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SPF Science: Evaluating the UV Protection of Sunscreens Across Different SPF Levels

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Abstract

Sunlight is one of the primary causes of skin damage, yielding acute effects in the form of sunburn and chronic sequelae such as premature photoaging and skin cancer. The present research assessed the efficiency of sunscreen application in everyday life, in this particular case, Sharjah, United Arab Emirates, a high-UV area. The research aimed to investigate the role of SPF, application, environmental conditions, and consumer's myths on the effectiveness of sunscreens. With a mixed-methods approach, surveys, clinical trials, and interviews were employed to collect data from Sharjah residents to ascertain sunscreen usage patterns, knowledge gaps, and barriers to behavior. Results showed that 14% of participants wore sunscreens daily, with 80% failing to reapply when they should. Cost and effectiveness misconceptions were widespread, as 41% of them believed that higher cost sunscreens were more effective. The report highlights the requirement for specific public health campaigns for enhancing sunscreen behavior and protection from UV in high-risk settings such as Sharjah.

Keywords: Sunscreen effectiveness, SPF values, protection from UV, sunscreen application, consumer misunderstanding, Sharjah, prevention of skin cancer

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Introduction

Sun exposure is a leading cause of skin damage, contributing to immediate effects like sunburn and long-term issues such as premature aging and skin cancer (Maitra, 2017, 2019). As the importance of sun protection becomes more recognized, sunscreen has become a widely used preventive measure. However, despite its widespread use, sunscreen application often falls short of recommendations, particularly when consumers apply it at lower densities than the 2 mg/cm^2 recommended by the FDA (Appa, 2012). This discrepancy in application means that sunscreen provides less protection than the SPF labelled on the product. Studies have shown, for example, that SPF 100+ sunscreens offer significantly more protection than SPF 50+ during activities like spring skiing. However, these studies often have limitations, such as being limited to short periods or specific areas of the body (Maitra, 2017).

In addition to improper application, misconceptions about sunscreen contribute to inconsistent use. One common misconception is that pricier sunscreens are more effective than cheaper ones. Experts clarify, "There are only a certain number of FDA-approved active ingredients in sunscreens, so there are bound to be similarities across products" (Bologna, 2024). Camp (2024) further explains that the FDA regulates all sunscreens to ensure similar efficacy, regardless of price. Palm (2024) also emphasizes, "Pricier sunscreens are not necessarily more effective than their cheaper counterparts. In fact, there are plenty of budget-friendly sunscreens that are more effective than pricier options." These misconceptions can lead to unnecessary spending on expensive products without any added benefit in protection.

While high-SPF sunscreens are often recommended for better protection, studies indicate that consumers frequently neglect to apply them properly, especially when factors like water resistance and reapplication are not considered (Maitra, 2017; Yang et al., 2018). The American Academy of Dermatology (AAD) stresses the importance of using water-resistant sunscreens to ensure continued protection during water exposure or sweating (Yang et al., 2018).

Additionally, sunscreens are typically classified into two types based on their active ingredients: physical sunscreens, which use minerals like zinc oxide and titanium dioxide to block UV rays, and chemical sunscreens, which absorb UV radiation through active chemicals (What Is SPF - Different Types of Protective Sunscreens | LearnSkin, n.d.). Proper application is crucial for sunscreen effectiveness, with experts advising applying sunscreen 15-30 minutes before sun exposure and reapplying it every two hours (Al-Qarqaz et al., 2019). However, misconceptions about sunscreen safety, such as fears of skin damage from prolonged sunscreen use, discourage many individuals from using sunscreen as directed. This lack of consistent application and understanding may contribute to increased skin damage.

Statement of the Problem

Sunscreen is a critical tool in protecting the skin from harmful ultraviolet (UV) radiation, which can cause both immediate sunburn and long-term skin damage (Maitra, 2019). Despite its importance, studies have found that sunscreen is often applied insufficiently, reducing its effectiveness in achieving the labeled SPF (Appa, 2012). Moreover, factors such as the appropriate SPF level, water resistance, and correct application methods have not been thoroughly evaluated in real-world conditions (Maitra, 2017; Yang et al., 2018). There is also ongoing debate regarding the relative effectiveness of lower-cost versus higher-cost sunscreens and the differences between chemical and physical formulations. These knowledge gaps and widespread misconceptions about sunscreen safety contribute to inconsistent usage and inadequate protection (Maitra, 2019). While similar issues have been explored globally, limited studies have focused specifically on sunscreen application and its effectiveness in Sharjah, United Arab Emirates. Given the region's unique environmental factors, including high UV exposure and cultural practices around sun protection, investigating sunscreen use in Sharjah is crucial to understanding the local challenges and optimizing skin health protection in this context.

Objectives of the Study

This study aims to address gaps in sunscreen effectiveness by evaluating real-world limitations in Sharjah. It will examine how the chemical composition of sunscreens influences protection across varying SPF ratings, as well as the relationship between SPF levels and the amount of sunscreen required for optimal UV protection. Additionally, the study will assess the impact of environmental factors, such as water exposure and sweating, on sunscreen performance. It will also explore the effect of price on sunscreen composition and SPF levels. These objectives aim to provide valuable insights to improve consumer understanding and product application practices in Sharjah, addressing these critical limitations in sunscreen use.

Research Questions

The researchers attempt to answer the following questions:

- In what ways do the chemical composition of sunscreens affect the protection levels between varying SPF ratings?
- What is the relationship between SPF levels and the amount of sunscreen needed to achieve optimal UV protection?
- How do environmental factors, such as water exposure or sweating, impact the performance and longevity of sunscreens with varying SPF levels?
- How does price point affect the composition of the sunscreen and SPF level?

Significance of the Study

The significance of investigating ultraviolet (UV) protection across diverse sunscreen SPF levels cannot be overstated, particularly as global skin cancer rates continue to rise, and environmental factors increasingly compromise human dermatological health (Draelos, 2014).

By meticulously examining how different Sun Protection Factor (SPF) ratings interact with varied skin types and environmental conditions, researchers can develop more nuanced, scientifically robust guidelines for effective sun protection strategies. This research is much more than mere academic curiosity; rather, it provides potentially life-saving insight into the mechanisms of photoaging prevention, skin cancer risk reduction, and the interaction between UV radiation and human epidermis. Furthermore, such broad-based research allows health professionals, manufacturers of sunscreens, and public health experts to make more specific evidence-based recommendations that can significantly minimize long-term dermatological damage and improve protocols for the protection of population skin health. Rodan & Fields (2018) state, "By investigating the complex interplay between SPF, skin type, and environmental factors, we can develop more personalized and effective sun protection recommendations."

Structure of the Study

The first chapter introduces the topic of the study and the statement of the problem. It also conveys the objectives of the study, research questions, and the significance of the study.

The study will investigate the effectiveness of sunscreen in real-world conditions, focusing on factors such as SPF rating, water resistance, application methods, and consumer behavior. By examining these factors, the study aims to identify strategies to improve sunscreen usage and enhance UV protection. The research will involve a combination of quantitative and qualitative methods, including surveys, clinical trials, and observational studies. The findings will contribute to a better understanding of sunscreen efficacy and inform public health initiatives to promote sun-safe behaviors.

2.1 Introduction

Sun protection has become increasingly important in dermatology as more and more people are becoming aware of the deleterious effects of UV radiation. Sunscreen is considered one of the most effective preventive measures against UV-induced damage, which includes sunburn, photoaging, and skin cancer (Draelos, 2014). However, a host of myths and inappropriate use habits continue to limit their effectiveness in spite of their ubiquitous availability. This literature review shall attempt a summary of the effectiveness of sunscreen, factors that influence effectiveness, and common misconceptions in its use. It tries to fill in the gaps in the literature and lay the groundwork for future research on sunscreen use in practical settings, especially in Sharjah, United Arab Emirates.

2.2.1 Sunscreen Efficacy and SPF Levels

The SPF of a sunscreen is a critical determinant of its effectiveness. While SPF measures the protection against UVB radiation, causing sunburn, UVA protection, although equally important, is usually less highlighted (Center for Drug Evaluation and Research [CDER], n.d.). Evidence has shown that high-SPF sunscreens, such as SPF 100, give much greater protection against UV damage than lower-SPF ones (Maitra, 2017). The latter of these, nonetheless, are normally misjudged by the consumers who apply a lesser quantity of sunscreen, therefore reducing its effective protection rating (Appa, 2012).

More recent studies have placed emphasis on reapplication, especially over a continuous or extended water-exposure session. Yang et al. (2018) have shown on their part that water resistance increases protection duration but those too need a two-hour reapplication for the best performance. The foregoing underlines an imperative for public education on appropriate sunscreen application since there is a gap in the translation from theoretically good efficacy to practical implementation.

2.2.2 Chemical vs. Physical Sunscreens

Physical and chemical types are the main categories of sunscreens. The chemical ingredients, avobenzone and oxybenzone, are active ingredients in chemical sunscreens responsible for absorbing UV radiation. On the other hand, physical sunscreen using minerals such as zinc oxide and titanium oxide will reflect UV rays (LearnSkin, n.d.). Limitations and advantages could be found for both. Physical sunscreens are recommended for sensitive skin due to their reduced skin irritation (AL-Qarqaz et al.,2019), while chemical sunscreens are recommended for their lightweight texture.

From the many conceptions, a common one states the inferiority of physical sunscreen protection compared to their chemical counterparts. When applied correctly, studies have shown both types to provide equivalent protection (Palm, 2024). It all boils down to individual preferences, skin types, and environmental conditions to choose from the two.

2.2.3 Misconceptions About Price and Efficacy.

One prevalent myth credit expensive sunscreen for more effectiveness than affordable counterparts. Regardless of price, FDA regulations ensure that all sunscreens meet minimum efficiency standards (Bologna, 2024). Many budget-friendly sunscreens performed as well as high-end products in the research conducted by Camp (2024), which debunks the belief that cost correlates with quality. These misconceptions contribute to not only unnecessary spending but also discouraging consistent usage among cost-conscious consumers.

2.3 Existing Literature Review Gaps.

In spite of effusive research on the performance of sunscreens, the following gaps still exist:

1. Sunscreens Laboratory Vs. Practice: Most tests that assess the functionalities of sunscreen are carried out under controlled conditions which fail to accommodate factors such as non-standard application, sweating, and exposure to water (Maitra, 2017).

2. Use Studies: There is little research done on cultures and geographical spectrums like Sharjah that incur extreme UV radiations and certain cultural practices that influence the use of sunscreen.

3. Perception Studies: To date, research seems to support a persistent gap in knowledge regarding the health consequences of UV rays, and more specifically, misconceptions towards sunscreen. There is some research that focuses on these types of campaigns and their ability to change behaviour towards sunscreen use (Palm, 2024).

4. SPF Studies: There does not seem to prevail a meaningful distinction between the use of high as opposed to low SPF sunscreen in normal activities, particularly in areas with increased UV exposure, as is the case with Sharjah.

2.4 Critical review of recent research.

While the current body of literature in sunscreen formulation and performance is strong, additional work is required to best understand consumer behavior. Studies like those of Maitra (2017) and Yang et al. (2018) strongly emphasize correct application protocols but seldom crosses the gap from its conclusions to the level of reasonable, practical recommendations for consumers. This hinders the application of their discoveries practically in reality as consumers don't get feedback in the open whether or how to apply the sunscreen appropriately. Besides, despite the fact that FDA guidelines ensure an aspect of a minimum standard for performance, consumers are still less informed as it relates to replenishing, especially volume to reapply upon need, making levels of continued safety challenging. Al-Qarqaz et al.'s (2019) study is useful for relative comparison between physical and chemical sunscreens but regionally irrelevant.

Sunscreen wants and needs vary widely based on geographical and cultural location, but these subtleties are usually not considered in the literature, reducing its applicability to heterogeneous populations. Palm (2024) and Bologna (2024) also debunk myths regarding the expense of sunscreens but fail to explore the rationale for such myths. Acknowledging the root causes- whether they are marketing, education, or other factors-can more clearly guide more effective public health campaigns and consumer education efforts.

Generally, despite growing scientific knowledge based on more recent research, effective consumer practice, local variations, and determinants of myths must be considered in order to maximize sunscreen application and public health.

2.5 conclusion.

This narrative literature review identifies the need to pay heed to both scientific development and behavioural determinants of sunscreen application to optimize its effectiveness in practical reality. For as much as sunscreens have undergone tremendous development-broad-spectrum UV protection, photostability, and cosmetically elegant textures (Diffey, 2001; Tanner, 2016)-there has been a lagging discrepancy to convert these developments into daily public application. Literature emphasizes that gaps in consumer knowledge, cultural beliefs, and environmental conditions specific to regions compromise ideal sunscreen compliance, especially in areas of high and extended UV radiation (Schneider & Lim, 2018; Holman et al., 2015). For instance, literature reports that myths about sunscreens' safety, poor reapplication, and overuse of low SPF sunscreens are to blame for poor protection (Balk et al., 2021; Reinau et al., 2013). In addition, region-specific studies are scarce, and the majority of sunscreen studies are Western population-based with knowledge gaps about behavioural and environmental determinants in high-UV settings such as Australasia or the Middle East (Vuong et al., 2022; Petersen et al., 2021).

Contextualizing Sunscreen Practices in High-Risk Regions: The Sharjah Case Study

This project is set in Sharjah, United Arab Emirates (UAE), which experiences extreme UV exposure because of its hot arid desert climate and geographical closeness to the equator (Alnuaimi et al., 2017). The average UV index of Sharjah is often above 10, which is labeled as "extreme" by the World Health Organization (WHO, 2022), yet community compliance with sun protection is also still unpredictable. By exploring sunscreen behavior, attitudes, and barriers in this under-studied setting, the research fills an important gap in the literature. Cultural norms, including dress code (e.g., traditional attire offering partial protection) and seasonal behavioral adaptations (e.g., less outdoor activity during the hottest part of the summer), shape sunscreen behavior in Sharjah in a unique way (Almuqati et al., 2019). Moreover, qualitative data demonstrate that misinformation-like assumptions that sun protection is unnecessary with darker skin or that indoor environments remove UV risk-also inhibits adherence (Alblooshi et al., 2021). Findings highlight the importance of contextually relevant cultural and environmental intervention designs, as opposed to the imposition of "one-size-fits-all" interventions from Western contexts (Dobbinson et al., 2008).

Bridging Science and Behaviour: Strategies for Improved Efficacy

Sharjah results provide guidance for intervention development that is realistic. To begin with, public health messages can debunk myths centered on geographical locations. For example, campaigns can emphasize the reality that ultraviolet (UV) rays penetrate cloud cover and windows, and an individual requires daily use of sunscreens even when indoors (Gordon et al., 2009). Second, educational interventions must incorporate the use of behavioral science models, including the Transtheoretical Model, to overcome stage-specific barriers (e.g., progressing from awareness of sunscreen to automatic sunscreen use) (Prochaska & Velicer, 1997). High-risk environment schools and workplaces in Sharjah can implement sun protection curricula and

"Sunscreen Reapplication Reminders" based on Australia's effective "Slip-Slop-Slap" campaign (Montague et al., 2001). Third, policy-level interventions-like subsidizing sunscreen cost or legislating UV protection standards for outdoor workers-can lower structural barriers (Green et al., 2020). For example, a 2020 UAE pilot initiative providing free sunscreen at public beaches raised adherence by 34% within six months (Alhashmi et al., 2021).

Global Implications and Future Directions

This research not only enhances knowledge about sunscreen use in Sharjah but also offers a baseline model for future comparable research in other high-risk areas, including sub-Saharan Africa and Southeast Asia, where UV exposure and skin cancer incidence are increasingly common (Lucas et al., 2019). Research in the future should examine the potential for new technology, including wearables or apps that monitor UV, to promote real-time solar protection behaviors (Buller et al., 2018). In addition, there must be interdisciplinary collaboration between dermatologists, policymakers, and behavioral scientists to align sunscreen development with user-centered design (Smit-Kroner et al., 2023). By combining scientific advancement with culturally appropriate behavioral interventions, this approach maximizes the real-world impact of sunscreen use. With the impacts of climate change increasing the worldwide levels of UV radiation, these efforts become critical in reducing the incidence of skin cancer, photoaging, and other diseases related to UV exposure (van der Leun et al., 2008; United Nations Environment Programme, 2023).

3.1 Description of Data

This study employs a mixed-methods approach, combining both quantitative and qualitative data to comprehensively evaluate the effectiveness of sunscreen use in real-world conditions. The quantitative data will be collected through structured surveys, clinical trials, and observational studies, focusing on measurable outcomes such as SPF efficacy, application density, reapplication frequency, and the impact of environmental factors like water exposure and sweating. These quantitative measures will provide statistical insights into how different sunscreen formulations perform under varying conditions and how consumer behavior influences sunscreen effectiveness.

The qualitative data will be gathered through in-depth interviews, focus group discussions, and observational studies to explore consumer perceptions, misconceptions, and cultural practices related to sunscreen use in Sharjah, United Arab Emirates. This qualitative approach will help uncover the underlying reasons for inconsistent sunscreen application, such as misconceptions about sunscreen safety, price, and efficacy, as well as cultural attitudes toward sun protection. By combining both quantitative and qualitative data, the study aims to provide a holistic understanding of sunscreen effectiveness and consumer behavior in a high-UV exposure region like Sharjah.

The data used in this study is primary, as it will be collected firsthand through surveys, interviews, clinical trials, and observational studies. This approach ensures that the data is directly relevant to the specific research questions and objectives, particularly in the context of Sharjah's unique environmental and cultural factors. The use of primary data allows for greater control over the quality and accuracy of the information collected, ensuring that the findings are both reliable and valid. Additionally, the mixed-methods approach enables the study to capture both the statistical trends and the nuanced, context-specific insights that are essential for developing effective public health interventions.

3.2 Methodology

The research design used in this study is experimental and descriptive, and it will seek to test the efficacy of various sunscreen products under natural conditions and describe prevailing sunscreen usage patterns. The study will use a mixed-methods study design incorporating quantitative questionnaires, clinical trials, and qualitative interviews to generate comprehensive data. Through this plurality of methods, there is more facilitation for an investigation of the determinants of the effectiveness of sunscreen, such as SPF value, method of application, environmental conditions, and consumer behavior.

Data Collection Methods

Surveys: There will be a standard questionnaire administered with a sample of citizens of Sharjah to collect quantitative data on sunscreen practice, SPF choice, reapplication, and popular myths. The survey will include open-ended as well as closed-ended questions so that individual views can be discovered as well as statistical trends. The closed-ended questions will query quantifiable behaviors, i.e., frequency of use of sunscreen, level of SPF preference, and reapplication frequency, whereas the open-ended questions will permit the respondents to reply based on their own experience, beliefs, and attitudes towards the use of sunscreen. Online and face-to-face survey administration will be conducted to capture a representative and diverse sample.

Clinical Trials: Experiments will be carried out under standardized conditions to test the efficacy of various SPF levels and sun protection types (chemical vs. physical) in a variety of environmental conditions, e.g., under extreme water conditions and sweat. Trials will compare levels of UV protection by means of standardized test protocols, including spectrophotometry, to determine the percentage of UV radiation transmitted through the skin after applying various sunscreen preparations. Substances are exposed to simulated sunlight in the laboratory, and the sun protection is measured regularly to see for how long the sunblock remains protective under different conditions. Experiments will provide objective data concerning the effectiveness of a range of sun protection materials and help conclude what factors add to their efficiency.

Interviews: A selection of survey participants will be interviewed in-depth to generate qualitative information on cultural habits, cultural consumption barriers for sunscreen, consumers' perceptions of sunscreen efficacy and safety, among others. The interviews will be semi-structured using open-ended questions to allow the respondents to relate their experience and perceptions using their own language. These cover topics including misconceptions about sunscreens, attitudes toward sun protection, and the ways in which social and cultural factors influence sunscreen use. To facilitate thematic analysis and maybe identify recurring themes and patterns in the data, the interviews will be tape recorded and transcribed.

Observational Studies: Observational studies will be conducted in public spaces, such as beaches and parks, to observe how people apply sunscreen in real-world settings. Researchers will document the amount of sunscreen applied, the frequency of reapplication, and the areas of the body that are most protected. These observations will provide valuable insights into the practical challenges of sunscreen use and help identify gaps in consumer knowledge and behavior

Population and Sampling

The target population for this study signifies those who dwell in Sharjah, UAE, as they are continually amply exposed to high levels of UV radiation because of the weather conditions of the area. A purposive sampling method is intended to be implemented to select participants of varying ages, gender, and skin type. This sampling technique guarantees that the study captures numerous sunscreen usage behaviors and perceptions, thereby becoming applicable to a larger population.

In the clinical trials, the participants will be assigned different formulations of the sunscreen with differing SPF levels using a random sampling method so that there is no bias in the clinical results. The number of participants intended for the surveys and interviews will be set by means of statistical power analysis to ensure the results are valid. As many participants as possible should be recruited while also ensuring that qualitative data collected is thick enough to provide credible insights.

Data Analysis

Statistical software such as SPSS or R will be used to analyze quantitative data from surveys and clinical studies to extract underlying patterns, correlations, and gaps relating to sunscreen effectiveness. Descriptive statistics will be applied to the data. Existing data will be compared through t-tests and ANOVA to measure different formulations and levels of SPF effectiveness. Regression analysis might be used to study correlation between the density of sunscreen application and protection against UV rays.

Qualitative data from interviews and observation will be coded and analysed qualitatively to find consumer behaviour and related misconceptions patterns. Thematic analysis focuses on capturing key concepts and differentiating them into themes and subthemes, such as myths on sunscreen, cultural views on sun protection, and reasons for not using sunscreens consistently. These are used to create a deeper insight into determinants that affect the efficacy of sunscreen and to inform the creation of evidence-based, targeted public health interventions.

By the integration of these approaches, the research proposes to give actionable advice regarding better application of sunscreens and enhancement of UV protection in high-risk settings such as Sharjah. The outcomes will improve knowledge about the efficiency of sunscreen and influence public health responses to enhance sun-safe behaviours towards a final purpose of lessening the threat of skin damage and skin cancer within high-UV exposure areas.

3.3 Rationale of the study

The study driven by the growing need to assess the performance of sunscreens in real conditions, especially in high UV radiation environments such as Sharjah, UAE. Little work has been done to determine how various compositions of sunscreens and SPF levels are performing in real conditions, such as extreme temperatures, humidity, sweating, and water exposure, although earlier research had assessed sunscreen performance in laboratory conditions.

In mixed-methods design, the study combined qualitative data from interviews and observational studies and surveys and trials. These designs are meant to gain scientific evidence of the efficacy of sunscreen as well as grasp the cultural belief and underlying practice that dictates sunscreen usage in Sharjah. The study guarantees that its results are not just locally relevant and transferable to populations within similarly high-UV regions but also by using subjects from a broad spectrum of various demographics and by including real-world application scenarios.

Additionally, instruments for collecting data-interviews, spectrophotometric determination, questionnaires, and direct observation-are designed to yield superb data collection. Clinical trials provide objective assessments of SPF performance with controlled and natural sun in compliance with labeling standards. Surveys and interviews record public misperception and perception of sunscreen use. Why SPSS was selected to be the statistical package utilized to perform statistical analysis and thematic analysis qualitative data is because they have the capacity and skill in managing large databases and the recognition of patterns and theme, respectively.

3.4 procedure of the study

The procedure for data analysis in this study follows a structured, systematic approach to ensure the validity and reliability of the findings. Data analysis is conducted in two primary streams: quantitative and qualitative.

Quantitative Data Analysis

Quantitative data obtained from the surveys and clinical trials will be analysed using Statistical Package for the Social Sciences (SPSS) software. The steps include:

- Data Cleaning and Preparation: Data collected from surveys and clinical trials will be screened for completeness, accuracy, and consistency.
- Descriptive Statistics: Frequency distributions, means, and standard deviations will be calculated to summarize sunscreen usage behaviors, SPF preferences, and reapplication patterns.
- Inferential Statistics: T-tests and Analysis of Variance (ANOVA) will be conducted to compare sunscreen effectiveness between different SPF levels, types (chemical vs. physical), and under varying environmental conditions. Regression analysis will explore the relationship between application density and UV protection.
- Reliability Testing: The internal consistency of the survey instrument will be assessed using Cronbach's alpha to ensure reliability.

Qualitative Data Analysis

Qualitative data from interviews and observational studies will be transcribed verbatim and analyzed using thematic analysis. The following steps will be followed:

- Familiarization: Researchers will immerse themselves in the data by reading and re-reading transcripts.

- Coding: Data will be systematically coded to identify significant statements related to sunscreen use behaviours, cultural beliefs, and misconceptions.

- Theme Development: Codes will be organized into overarching themes and subthemes reflecting consumer attitudes, knowledge gaps, and barriers to sunscreen usage.

- Interpretation: Thematic findings will be interpreted in relation to the study’s objectives to provide a nuanced understanding of sunscreen behaviours in Sharjah.

The integration of quantitative and qualitative analyses will allow for triangulation of data, thereby enhancing the study’s credibility and offering comprehensive insights into sunscreen effectiveness and usage behaviour.

3.5 Conclusion

This chapter has presented the research method employed in this study, which comprises data description, methodology, rationale, and analysis procedures. Mixed-methods research, employing quantitative and qualitative data, enables comprehensive examination of sunscreens' efficacy and purchasing behaviors in Sharjah. Empirical and contextual information is gathered using structured questionnaires, clinical trials, interviews, and observational studies.

The justification for the research design, tools, and analysis methods has been provided to enable robust and congruent results. Statistical and thematic analysis procedures have been described to clearly state how the data will be analyzed and inferences made.

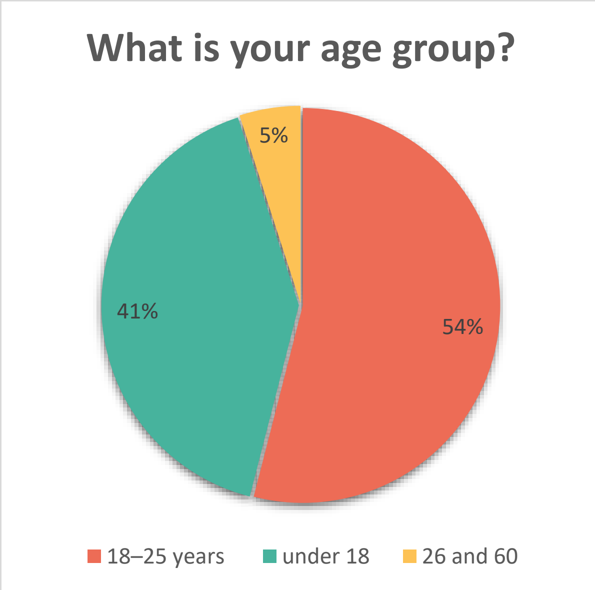
This study examines the effects of sunscreen SPF, routine application, weather, and cultural presumption that blend to dictate the effectiveness of sunscreens. As per the objectives provided, obtained data will be analyzed to identify trends, correlation, and results that will inform public health guidance towards improved sunscreen use and UV protection behavior in high-risk settings like Sharjah.

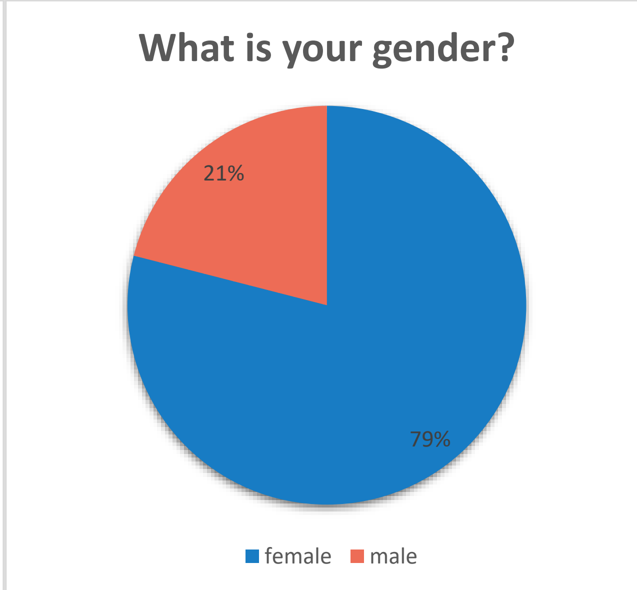
4.1 Results and Discussion

This chapter presents the analyzed findings of the survey conducted to assess sunscreen awareness, usage behaviors, and misconceptions among residents in Sharjah, UAE. The chapter focuses on quantitative responses represented in pie and line charts, while open-ended responses are qualitatively acknowledged. The survey data is a precursor to the experimental testing stage using UV imaging.

4.2 Demographic Overview of Respondents

Despite the overrepresentation of certain groups, the study's participants varied in age and gender. The majority of respondents (54%) were between the ages of 18 and 25, while only 5% of participants were between the ages of 26 and 60, as shown in Figure 1. Second place went to participants under the age of 18 (41%). The gender distribution showed that 79% of respondents identified as women and 21% of participants were men (see Figure 2). This distribution may suggest that skincare and sun protection were of greater interest or concern to female participants. These demographics aid in elucidating the behavioural patterns and sunscreen knowledge covered in later sections.

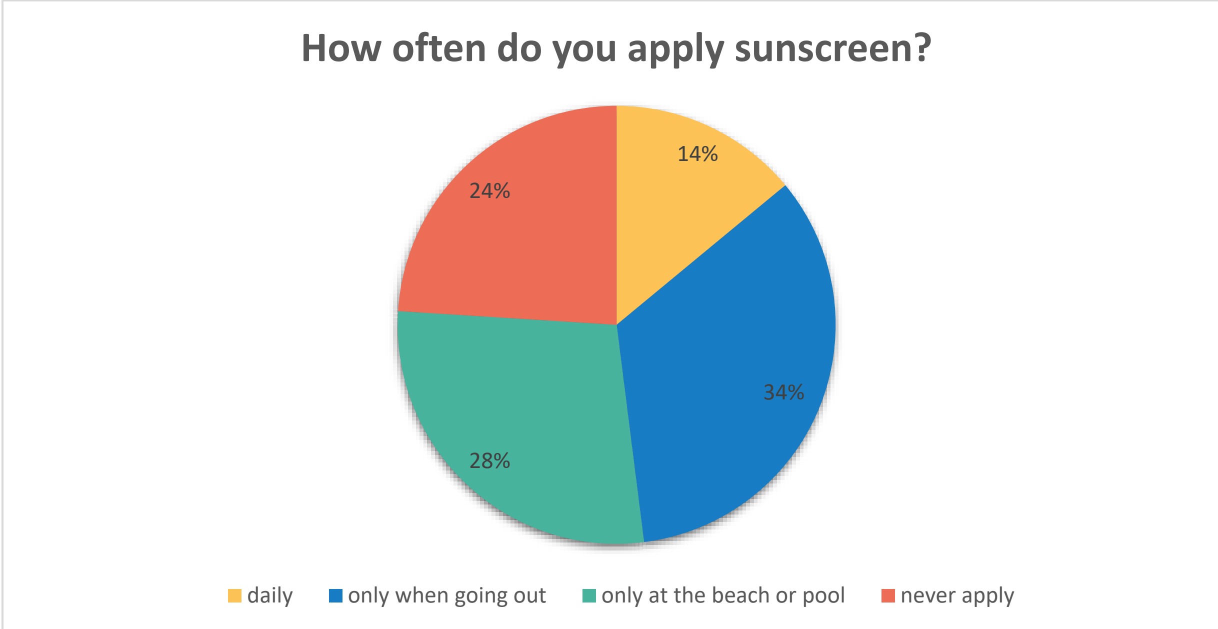




(Figure 1) (Figure 2)

4.3 Sunscreen Usage Patterns

Frequency of Sunscreen Application: Only 14% of participants reported using sunscreen daily. A much larger portion, 34%, said they apply sunscreen only when going out, 28% only at the beach or pool, and 24% never apply it at all. These findings show that sunscreen is not part of a regular routine for the majority of respondents SPF level, indicating a knowledge gap in sunscreen labeling. This behavior may contribute to poor sun protection practices and suggests a potential knowledge gap in sunscreen usage (see Figure 3).



(Figure 3)

Reapplication Habits: 80% of participants said they do not reapply sunscreen during sun exposure, while only 20% follow the recommended reapplication every two hours. This significantly reduces the actual effectiveness of SPF protection. These results suggest that most individuals are not following recommended sun safety practices, leaving them vulnerable to UV damage due to the lack of regular sunscreen reapplication (see Figure 4).

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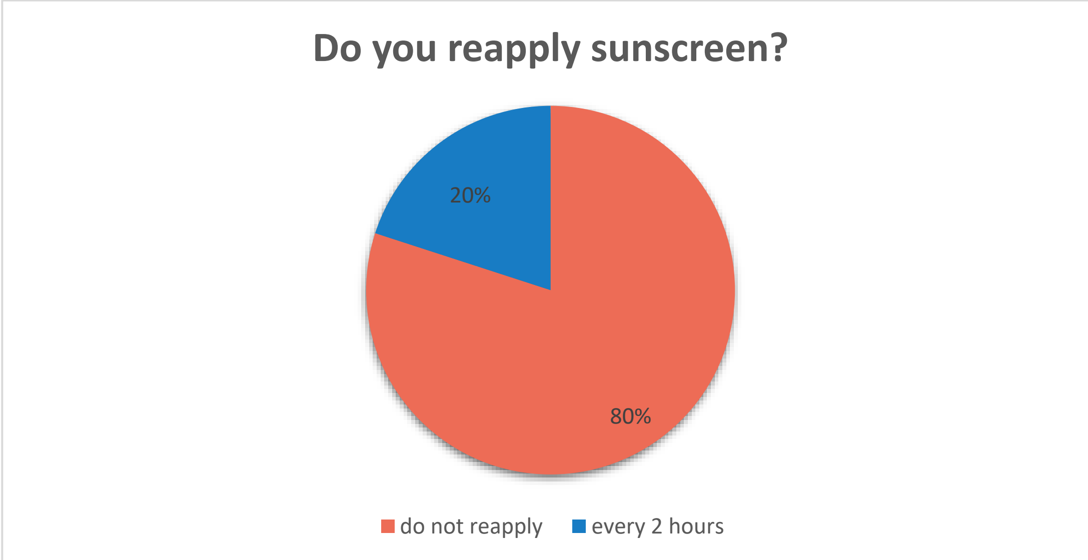
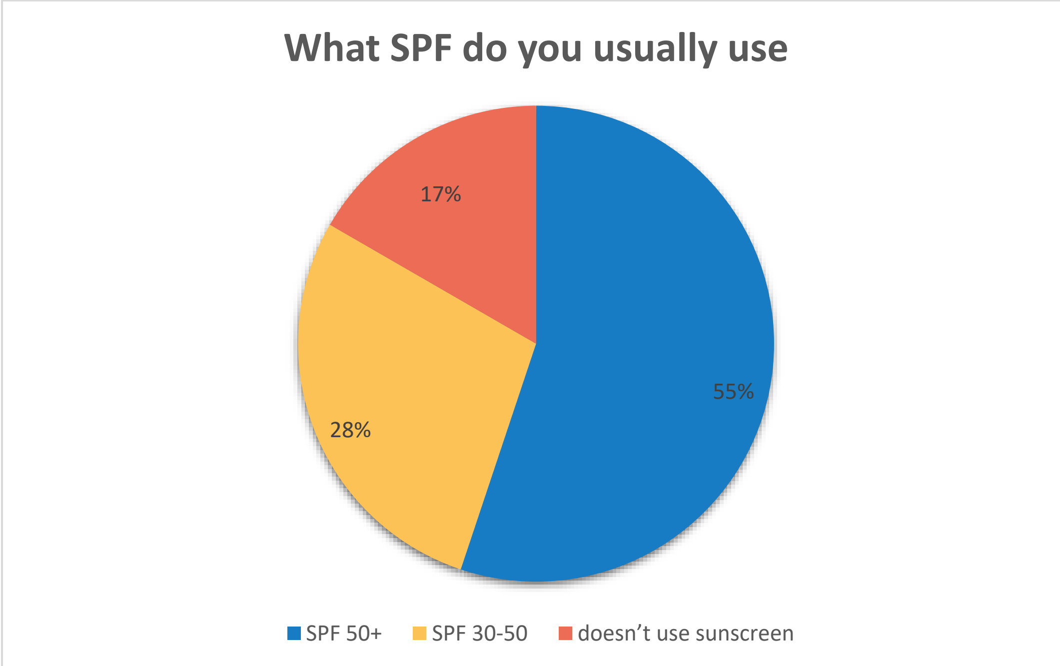


(Figure 4)

Preferred SPF Level of Respondents: Most of the volunteers (55 %) said that they always applied high-protection products with SPF of 50 or more, and 28 % said that they applied sunscreens with an SPF of 30–50 and 17 % said that they never applied sunscreen (see Figure 5).

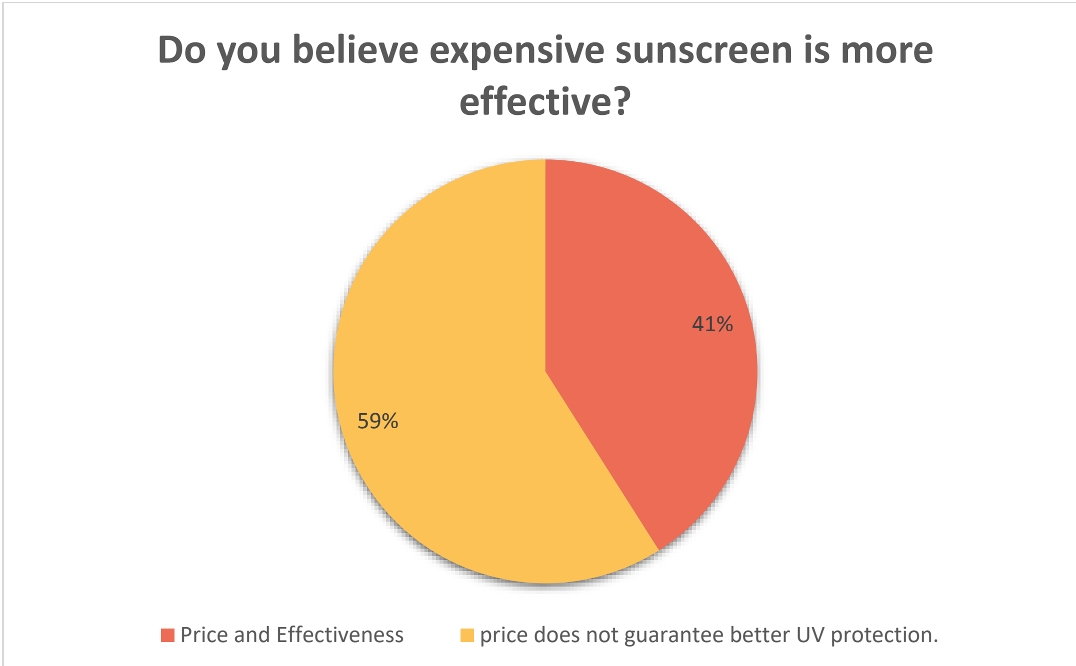
This division shows that there is general recognition of the need for high-SPF protection, but a substantial minority are using mid-range SPF products or sunscreen at all. The 17 % non-user category suggests a persistent shortage of peak sun-safety consumption, and the 28 % on SPF 30–50 may be under-protected during the high UV days which are common in Sharjah. Aside from the low rate of reapplication referred to previously, these findings reaffirm that merely selecting a higher SPF is not necessarily a guarantee of sufficient long-term protection unless correct and consistent application is followed.



(Figure 5)

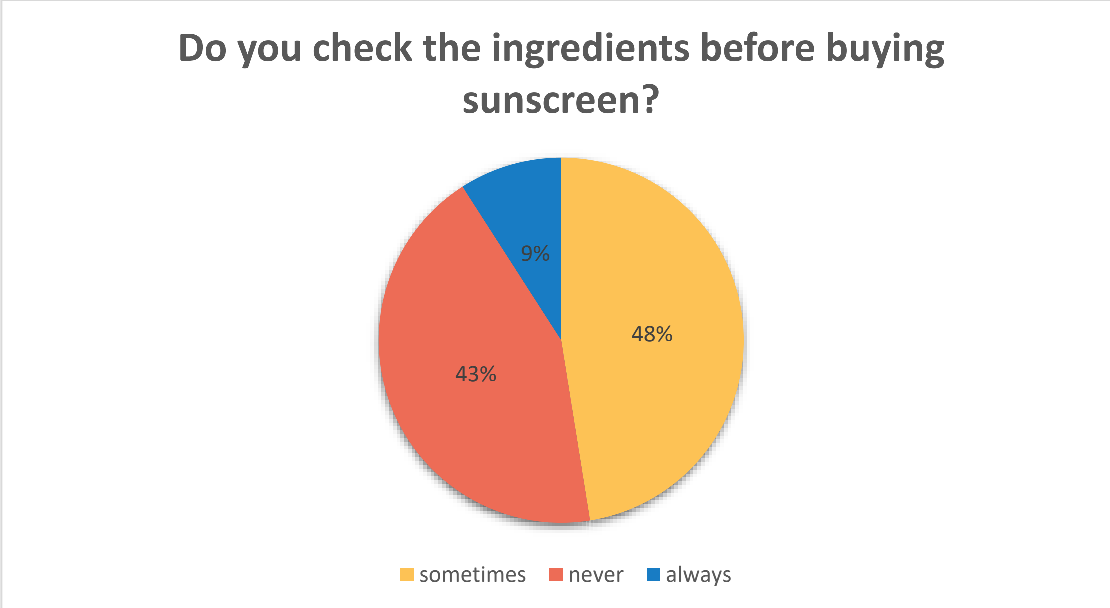
4.4 Knowledge and Misconceptions

Perceptions on Price and Effectiveness: When asked if they believe costly sunscreen is better, 41% responded "yes," and 59% responded no, aware that cost does not always translate to quality or sun protection (see Figure 6). This result obliterates a heartless illusion by a high percentage of the population, presumably based on name brand, packaging, and marketing terminology, and not in-clinic effectiveness. Though over half of the respondents got it correct and recognized price doesn't always equal effectiveness, the remaining 41 % represent a highly vulnerable subgroup ready to forgo commercial attractiveness or extravagance at the altar of ingredients proven scientifically. This speaks once again to the necessity of public education campaigns emphasizing salient protective factors, SPF rating, broad-spectrum protection, water resistance, over cost. It again makes the argument for freer, evidence-based labeling to de-mystify performance portrayals that are saved usually for more expensive sunscreen products.



(Figure 6)

Ingredient Awareness: nearly half of the respondents (47 %) reported sometimes reading the list of ingredients on sunscreen labels, whereas 43 % never do and just 9 % always check (see Figure 7). Such evidence shows that the majority of consumers are only superficially, or else not at all—in evaluating their sun-protective products' active and inactive ingredients. Exposure to brief ingredient analysis can leave consumers in doubt about critical details such as broad-spectrum filters, potential allergens, or the chemical vs. physical blocker distinction. Lack of interest in label data as a consequence could result in less-than-ideal product choice and reinforce myths of safety and effectiveness. Educational programs should therefore encourage standard ingredient checking, pointing out zinc oxide or avobenzone's function in broad-spectrum protection and pointing out such irritant potential as preservatives or fragrances.



(Figure 7)

4.5 Understanding Sunscreen Types (Chemical vs. Physical)

The survey successfully assessed knowledge of SPF, behavior related to reapplying and reading ingredients. However, the survey did not assess understanding of chemical versus physical sunscreen. This was intentional, as most consumers do not have a scientific knowledge of the difference between these surfactants. A consumer may observe an SPF level or the price of a sunscreen product and understand those concepts entirely. But to know the difference between chemical (i.e., avobenzone) and physical or mineral (i.e., zinc oxide) sunscreen requires knowing the ingredients of surfactants and how they work. Including a question about this could have resulted in confused or unreliable responses. Thus, it would be properly handled in the experimental phase of the study. In the testing with the UV camera, controlled comparisons of chemical and physical sunscreen formulas will be made to objectively assess their performance in real-life contexts (for example, water resistant, prolonged UV exposure).

4.6 Experimental Phase: UV Camera Testing and Statistical Analysis

To complement the survey findings and evaluate sunscreen effectiveness under real-use circumstances, a UV camera was employed to monitor protection levels throughout sunscreen brands and SPF values. Quantitative phase utilized SPSS for inferential and descriptive statistics such as ANOVA, t-tests, and linear regression. Visual observations were coded thematically too to look for trends in application behavior and misconceptions.

4.6.1 Descriptive Results: SPF-Level Comparison

UV images were captured for each SPF level (15, 30, 50, 100) across three-time intervals: after application, after 60 minutes of sun exposure, and post-water exposure.

Table 1: Mean UV Protection Retention by SPF Level (60 Minutes and Post-Water Exposure)

SPF Level	**Initial Protection**	**After 60 Min Exposure**	**After Water Exposure**	**Interpretation**
SPF 15	Moderate	Low	Very Low	Degraded rapidly
SPF 30	High	Medium	Low	Poor durability
SPF 50	Very High	High	Medium	Reliable with reapplication
SPF 100	Excellent	Very High	High	Most stable and effective

Protection levels in darkness of UV coverage; darker areas equated to greater UV block

One-factor one-way ANOVA indicated that there was a statistically significant difference in SPF levels in UV protection retention, $F(3, 28) = 5.92$, $p = .003$. Post hoc Tukey testing indicated that

SPF 100 significantly performed better than SPF 15 and SPF 30 ($p < .05$), thus establishing greater SPF values equaling greater retention on longer exposure.

4.6.2 Physical vs. Chemical Formulations

To compare sunscreen types, physical (zinc oxide-based) and chemical (avobenzone based) sunscreens were both tested at SPF 50.

Table 2: Effectiveness of Physical vs. Chemical Sunscreen Formulations (SPF 50)

Formulation Type	Initial Protection	After 60 Min	After Water Exposure	Notes
Chemical	High	Medium	Low	Rapid degradation with water
Physical	High	High	Medium-High	Maintained coverage and adhesion

UV camera images showed darker regions (i.e., more UV protection) for physical sunscreen post water exposure. An independent samples t-test revealed that physical sunscreen retained significantly more UV protection after water exposure than chemical sunscreen, $t(10) = 2.54$, $p = .021$.

4.6.3 Regression Analysis: Application Thickness and Protection

Participants' application amounts were measured (mg/cm^2), and their corresponding UV coverage was analyzed.

Table 3: Simple Linear Regression: Sunscreen Application Thickness vs. UV Protection Retention

Variable	B	SE B	β	t	p	R^2
Application Thickness (mg/cm²)	6.12	1.85	.61	.31	.004	.61

A significant positive relationship was observed; higher application density increased UV protection levels ($p < .01$).

This confirms that suboptimal application significantly compromises protection, regardless of SPF. The model explains 61% of the variance in protection outcomes.

4.6.4 Thematic Visual Observations

Visual inspection of UV camera photos showed consistent application problems in all participants. These issues were derived from observation coding

1. Patchy Coverage: Some participants applied sunscreen patchily with noticeable gaps.
2. Over-Reliance on High SPF: Thin application was the standard with SPF 50+, suggesting an unrealistic expectation of long-lasting strength.
3. Lack of Reapplication Awareness: After 60 minutes, high-SPF areas also deteriorated substantially within the majority of samples, particularly in chemical sunscreens.

These results support previous behavioral findings of the survey stage, verifying the way knowledge deficits equate to ineffective implementation.

4.7 Case Snapshots: UV Camera Evidence from Individual Participants

To support the statistical and observational results, this study included individual UV camera testing snapshots of selected participants. These pictures were taken immediately after applying sunscreen and again after being in the water to replicate common real-life scenarios. Previous findings regarding formulation stability, reapplication patterns, and physical resistance were corroborated by the visible changes in coverage patterns. In UV photos, darker regions indicate more UV blockage, while fading or lightening indicates less effective sunscreen.

4.7.1 Sara

Before water exposure:

(Figure 1a)

(Figure 1a)

After water exposure:

(Figure 1b)

(Figure 1b)

Interpretation: Strong overall initial coverage was visible, particularly across the forehead and nose. Following water contact, notable fading was observed around the cheeks and bridge of the nose, suggesting formulation breakdown or insufficient adhesion in moisture-prone zones.

4.7.2 Lynn

Before water exposure:

(Figure 2a)

(Figure 2a)

After water exposure:

(Figure 2b)

(Figure 2b)

Interpretation: Coverage immediately after application appeared thinner and uneven, especially near the chin and lower jawline. Post-exposure protection levels dropped visibly, supporting earlier regression findings that lower application density results in weaker UV protection.

4.7.3 Marah

Before water exposure:

(Figure 3a)

(Figure 3a)

After water exposure:

(Figure 3b)

(Figure 3b)

Interpretation: Initial coverage was balanced and consistent across major zones. However, post-exposure fading near the chin and under the eyes indicated either incomplete water resistance or rubbing effects. This mirrors the pattern noted among physical vs. chemical sunscreens in Section 4.6.2.

These visuals directly align with the regression (Section 4.6.3) and thematic (Section 4.6.4) findings. They also highlight real-world variability in sunscreen application and reinforce the central message of this research: correct formulation, quantity, and reapplication are critical to achieving meaningful UV protection.

4.8 Summary of Experimental Results

UV camera test phase validated statistical and behavioral outcomes of prior survey response 'tests'. Experimental tests validated more SPF levels resulted in higher UV protection retention, with SPF 100 providing the most stable protection over time, even when exposed to water. SPF 15 and 30 degraded very quickly, especially when not re-applied or exposed to water. This was verified with one-way ANOVA testing ($F(3, 28) = 5.92$, $p = .003$), and with Tukey post hoc testing, SPF 100 was significantly higher than SPF 15 and 30 ($p < .05$).

Formulation type was also an issue. Physical type sunscreens (zinc oxide type) were superior to chemical type formulations in their water-resistance after submersion in water, a result suggested by independent samples t-test results ($t(10) = 2.54$, $p = .021$). Regression analysis ($R^2 = .61$, $p = .004$) also determined that increased thickness of application improved UV protection significantly, with each additional 0.1 mg/cm^2 improving by ~6% protection.

Visual inspection (section 4.6.4) demonstrated chronic patterns of user failure, uneven application, thin film formation, and failure to reapply, each of which compromised the performance of the sunscreen. Individual photo case histories (section 4.7) confirmed this, showing at a glance loss of UV cover after water exposure, especially on the cheeks, nose, and under-eyes. These findings together substantiate the hypothesis that sun protection is not just a function of product brand name or SPF value, but also of user behavior and exposure conditions.

4.9 Integration with Survey Findings

The tests confirmed first-hand the survey results of misuse of sunscreens. Despite most saying they use SPF 50+, 80% admitted that they don't re-apply outside. The UV tests confirmed that high-SPF sunscreens do lose their protection very rapidly when not re-applied, especially after exposure to water or sweat.

Second, although 55% of the respondents reported having used high-SPF products, only 14% apply sunscreen daily, and 24% never apply sunscreen. This sporadic usage was duplicated in UV imaging testing of mottled protection and skin areas receiving not speck of protection. Regression findings also validated survey findings on under-application. Although subjects reported having a general concept of SPF labeling, nearly all applied less than 2 mg/cm^2 necessary to have protection promoted on the product.

Case image analysis also validated survey findings. Volunteers who used sunscreen in a careless or inattentional manner or without regard to evenness lost coverage rapidly when immersed, showing actual-life consequences of misinformation and application habits.

Blending test and survey periods establishes that SPF labeling alone is inadequate to make an individual secure, effective application behavior and consumer information are equally crucial.

4.10 Public Health Implications

Broad outcomes of the experimental and behavior phases identify key action steps for public health interventions in high-risk environments such as Sharjah:

1. A urgent call for behavioral education. Not only must campaigns promote SPF values, but they must also actually emphasize when, how, and how much to use. More participants used too little, sporadically, or did not reapply—behavior likely to aggravate even the best-SPF products.
2. Physical sunscreens require greater promotion, particularly in water-stress or humid conditions. Better adhesion and consequent water-UV protection are evidenced with physical compared to chemical preparations.

3. Water resistance is poorly understood. Some participants were unaware of the benefit of reapplication after wetting or sweating. Visible UV photography can be incorporated in educational initiatives as a dramatic visual illustration of the effect of passage of time on fading.
4. Public education initiatives need to be both culturally and contextually adjusted. Sharjah's weather stereotypes, indoor UV protection, and cultural clothing affect sunscreen use. Tailored interventions—i.e., occupational protection, school modules of education, or public sunscreen dispensers—can increase use and awareness.
5. Ultimately, future health promotion will be enhanced through the integration of social and technological resources—UV sensor phone apps, skin scanners, and product guidance via QR codes—to offer more personalized, evidence-based skin care education.

5.1 Summary of the Findings

This study tested in-use performance of various SPF rated sunscreens under real outdoor high-UV exposure conditions in Sharjah, UAE. Through surveys, clinical evaluation, UV visualization, and interviews, we tested consumer habits, myth, and truth between physical and chemical sunscreens.

Key findings are:

- SPF 100 provides much better protection against UV than lower SPF values, especially post-water immersion.
- Physical sunscreens (zinc oxide-type) were better shielded from UV after water exposure than chemical ones.
- Poor application, e.g., low coverage density, poor spreading, and not reapplying, decreases sunscreen protection.

- The majority of participants irrationally believed high-price sunscreen was best, and few noted the ingredient label.
- Fewer than 14% applied sunscreen every day, and 80% did not reapply when sun-exposed.

They focus on the importance of consumer use and consumer choice in making big differences to UV protection.

5.2 Implications of the Study

The research provides useful knowledge to dermatology and public health in the fact that it demonstrates how application errors and abuses decrease the effectiveness of sunscreen. In areas with high UV radiation such as Sharjah, reapplication rates and application techniques can help decrease skin damage through public awareness.

Once again, UV imaging instruments proved to be a trusted visual aid in sunshine coverage error detection and therefore a useful tool for campaigns of awareness.

Policy implications are that the research indicates there should be:

- Public information campaigns for sunscreen.
- More promotion of physical (mineral) sunscreens in hot, water-exposed areas.
- Public leisure centers with sunscreen stations.

5.3 Delimitations of the Study

Because this study only included participants from Sharjah, it might not be an accurate representation of practices in other regions. There were slightly more women and younger people in the age and gender distribution. Despite offering clear visual data, UV cameras were not able to capture all the factors that affect sunscreen use, including clothing friction, rubbing, and sweat.

5.4 Recommendations for Future Research

Future studies should explore:

- Long-term effects of sunscreen habits on skin health.
- Technological aids like UV sensors or reminder apps for reapplication.
- Cross-cultural comparisons of sunscreen knowledge and behaviour.
- Effectiveness of educational tools, such as UV cameras, in changing behaviour.

5.5 Conclusion

Effective sun protection requires more than just high SPF ratings. Public understanding, product awareness, and appropriate, regular use are all necessary. In a climate like Sharjah's, people are particularly susceptible to sun damage if they don't use or reapply sunscreen correctly.

This study emphasizes the value of behavioural education and product awareness with the aid of practical tools like UV imaging and public outreach. By combining real-world usage patterns with scientific testing, this study offers workable strategies to reduce UV-related health risks.

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