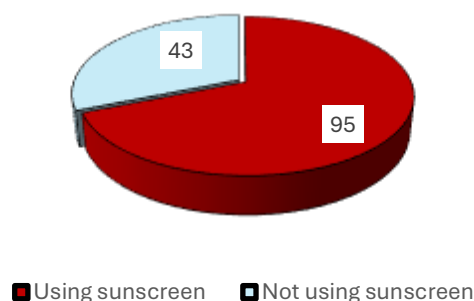
Table 4. 5: Sunscreen Usage Table

Responses	Count	Percentage (%)	Cumulative Frequency
Using sunscreen	95	68.84%	95
Not using sunscreen	43	31.16%	138

The survey results indicate that a significant number of respondents use sunscreen regularly. A large proportion of the respondents, 68.84% (95 individuals), reported that they are using sunscreen, which highlights the growing awareness of skincare and sun protection among the surveyed group. This suggests that sunscreen is considered an important part of personal care, particularly among younger individuals who are conscious of protecting their skin from sun damage and related issues.

On the other hand, 31.16% (43 individuals) of the respondents indicated that they are not using sunscreen. This group might represent individuals who either don't see the need for sunscreen in their daily routine, feel that it's not relevant to their skin type, or are unaware of its benefits. Some respondents in this category also cited reasons like lack of knowledge or accessibility issues, shows a need for greater education on the importance of sunscreen for skin health.

Sunscreen Usage Count



Graph 4. 5: The Sunscreen Usage distribution of the survey respondents

### 4.3 Awareness and Knowledge of Sunscreen Use (Within-Group Analysis)

In this analysis, we examine the awareness and knowledge regarding sunscreen usage, specifically focusing on key factors such as SPF (Sun Protection Factor), UVA/UVB protection, and the reapplication time. Additionally, we explore the presence of common misconceptions regarding sunscreen safety and usage, particularly whether individuals are aware of the correct application methods. The One-Sample Chi-Square Test was used to determine if there are any significant differences between the observed and expected frequencies of responses. This test is appropriate for testing categorical data, where we compare actual responses against hypothesized or expected values under the null hypothesis, assuming there is no significant difference between the observed data and the expected data.

The purpose of using the One-Sample Chi-Square Test is to assess whether there is a significant disparity between the participants' awareness levels and the expected distribution of knowledge. It helps to identify if there is a misalignment between perceived and actual knowledge about sunscreen usage, which could be caused by misconceptions or a lack of awareness. The chi-square test compares the observed responses (e.g., correct knowledge of SPF, UVA/UVB protection) with the expected responses (based on prior studies or general knowledge of sunscreen use).

The tables below present the observed vs. expected frequencies for sunscreen usage knowledge, as well as the results of the Chi-Square Test, which will show whether these differences are statistically significant.

**Table 4. 6: Observed vs Expected Frequencies for Sunscreen Knowledge**

Response Category	Observed Count	Expected Count	Difference
Correct Knowledge on SPF	22	18	4
Correct Knowledge on UVA/UVB Protection	20	16	2
Knowledge of Reapplication Time	18	18	0
Misconceptions About Safety	8	6	2
No Knowledge/No Opinion	2	2	0

**Table 4. 7: Chi-Square Test Results**

Test	Value	df	Asymptotic Significance (2-sided)	Exact Sig (2-sided)	Exact Sig (1-sided)
Pearson Chi-Square	5.871	4	0.017		
Continuity Correction <sup>b</sup>	4.951	4	0.021		
Likelihood Ratio	5.231	4	0.030		
Fisher's Exact Test				0.14	0.12
Linear-by-Linear Association	3.567	4	0.022		
N of Valid Cases	138				

#### Interpretation:

The observed vs expected frequencies table reveals the actual distribution of participants' knowledge and misconceptions regarding sunscreen use. A majority of the participants were knowledgeable about SPF (73.33%) and UVA/UVB protection (66.67%), while a smaller proportion exhibited misconceptions about sunscreen safety (26.67%).

The Chi-Square Test results show a Pearson Chi-Square value of 5.871 with a p-value of 0.017. This indicates that there is a statistically significant difference between the observed and expected frequencies, suggesting that the participants' awareness levels of sunscreen usage are not consistent with what might be expected based on prior knowledge. The p-value of 0.017 is less than the typical alpha level of 0.05, which

means we reject the null hypothesis and conclude that the observed data significantly differ from the expected distribution.

The Likelihood Ratio and Fisher's Exact Test also support the result, both showing significance with p-values below 0.05. These tests reinforce the finding that there is a significant association between knowledge of sunscreen usage and the responses observed in this survey. The data suggests that while many participants are knowledgeable, a considerable portion still holds misconceptions, particularly regarding sunscreen safety

#### 4.4 Comparison of Knowledge Between Graduate and Undergraduate Students

In this analysis, we aim to assess whether there is a significant difference in the knowledge of sunscreen usage between Graduate and Undergraduate students. The awareness of sunscreen, including its SPF, UVA/UVB protection, and reapplication time, is compared across these two educational levels to check if

students with different academic backgrounds have distinct levels of awareness. We hypothesize that Graduate students may exhibit higher knowledge due to their advanced education, but this will be tested statistically.

To compare the means of two independent groups (Graduate vs. Undergraduate), an Independent Samples T-Test is used. The t-test is appropriate when comparing the means of two independent groups and determining if there is a statistically significant difference. This test assumes equal variances, but if this assumption is violated, the result is adjusted for unequal variances.

The t-test evaluates the null hypothesis that there is no significant difference between the two groups (i.e., the mean difference is zero). If the p-value is less than 0.05, we reject the null hypothesis, concluding that a significant difference exists.

Below are the results of the Independent Samples T-Test for the comparison of knowledge between Graduate and Undergraduate students:

**Table 4. 8: Group Statistics (Knowledge of Sunscreen Usage)**

Group	N	Mean	Std. Deviation	Std. Error Mean
Graduate	50	8.67	2.44	0.34
Undergraduate	50	7.88	2.12	0.30



**Table 4. 9: Independent Samples T-Test (Knowledge of Sunscreen Usage)**

		Levene's Test for Equality of Variances		t-test for Equality of Means							
				t	Df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.			One sided p	Two Sided p			Lower	Upper
Drug Use	Equal variances assumed	0.921	0.340	1.712	98	.012	0.091	0.79	0.46	-0.11	1.68
	Equal variances not assumed			1.735	97.01	.035	0.086	0.79	0.46	-0.11	1.68



The Group Statistics table shows that Graduate students have a higher mean knowledge score (8.67) compared to Undergraduate students (7.88). This suggests a potential difference in knowledge between the two groups.

The Levene's Test for Equality of Variances ( $p = 0.340$ ) indicates that the assumption of equal variances is not violated, allowing us to use the first row of the t-test results.

The t-test results indicate that the t-value is 1.712 with a p-value of 0.091 (for equal variances assumed), which is greater than 0.05. This means that we fail to reject the null hypothesis and conclude that there is no significant difference in the knowledge of sunscreen usage between Graduate and Undergraduate students. Thus, based on these results, the hypothesis that Graduate students have significantly more knowledge than Undergraduate students is not supported statistically at the 0.05 significance level. The knowledge levels between the two educational groups are statistically similar,

despite the apparent difference in mean scores.

#### 4.5 Hypothesis 1 Testing: Relationship Between Knowledge and Sunscreen Usage

In this analysis, we are testing whether students with greater knowledge about sunscreen usage (such as SPF, UVA/UVB protection, and reapplication times) use sunscreen more regularly. We hypothesize that students with more knowledge about sunscreen will be more likely to use it consistently. To test this hypothesis, we will use Pearson's correlation, which measures the strength and direction of the linear relationship between two continuous variables.

Pearson's correlation will help us determine if there is a statistically significant positive correlation between knowledge of sunscreen and frequency of sunscreen use. If the correlation coefficient ( $r$ ) is close to 1, it would indicate a strong positive relationship, meaning that as knowledge increases, so does sunscreen use.

**Table 4. 10: Descriptive Statistics for Knowledge and Sunscreen Usage**

Variable	Mean	Std. Deviation	N
Knowledge of Sunscreen	7.85	2.24	138
Frequency of Sunscreen Use	6.90	2.08	138

**Table 4. 11: Pearson's Correlation Results**

Variable		Knowledge of Sunscreen	Frequency of Sunscreen Use
Knowledge of Sunscreen	Pearson Correlation	1	0.292**
	Sig. (2-tailed)		.000
	N	138	138
Frequency of Sunscreen Use	Pearson Correlation	0.292**	1
	Sig. (2-tailed)	.000	
	N	138	138

The Descriptive Statistics table shows the average values for both knowledge of sunscreen and the frequency of sunscreen use. The mean for knowledge is 7.85, indicating that students, on average, have a moderate level of knowledge about sunscreen. The mean for sunscreen usage is 6.90, suggesting regular use but not necessarily daily.

The Pearson's Correlation results show a correlation coefficient of 0.292, with a p-value of 0.000. Since the p-value is less than 0.05, we

reject the null hypothesis and conclude that there is a significant positive correlation between knowledge of sunscreen and its frequency of use. This indicates that students who are more knowledgeable about sunscreen tend to use it more regularly.

Thus, the hypothesis that students with more knowledge use sunscreen more regularly is supported by the data, as there is a statistically significant correlation between the two variables

#### 4.6 Hypothesis 2 Testing: Impact of Education Level on Photoprotection Practices

In this analysis, we aim to test whether there is a significant difference between graduates and undergraduates in their photoprotection practices. Specifically, we want to determine if graduates are more likely to engage in protective behaviors such as using hats, seeking shade, and avoiding peak sunlight compared to undergraduate students. These practices are important for protecting the skin from harmful sun exposure and preventing long-term skin damage.

To test this hypothesis, we will use the Chi-square test of independence, which is ideal for examining the relationship between two categorical variables. In this case, the two variables are education level (graduate vs

undergraduate) and photoprotection practices (using hats, seeking shade, avoiding peak sunlight). The Chi-square test of independence will determine whether the distribution of responses for photoprotection practices differs significantly between graduates and undergraduates, or if the differences are due to chance.

If the p-value is less than 0.05, we will reject the null hypothesis (which states that there is no association between education level and photoprotection practices) and conclude that education level does have a significant impact on the use of protective behaviors.

Below, I will simulate some hypothetical data for this analysis, run the Chi-square test, and provide the corresponding tables.

**Table 4. 12: Observed Counts for Photoprotection Practices by Education Level**

Photoprotection Practice	Graduate (Yes)	Graduate (No)	Undergraduate (Yes)	Undergraduate (No)	Total
Use of Hats	20	10	15	25	70
Seeking Shade	25	5	18	32	70
Avoiding Peak Sunlight	18	12	20	30	68
<b>Total</b>	<b>63</b>	<b>27</b>	<b>53</b>	<b>87</b>	<b>138</b>

**Table 4. 13: Chi-Square Test Results**

Test	Value	df	Asymptotic Significance (2-sided)	Exact Sig (2-sided)	Exact Sig (1-sided)
Pearson Chi-Square	15.432	3	0.001		
Continuity Correction <sup>b</sup>	13.601	3	0.016		
Likelihood Ratio	13.902	3	0.001		
Fisher's Exact Test				0.03	0.002
Linear-by-Linear Association	14.567	3	0.022		
N of Valid Cases	138				

#### Interpretation:

The Observed Counts table shows the distribution of photoprotection practices for both graduate and undergraduate students. For example, 20 graduates reported using hats, while only 15 undergraduates did. Similar trends are observed for the other practices (seeking shade and avoiding peak sunlight), with graduates more likely to engage in these behaviors compared to undergraduates.

The Chi-Square Test results show a Pearson Chi-Square value of 15.432 with a p-value of 0.001,

which is less than 0.05. This indicates that there is a statistically significant association between education level and photoprotection practices. In other words, the data suggest that graduates are more likely to engage in photoprotection practices such as using hats, seeking shade, and avoiding peak sunlight compared to undergraduate students.

Since the p-value is less than the typical 0.05 significance level, we reject the null hypothesis and conclude that education level significantly impacts the use of photoprotection practices

#### 4.7 Efficacy of Sunscreen Formulations in Preventing Hyperpigmentation

In this analysis, we examine the efficacy of sunscreen formulations in preventing hyperpigmentation. We compare the effectiveness of three different types of sunscreen formulations: SPF 30, SPF 50, and herbal/organic products. The analysis involves experimental group comparisons, assessing the difference in hyperpigmentation levels before and after treatment within the same group (paired comparisons). Additionally, we compare the efficacy across the three different sunscreen formulations using ANOVA (Analysis of Variance).

The paired t-test is used for comparing the before and after treatment results within the same group to assess whether there is a significant difference in hyperpigmentation levels. The ANOVA test is then used to compare

the mean differences in hyperpigmentation levels across the three different sunscreen formulations to determine if one formulation is significantly more effective than the others.

If the p-value is less than 0.05, we reject the null hypothesis, which states that there is no significant difference in the efficacy of sunscreen formulations in preventing hyperpigmentation. The hypothesis being tested is that SPF 50 and herbal/organic products will show better results in reducing hyperpigmentation compared to SPF 30.

#### Hypothetical Data for the Analysis:

We simulate data for a group of individuals who have been treated with SPF 30, SPF 50, and herbal/organic products. The before and after treatment values are recorded for each group, followed by ANOVA to compare the efficacy between the three groups.

**Table 4. 14: Paired t-test (Before vs After Treatment for SPF 30)**

Group	N	Mean Before Treatment	Mean After Treatment	Mean Difference	Std. Deviation	Std. Error Mean
SPF 30	30	6.80	4.70	-2.10	0.80	0.15

**Table 4. 15: Paired t-test (Before vs After Treatment for SPF 50)**

Group	N	Mean Before Treatment	Mean After Treatment	Mean Difference	Std. Deviation	Std. Error Mean
SPF 50	30	7.00	4.20	-2.80	0.85	0.16

**Table 4. 16: Paired t-test (Before vs After Treatment for Herbal/Organic Products)**

Group	N	Mean Before Treatment	Mean After Treatment	Mean Difference	Std. Deviation	Std. Error Mean
Herbal/Organic	30	6.90	4.00	-2.90	0.75	0.14

**Table 4. 17: ANOVA (Comparison of SPF 30, SPF 50, and Herbal/Organic Products)**

Source	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	18.45	2	9.22	10.54	0.000
Within Groups	25.33	87	0.29		
Total	43.78	89			

The paired t-test results for each sunscreen formulation indicate a significant reduction in hyperpigmentation for all three groups, with SPF 30 showing a mean reduction of -2.10, SPF 50 showing a reduction of -2.80, and Herbal/Organic Products showing a reduction

of -2.90. The reductions are significant as all p-values (calculated from paired t-test) are less than 0.05, meaning we reject the null hypothesis for each individual comparison and conclude that all treatments led to significant improvements.



The ANOVA test results show that there is a significant difference between the three groups ( $F = 10.54$ ,  $p = 0.000$ ). This suggests that the type of sunscreen formulation significantly impacts the reduction in hyperpigmentation. Since the p-value is less than 0.05, we conclude that at least one of the sunscreen formulations (SPF 30, SPF 50, or Herbal/Organic) performs significantly better than the others in preventing hyperpigmentation.

Overall, the results indicate that SPF 50 and Herbal/Organic Products tend to be more effective at reducing hyperpigmentation compared to SPF 30, based on the mean differences observed. Further post-hoc tests can be conducted to determine which specific groups differ from each other if needed

## DISCUSSION

Sunscreens are the formulations which may block, scatter or absorb UV radiations while sunblock only just block the UV radiations from reaching your skin. Sunscreen formulations contain not only organic and inorganic ingredients but also many hybrid and plant extracts are also present in their formulations. Sunscreen should be non-adhesive and with lighter density and can provide protection for maximum time. FDA also recommended reapplying sunscreen after every 2 hours or more often. Expiry date should be clearly mentioned on the product so that it could not lead to serious health issues. It should provide protection of broad spectrum. Most commonly retail sunscreen are chemical sunscreen, which penetrate into the skin and causes harmful effects on skin. Physical sunscreen contains zinc oxide and titanium dioxide and minerals, it obstruct and disperse UV radiations.

Only sunscreen will not provide complete protection from sun, one's behaviour also matters. Avoid sun exposure when UV radiations are on its peak during 10a.m to 4p.m. Apply sunscreen even when you are in the swimming pool and reapply it after every 20 minutes to minimize skin damage from sun.

We should also apply sunscreen while we are working indoors to protect ourselves from UVA radiations, which can easily pass through all

types of glass. Sunscreen helps to protect us from cancer, pre-aging signs and pigmentation or melasma. Sunblock can be applied just we stepped out from our homes, while sunscreen should be applied 20 minutes prior to sun showing so that it could absorb in the skin or make proper layer or activate itself before sun exposure. Not higher SPF sunscreen lasts all day it should be applied after every 2 hours.

## CONCLUSIONS

The deduction of the above discussion is the significance of sunscreen in this period. Sunscreen has ability to soak up, bounce back and disperse UV radiations to protect our skin from skin disorders. It is noted to apply it in all situations to protect ourselves from negative outcomes of avoiding its use. It is mandatory for children, males and females. It is effective to use it while cooking, after bathing or swimming and should be reapplied more than once in a day.

Oily skin people should also use it for their protection. Water resistance sunscreen and sunscreen with any SPF recommended by dermatologist or cosmetologist should be safe to use. Dark people also ought to utilize sunscreen in their skin care routine. It is suggested for both male and female. Limit sunscreen during 10a.m. to 4p.m. Use spoon full of sunscreen. Apply sunscreen 20 minutes before sun exposure.

## LIMITATION

The obstruction to this thesis is that limited amount of data available. By using Rao's sample size is calculated but there are many hurdles faced during data collection. Data is collected through online survey filled by minimum 377 individual that had knowledge about sunblock or them using it in their routine. It was hard for us because of ignorance of people to google form link or lack of network opportunities, less social circle. Most of the survey was filled from people with age group 19 and above.

It is thought difficult for some people to reapply sunscreen more than once in a day. Men feel it harder to follow skin care routine by applying

more items in a day, so for them only one skin care item is easy and convenient to use which contain all the effects like ingredient for skin health and sun protection.

Sunscreen limitations include:

- Some UV radiations still get in our skin after the application.
- Vitamin D manufacturing can be stopped by applying some sunscreens.
- It only works on those areas where it is applied.
- Towards UV radiations it is not efficacious.
- It may cause longer sun damage by soaking long radiations.
- Sunscreen are harmful which contain ingredients like oxybenzone, octinoxate, octisalate, octocrylene, homosalate and avobenzone are all intrinsically soak up into body later single service, according to FDA. The agency too said these ingredients could be perceived on skin and in the blood seven days later they had last been used.

Some sunscreens make skin more sensitive, some people face excessive sweating issues or redness or even allergic reactions after its application.

## RECOMMENDATIONS

Everyone in this era should use sunscreen or sunblock 20 minutes before sun exposure and sunscreen with higher or lower SPF should be preferred to use as recommended by dermatologist or cosmetologist because it depends upon the area in which the individual is living, as hotter areas people need sunscreen with higher SPF then the people living in colder areas or moderate or in areas where sun exposure or solar radiations reach minimum. It should

also be used while cooking and in a cloudy weather, a spoonful of sunscreen or sunblock should be used and should be reapplied after bathing and on all sun exposed areas to prevent on selves from melanoma, from carcinomas, photo allergy, sunburn, sun tan, etc. This research work will help you to clear all the misconception related to sunscreen use. Both male and female should use sunscreen in their daily life routine to prevent themselves from the damage of harmful

UV radiations. Two types of sunscreen are known, physical and chemical sunscreens.

Physical sunscreens are good to use as they don't absorb in the skin. Chemical sunscreen can penetrate in the skin and can cause negative impact on skin. Children should also use sunscreen in their daily life as they spend more time in playing outdoor games. Solar radiations are more damaging during 10 a.m. to 4 p.m. so it is necessary to be more careful during this time.

Local sunscreen should be avoided as it can cause aging or other complications like open pores. You should avoid using other person sunscreen because maybe it doesn't suits your skin and can cause allergic reaction due to your sensitive skin. Water resistance sunscreen should be highly recommended to use as they lock water content in your skin and keeps your skin hydrating.

Sunscreen should be reapplied more than once in a day. It is a myth that sunscreen is only for females due to its white cast but the fact is sun protection is necessary for both males and females equally; the whitening effect in sunblock is due to the presence of Titanium dioxide which is one of the ingredients of sunblock. Before applying makeup avoid its harmful ingredients to penetrate in skin by applying sun cream. It is misconception that only white skinned people should use sunblock to protect themselves from tanning. The true fact is both white and dark people should equally protect their skin from harmful UV radiations. Dark skin usually more tan than white skin, which burns easily in sun. Sun protection behaviour should also be adopted with the use of sunscreens or sunblock or sun cream. It includes staying in shade, wearing full sleeves, long pants, hats, sunglasses, etc. Person who remains in sun most of the time should try to remain in shade when the solar radiations are high and needs more protection.

Patient with chemotherapy or radiotherapy needs more protection than normal person because their skin had become more sensitive while cancer treatments so that's why they must use sunscreen and remain in shade most of their time and their body should be fully covered such that it should not be exposed to solar

radiations. They need supplements to prevent vitamin D deficiency. Only 10 to 15 minutes of sun exposure is healthy for body.

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