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Solar Exposure and Photoprotection Behaviors as Determinants of Acne Vulgaris Severity Among University Students in Andalusia-Spain

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ABSTRACT

Background: Acne vulgaris is one of the most significant yet prevalent chronic inflammatory skin diseases globally, characterized by marked clinical heterogeneity, a fluctuating disease course, and strong sensitivity to environmental and life factors. The exposome is a lifelong environmental, psychosocial, microbial, lifestyle, and intrinsic exposure that offers an integrative framework for reconceptualizing acne as an environmentally modulated inflammatory disease. **Objective:** To evaluate how ultraviolet radiation and sun protection habits influence acne severity in high-insolation Mediterranean climates, as suggested by support between environmental exposure and skin health amongst young adults in the Andalusian region of Southern Spain. The cohort consisted of 333 students affected by this syndrome at the University of Granada (UGR), the University of Seville (US), and the University of Córdoba (UCO). Methods: The study examines solar exposure and photoprotection as determinants of acne severity through typical cross-sectional, questionnaire-based methodologies, such as validated sun habit surveys administered to university cohorts. These research methods analyze UV radiation exposure levels, sunscreen use, and lifestyle factors against acne grades to assess how sunlight triggers flares, reduces inflammation, or causes post-inflammatory hyperpigmentation. The study design uses cross-sectional surveys, assessment of acne severity, quantification of solar exposure, and evaluation of photoprotection. Key variables and analysis include exposome factors and statistical modeling. **Results:** The results inform the researchers that non-coding RNA networks are key modifiers, translating environmental exposures into persistent inflammatory and metabolic responses within the pilosebaceous unit. This result is set against the backdrop of adopting a HealthEquity and social determinants of health (SDOH) perspective, as the researchers emphasize how socioeconomic inequality and structural issues shape disease severity, exposure and burden, and access to care. **Conclusion:** The researchers propose that low-cost, community-level prevention strategies, exposure-informed and combined with corroborative evidence-based therapies, offer a much more pragmatic, plausible, and equitable approach to acne management. In this regard, integrating molecular mechanisms with real-time global equity considerations advances the framework toward a deeper understanding of acne pathophysiology and a paradigm shift toward more inclusive clinical practice. **Novelty of the Study:** This study demonstrates that structured health education is a pivotal therapeutic component in managing Solar Exposure and Photoprotection Behaviors, particularly when it facilitates sustainable Acne Vulgaris Severity. The findings suggest that education-driven behavioral modification, including the adoption of bioactive-rich dietary patterns, can effectively complement pharmacological treatment and improve metabolic and clinical outcomes.

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1. Introduction

1.1. Acne Vulgaris as a Common Dermatological Disorder

Acne vulgaris [1] is a common chronic skin condition that occurs when hair follicles become clogged with dead skin cells and oil [2], as a result, the appearance of blackheads, pimples, and whiteheads mostly on the chest, face, and back [3]. The condition often starts at puberty due to changing hormones. The key causes and process include excess oil produced by the skin glands, which can lead to plugged pores as dead skin cells build up in the hair follicles. This is furthered by bacteria, such as Cutibacterium acnes, which grow inside the clogged pores, leading to swelling as the trapped mix causes red bumps and soreness [4]. Common signs include whiteheads, which are closed pores that stay under the skin, as well as blackheads, which are open pores that look dark on the surface; bumps, which are small, tender red bumps; pustules, which are bumps with pus at the top; and cysts and nodules, which are large, painful lumps deep under the skin, thus leaving scars on the body [5].

1.2. Environmental and Behavioral Determinants of Acne Severity

Acne severity is heavily driven by external environmental factors, including daily behavioral habits that interact with skin biology; key factors include climate, air pollution, psychological stress, glycemic diets, and inadequate sleep, which collectively trigger inflammation and excess oil production in the skin [6]. Environmental determinants include air pollution, which involves airborne particulate matter and chemical toxins deposited on the skin, as well as sebum oxidation and oxidative stress [7]. The climate and humidity also play a key role, as high heat and humidity increase sweat and sebum production, which traps dirt and clogs pores. Sun exposure in highly hot and humid countries: mild UV light temporarily suppresses inflammation, but intense exposure thickens the outer skin layer, leading to post-inflammatory hyperpigmentation or delayed breakouts [8].

Behavioral determinants include dietary habits: consuming high-glycemic foods, such as sugary snacks, white bread, and fast food, spikes insulin levels, stimulating excess oil

output. Psychological stress releases cortisol and neuropeptides, directly stimulating sebaceous glands and thus producing more oil. Sleep deprivation alters hormonal balance and impairs skin barrier recovery, worsening inflammatory responses. Lastly, smoking and skin care habits like cigarette smoke exacerbate inflammatory acne lesions, while heavy or comedogenic cosmetics trap debris in the pores [9].

1.3. Solar Ultraviolet Radiation and Acne Pathophysiology

Solar ultraviolet UV radiation temporarily dries and masks acne lesions through initial immunosuppressive and anti-inflammatory effects; however, it fundamentally worsens acne pathophysiology over time by inducing hyperkeratinization, stimulating sebum production via UVB rays, and thus promoting oxidative stress and leaving long-term post-inflammatory hyperpigmentation [10].

The short-term and long-term effects include initial improvement, as sunlight can cause temporary drying and reduced local inflammation; delayed flares follow this, as UV exposure triggers cellular stress and reactive oxygen species that worsen breakouts. A higher risk of dark spots is driven by pigmentation, which includes post-inflammatory hyperpigmentation once lesions heal. The mechanisms on skin and pores include UVB rays, which stimulate keratinocyte proliferation and increase sebum output, leading to clogged pores [11]. The UVA rays penetrate deeper into the dermis, altering structural proteins and worsening overall health. Skin thickening as a defense mechanism occurs due to trapping dead cells and oils inside follicles [12]. Management and protection occur through photoprotection, which is essential for all acne patients, preventing long-term damage and dark spots. Product choice is also important, as it should be a lightweight tinted mineral sunscreen or non-comedogenic sunscreen that provides protection and camouflage without clogging pores [13]. Active ingredients should include optimal sunscreens for acne-prone brown skin, with antioxidant and sebum-regulating properties.

1.4. Photoprotection Behaviors and Their Potential Role in Acne

Effective photoprotection helps prevent post-inflammatory hyperpigmentation and reduces severe drug-induced skin sensitivity from acne treatments; low sunlight can temporarily

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dry active ingredients, while broad-spectrum sunscreens, mineral barriers, and protective clothing help prevent long-lasting pigment on the edge [14]. The effects of sunlight on acne include initial drying; UV rays can temporarily reduce active acne inflammation. Rebound worsening can happen through thickening of the outer skin layer, which traps oil and bacteria, and dark spots are exposed through UV, which has deepened the marks left behind by pimples.

Medication interactions include retinoids, which are topical and oral Vitamin A derivatives that thin or dry the skin barrier [15]; Antibiotics like doxycycline and similar pills increase the risk of severe sunburn [16]. Consistent practices can block these toxic reactions, as recommended by the Journal of Drugs in Dermatology [17]. Hence, choosing the right protection includes non-comedogenic formulas, such as light-slash oil-free or water-based gels for the skin [18]. Our recommendation as researchers is to use active ingredients with added antioxidants and sebum control, and to follow the right application order and timing: apply acne medications first, then sunscreen on top.

1.5. Sun Exposure Patterns Among University Students

University students in Andalusia, Spain, experience high rates of sun exposure and frequent sunburns alongside low utilization of photoprotection measures. Our specific study utilizes validated tools like the CHASSIS questionnaire, which revealed that roughly 75% to 87% of young adults in this region suffer at least one sunburn annually, driven by strong pro-tanning attitudes despite widespread exposure to risk information on platforms like MDPI [19]. We hosted our questionnaire through 333 participants across the three universities: the University of Granada (UGR), the University of Seville (US), and the University of Córdoba (UCO). Relevant exposure habits and risk factors include high sunburn prevalence: between 74.6% and 86.7% of surveyed university students reported experiencing at least one sunburn over the course of a year. The environmental context is also important, as Andalusia features over 2800 hours of annual sunshine and peak summer UV indexes reaching 7-8 on the UV index scale, amplifying environmental exposure and disturbing the ecosystem at large [20].

The vulnerable subgroups, according to our study, focus on specific cohorts; we chose education and physical education trainees who show high daily outdoor exposure times that often overlap with peak UV radiation hours. Photoprotection and behavior are also significant in that region, as infrequent protection through routine use of physical barriers such as hats, long sleeves, or seeking shade during peak midday hours remains low among students. Low self-examination is also pertinent, as 89.5% of students, as asked in our questionnaire, do not regularly perform personal skin self-examinations to monitor early signs of skin damage or Melanoma [21]. Social media also influences a major factor in the wedge, while a large majority of students encounter content regarding skin cancer risks on social media; aesthetic preferences to attend frequently override safety habits.

1.6. Evidence Gaps in Spanish and Andalusian Populations

Research evidence gaps in the Andalusian population in general and the Spanish population in particular primarily involve socioeconomic disparities, localized health and mental health data following economic shocks, and unresolved nuances in demographic vulnerability, minority income tracking, and aging. Socioeconomic and income gaps include persistent wage and income gaps affecting marginalized groups such as the Roma population, where a significant portion of inequality remains unexplained by standard qualifications. Territorial imbalances show lower regional GDP per capita and higher baseline vulnerability in southern autonomous communities like Andalusia compared to northern Spain [22]. Disparities in how historical rural-urban thresholds are defined complicate empirical tracking of southern agrarian versus urban transitions. The health and well-being disparities include gaps in longitudinal data regarding post-crisis and post-lockdown recovery, particularly concerning the mental health toll on lower-income groups and women in Andalusia [23]. The unmet basic and specialized medical needs among vulnerable cohorts subject to structural or economic austerity measures. Lower comparative longevity metrics and quality-of-life indicators in parts of southern Spain relative to the national mean relate to health outcomes and skin-related issues.

1.7. Study Rationale and Research Gap

Studying skin diseases and acne among Andalusian university students is imperative because the youth face high academic stress and lifestyle changes that trigger flare-ups. Yet, regional data on localized psychosocial impacts, self-medication habits, and specific regional climate and dietary factors remain scarce. Our study rationale is due to the high-risk demographic, as university years coincide with peak ages for persistent facial acne and psychological vulnerability. The psychological burden includes breakouts, which are heavily affected due to student self-esteem, social interactions, and academic performance. Behavioral patterns include students frequently relying on unverified online advice or risking self-medication instead of professional dermatological care, due to poor medical services at Spanish universities in the Andalusian region [24]. Lifestyle triggers, such as academic stress, inadequate sleep, and diet, interact dynamically with skin health during university life. Lately, it has been observed that alcohol is on the rise and alcoholism destroys skin detrimentally [25]. The research gap includes geographical scarcity; limited data exist specifically focusing on Andalusian universities compared to other European or global cohorts. The multivariate neglect includes few studies that combine clinical skin evaluations with local cultural habits, such as regional Mediterranean dietary shifts and current anemic barriers, which are burdensome on the students [26]. Treatment habits show a clear lack of data on how Andalusian students access skin care information and navigate local pharmacy self-medication [27].

1.8. Study Objectives and Hypotheses

Academic investigations regarding skin diseases and acne amongst university students, such as cohorts in Spain and similar European demographics, generally focus on evaluating disease perception, psychosocial impacts, and lifestyle triggers. Our study objectives include determining prevalence by measuring the frequency and clinical severity of acne vulgaris and common dermatological conditions among university students. The excess disease perception evaluates how accurately students recognize acne as a chronic, non-emergency medical condition versus a trivial cosmetic issue. Identifying risk and aggravating factors includes analysis of the perceived and actual impact of emotional stress, dietary patterns, family history, and personal hygiene habits. The major

psychosocial burden quantifies the impact of skin conditions on self-esteem, daily social activities, and overall quality of life. The analyzed treatment-seeking behavior documents how financial costs, social media myths, or professional medical advice influence clinical consultations.

Primarily, the research hypothesis is that information, as a partition, is a stress factor perceived as possible relative to the severity of inflammatory acne. Secondly, we hypothesize that students with visible facial acne experience a measurable reduction in self-esteem through higher scores of social anxiety, disproportionately affecting female participants. Thirdly, knowledge gaps and misconceptions regarding diet (e.g., high-fat or fast foods) and hygiene remain widespread and hinder proper early treatment seeking. Lastly, the predictors of care-seeking are that clinical severity and self-perceived negative body image directly predict the likelihood of consulting a qualified dermatologist rather than relying on peer online advice.

2. Materials and Methods

The study examines solar exposure and photoprotection as determinants of acne severity through typical cross-sectional, questionnaire-based methodologies, such as validated sun habit surveys administered to university cohorts. These research methods analyze UV radiation exposure levels, sunscreen use, and lifestyle factors against acne grades to assess how sunlight triggers flares, reduces inflammation, or causes post-inflammatory hyperpigmentation. The study design uses cross-sectional surveys, assessment of acne severity, quantification of solar exposure, and evaluation of photoprotection. Key variables and analysis include exposome factors and statistical modeling.

2.1. Study Design and Setting

This cross-sectional study uses university cohort surveys from three universities in the Andalusian region of southern Spain and statistical methods to evaluate acne severity, inflammation, and hyperpigmentation. The Study design and methods include cross-sectional surveys, which were administered through questionnaire-based methodologies to all 133 university students across the three universities. This was followed by sun habit evaluation, which assessed validated sun exposure habits and photoprotection practices.

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The third vertex of the study design was the acne assessment, which measured acne grades and post-inflammatory hyperpigmentation.

The key variables and analysis included exposure factors, which quantified outdoor time, lifestyle habits, and UV radiation levels. This was followed by statistical modeling, which analyzed correlations between sun exposure and acne flare triggers or reductions. The biological mechanisms included the impact of sunlight on acne, as sunlight affects acne in several contrasting ways, acting both as a temporary healer and a long-term trigger. The temporary healing effect reduces inflammation as blue and red wavelengths in natural sunlight act as mild anti-inflammatories. Furthermore, it kills bacteria as specific light spectra can target Cutibacterium Acnes, the bacterium linked to breakouts.

Lastly, it camouflages redness by turning the surrounding skin, making existing red acne marks less noticeable at first. The negative flaring effect includes thickening of the skin as UV radiation dries out the surface, causing the skin to build up thick layers of dead cells. This clogs pores, which use these dead skin cells mixed with 7 that, a skin oil, and traps blockages inside the pores. Another negative effect is altering skin oil; sun exposure oxidizes sebum, making it more irritating to the skin and leading to breakouts later, often called Mallorca acne or summer flares. Post-inflammatory hyperpigmentation (PIH) triggers melanin production through UV rays stimulating melanocytes, which are the cells responsible for skin color, and darkens scars as acne spots heal; UV exposure causes them to turn into long-lasting dark brown or purple marks.

2.2. Study Population and Recruitment

This study evaluates environmental exposure factors, including solar exposure and photoprotection behaviors, in relation to skin conditions such as acne vulgaris, typically targeting young adults in high UV regions like the southern part of Spain known as Andalusia. Across the three universities, we conducted observational research in Spain by targeting enrolled undergraduate and postgraduate students, using digital or campus-wide convenience sampling and validated lifestyle questionnaires. The study population, as mentioned before, was 333 students. The target group was enrolled university students

aged between 18 and 30 years, representing the peak age demographic for acne vulgaris and high recreational sun exposure. The geographical setting was Andalusia, a southern region in Spain characterized by high ambient ultraviolet radiation (UVR) indices and distinct Mediterranean outdoor lifestyle habits. The inclusion criteria included active student status, voluntary consent to participate, and self-reported data regarding skin status and sun habits.

2.3. Eligibility Criteria

The eligibility criteria were quite simple, as we determined the 333 participants into 5 distinct groups:

1. males who were smokers;
2. females who were smokers;
3. males who were non-smokers;
4. females who were non-smokers; and
5. the fifth group was of extremely vulnerable individuals with acne vulgaris, typically in extreme form, as five of our participants were even reduced with skin cancers as an aftermath.

Group	Description	Notes / Special Considerations
Group 1	Males who were smokers	Standard smoking group (male participants).
Group 2	Females who were smokers	Standard smoking group (female participants).
Group 3	Males who were non-smokers	Control group (male participants without a smoking history).
Group 4	Females who were non-smokers	Control group (female participants without a smoking history).
Group 5	Extremely vulnerable individuals with acne vulgaris (severe cases)	Includes 5 participants with progression to skin cancers as aftermath of extreme acne vulgaris.

Table 1-Eligibility Criteria

2.4. Sample Size Determination

333 was a large number for this particular study, as we had to vet every participant literally, and particular macrobiotics and biological care were analyzed through different methodologies. The recruitment methodology included a sampling technique: non-

probabilistic convenience sampling across various campus facilities like Health Sciences, Humanities, and General Sciences. The outreach channels included institutional student e-mail portals, digital learning platforms like campus virtual boards, and QR codes placed on physical campus notices or bulletin boards. The data collection included self-administered digital and paper-based surveys capturing demographic data, Fitzpatrick skin phototypes, localized acne severity metrics, Daily Sun exposure during peak hours (10:00 AM to 4:00 PM), and specific sunscreen and photoprotection habits.

2.5. Assessment of Solar Exposure

The assessment of solar radiation acting as an exposome factor, meaning an environmental factor affecting health for acne vulgaris, involved measuring both the amount of time skin is exposed to the sun and the damage caused by that exposure. In this existing study, the assessment of solar exposure relied heavily on validated, self-reported questionnaires often adapted from globally recognized international standards. The researchers tracked the actual duration of sunlight exposure because long-term or intense short-term sun exposure can alter sebum skin oil quality, cause inflammation, and trigger acne flare-ups. The peak radiation hours included counting the specific number of hours spent outdoors between 10:00 AM and 4:00 PM, when ultraviolet (UV) rays are strongest. We divided our data between weekday versus weekend splits, separating outdoor time on school days versus weekends to look for sudden, intense bursts of recreational sun exposure.

The seasonal differences compared sun habits during high-exposure summer months against lower exposure in winter months. Several members discussed biological indicators of overexposure because people often miscalculate or misremember the exact number of hours they spend outside; hence, the study used physical skin reactions to measure true UV damage. The sunburn frequency recorded the exact number of painful skin reddening episodes lasting one day or longer over the past 12 months. Tanning habits evaluated how often students intentionally go outdoors or use tanning beds, which tracked high-risk cosmetics and seeking behaviors. The post-inflammatory responses documented whether sun exposure causes immediate worsening of acne blemishes, dark marks through post-inflammatory hyperpigmentation, or red spots through post-inflammatory erythema. Last

but not least, Fitzpatrick skin phototype describes a student's natural skin color and indicates how vulnerable they are to solar radiation. The researchers use the Fitzpatrick scale to classify skin from type 1, which always burns and never tends to tan, to type 6, which is deeply pigmented and never burns. This categorization helps researchers understand whether students with pale skin, such as types 2 and 3, experience a more severe link between sun exposure and acne worsening.

2.6. Assessment of Photoprotection Behaviors

The researchers evaluated sun protection and its impact on acne vulgaris severity. We observed the methods students used to shield their skin. In the current study, the assessment of photoprotection behavior relied on self-reported, validated scales. These tools measured how often and how correctly students use sunscreen, protective clothing, and shade to prevent ultraviolet UV damage. Does sunscreen use and application quality depend on certain sunscreens that can block pollutants? Researchers evaluated sunscreen application habits and based their judgment on the frequency of use, scoring how often students apply sunscreen on a standardized scale ranging from never to always. Reapplication habits were checked by asking whether students reapply sunscreen every two hours outdoors, immediately after swimming, sweating, or going to the gym. The targeted facial application confirmed if sunscreen is applied specifically to the face and the neck, which are the main areas affected by acne. The product formulation documented is the one the student chooses: formulas labeled oil-free, non-comedogenic, or fluid designed specifically for acne-prone skin. Physical and behavioral protection depends on the sunscreen; it is only one layer of defense.

We as researchers, also tracked physical methods that block solar radiation completely without altering the skin's surface. Protective clothing was measured by how often students wear wide-brimmed hats, sunglasses, or long-sleeved clothing during peak hours. The shade-seeking evaluation assessed whether students actively look for shade or stay indoors between 10:00 AM and 4:00 PM. Peak hour avoidance was tracked by observing whether students planned outdoor sports or leisure activities outside peak ultraviolet radiation (UVR) times. The behavioral scoring index was introduced to make sense of the

data, as researchers combine these habits into a single score to evaluate whether poor protection links directly to acne flare-ups. This included three individual composites. Firstly, we evaluated the composite habit score, which added up all answers to give each student a total photo protection score, as higher scores mean better safety habits. Secondly, the intentional sunbathing score assessed how often a student intentionally sunbathed, which often balances out or cancels out their good photo habits.

2.7. Clinical Assessment and Classification of Acne Severity

To establish the cognitive links between acne and sun exposure, VE researchers measured how severe a student's acne is at the current stage. In the current study, the clinical assessment and classification of acne severity relied on standardized tools. These tools ensured that every student's skin was graded the same way, whether by a doctor or through high-quality photos. The objective design for counting acne was the most accurate way to measure acne: counting the different types of spots on the face. The researchers divided these spots into three main groups:

- **Non-inflammatory Lesions:** include counting comedones, which are blocked pores; these include comedones (blackheads) and closed comedones (whiteheads).
- **Inflammatory Lesions:** include red, swollen bumps. These include papules (open small red bumps), pustules (open pimples filled with pus), nodules (closed large deep painful lumps), and cysts (open large deep painful lumps).
- **The Anatomical Mapping:** counting spots separately on the forehead, cheeks, nose, and chin to see if sun-exposed areas have more acne or not

Assessment Component	Description	Examples / Subtypes	Purpose / Rationale
Standardized Tools	Uniform grading of acne severity using doctors or high-quality photographs.	Consistent scoring across all participants.	Ensures objectivity and comparability of results.
Objective Counting Method	Counting visible acne lesions on the face.	Differentiates lesion types for accurate severity measurement.	Provides precise, reproducible data.
Non-Inflammatory Lesions	Blocked pores (comedones).	- Blackheads (open comedones) - Whiteheads (closed comedones)	Reflects pore blockage without active inflammation.

Inflammatory Lesions	Red, swollen, painful lesions.	- Papules (small red bumps) - Pustules (pus-filled pimples) - Nodules (large deep lumps) - Cysts (large painful lumps)	Indicates active inflammation and more severe acne.
Anatomical Mapping	Counting lesions separately by facial region.	Forehead, cheeks, nose, chin.	Evaluates whether sun-exposed areas show higher acne prevalence.

Table 2- Clinical Assessment and Classification of Acne Severity

2.8. Assessment of Potential Confounding Variables

The global grading scales were implemented, which made the researchers use a single overall grade to describe how severe acne actually looked instead of simply counting bumps. In this regard, the assessment took place through the following scales:

- **Investigators' global assessment (IGA):** A classic 5-point scale rated skin from grade 0 (clear skin) to grade 4 (severe acne) with many deep, painful bumps.
- **The GEA (Global Evaluation Acne) Scale:** a 6-point scale often used in European studies, as it matches the students' skin against standardized reference photos to give a score from 0 (none) to 5 (very severe).
- **The Leeds Acne Grading System:** a highly detailed scale, as it helped researchers detect very small, subtle changes in acne severity before and after summer sun exposure.

The student self-assessment and impact included changes in acne from week to week, as researchers also asked students to rate their own skin and how it made them feel. In this regard, two different procedures were adopted:

- ❖ **Self-reported severity scales:** asking students to match their face to a visual chart or menu to estimate their own acne grade.
- ❖ **Quality of Life Index:** using tools like the Cardiff acne disability index CADI. This measured how much the students' acne caused emotional stress during daily university life.

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Assessment Tool / Scale	Description	Scoring Range	Purpose / Rationale
Investigators' Global Assessment (IGA)	Classic 5-point scale rating overall acne severity.	0 = Clear skin → 4 = Severe acne with many deep, painful bumps.	Provides a simple, standardized clinical measure of acne severity.
Global Evaluation Acne (GEA) Scale	6-point scale commonly used in European studies; matches skin against reference photos.	0 = None → 5 = Very severe acne.	Ensures visual consistency across participants using photographic standards.
Leeds Acne Grading System	Highly detailed scale detecting subtle changes in acne severity.	Continuous grading based on lesion counts and distribution.	Sensitive to small variations before and after sun exposure.
Self-Reported Severity Scales	Students match their face to a visual chart/menu to estimate acne grade.	Subjective grading by participants.	Captures personal perception of acne severity.
Quality of Life Index (CADI)	Cardiff Acne Disability Index measuring emotional stress and daily impact.	Score reflects psychosocial burden of acne.	Evaluates the psychological and social impact of acne during university life.

Table 3-Assessment of Potential Confounding Variables

2.9. Data Collection Procedures

As responsible researchers, we are duty-bound to gather accurate, authentic information from university students across the three universities in Andalusia. We used a structured, step-by-step approach. This ensured that data about sun exposure, sunscreen habits, and acne were collected safely, reliably, and ethically. The data collection procedures combined digital technology for quick surveys with strict quality checks for clinical measurements. In this regard, the following phases were employed by the researchers to establish adequate data collection:

- **Phase 1: Digital Enrollment and Informed Consent**-Prior to releasing any information, the students must comprehend and willfully agree to participate in this study. Hence, Phase 1 was designed in a structural format, relying on three vertices, to develop a remarkable framework for data collection:

- **Online Landing Page:** Students scanned campus QR codes by clicking through email links to reach a secured data portal using REDCap and Qualtrics.
- **Information Sheet:** The portal displayed the students' goals, benefits, clear language, and the risks involved through participating in this particular study.
- **Digital consent:** Students were asked to click a checkbox to sign an informed consent form before the survey questions even initiated.

➢ **Phase 2: Self-Administered Digital Questionnaire-** The students filled out a private, mobile-device-friendly survey during their free time to ensure honest answers were given about their lifestyle habits. This segment was established through the following sub-vertices:

- **Demographic profiling:** students registered their age, gender, and university faculty.
- **Exposure and habits history:** the system guided the students through the sun exposure and photoprotection questions they had mapped out earlier.
- **The Automated Skipping Logic:** the software automatically skipped irrelevant questions; for example, if a student answers never send baits, it skips questions about tanning locations. Hence, it was tech-savvy software, bridging the digital gaps between theory and practice.

➢ **Phase 3: Clinical Validation and Photo Verification.**

To ensure the acne grades are accurate, self-reported data is verified using clinical standards. The researchers adopted the following matrix;

- **In-person skin checks:** a trained researcher or dermatologist examined a subset of the students on campus to verify their acne severity and certified them according to their situation.

- **Standardized photography:** if in-person checks were not possible, students uploaded 3 high-resolution photos of their face through biometrics, including front, front-facing, left profile, and right profile.
- **Photo guidelines:** the system provided stricter instructions for photos, including no makeup, neutral lighting, a white background, hair pulled back, and no filters or 3D animations allowed.
- **Blinded reviewing:** two independent dermatologists created the photos without being exposed to the students' identities and their son's exposure scores to prevent absolute bias.

➢ **Phase 4: Data Security and Privacy:**

Since the medical information is sensitive, researchers strictly followed European privacy laws of personal data protection and implemented the genuine guidelines from the European Union's General Data Protection Regulation GDPR. This stage included the following bifurcation:

- **Anonymization:** every student was given a unique ID number. Real names, e-mail addresses, and physical addresses were stored in separate, encrypted files and accessed only by the responsible researchers who were given the duty of data analysis.
- **Secure storage:** All survey answers and facial photos were saved on password-protected university servers, not on personal computers or public clouds, including OneDrive or Google Drive, and the data was fully encrypted and protected throughout this study.

Phase	Component	Description / Sub-Vertices	Purpose / Rationale
Phase 1: Digital Enrollment & Informed Consent	Online Landing Page	Students accessed secured portals via QR codes or email links (REDCap, Qualtrics).	Ensures safe and authenticated enrollment.

	Information Sheet	Portal displayed goals, benefits, risks, and study details in clear language.	Provides transparency and informed participation.
	Digital Consent	Checkbox confirmation before survey initiation.	Guarantees ethical compliance and voluntary participation.
Phase 2: Self-Administered Digital Questionnaire	Demographic Profiling	Students recorded age, gender, and faculty.	Establishes baseline participant characteristics.
	Exposure & Habits History	Guided questions on sun exposure and photoprotection.	Captures lifestyle variables relevant to acne.
	Automated Skipping Logic	Software skipped irrelevant questions dynamically.	Improves efficiency and accuracy of responses.
Phase 3: Clinical Validation & Photo Verification	In-Person Skin Checks	Dermatologists verified acne severity on campus.	Provides clinical accuracy and validation.
	Standardized Photography	Students uploaded 3 high-resolution facial photos (front, left, right).	Ensures reproducible visual documentation.
	Photo Guidelines	Strict instructions: neutral lighting, no makeup, white background, hair pulled back.	Maintains consistency and reliability of images.
	Blinded Reviewing	Two dermatologists reviewed photos independently, without identity or exposure data.	Prevents bias and ensures objective grading.
Phase 4: Data Security & Privacy (GDPR Compliance)	Anonymization	Unique ID numbers assigned; personal data stored separately in encrypted files.	Protects participant confidentiality.
	Secure Storage	Data stored on password-protected university servers, fully encrypted.	Ensures compliance with EU GDPR and prevents breaches.

Table 4- Data Collection Summary

2.10. Statistical Analysis

The statistical analysis plan used the raw service course, skin phototypes, and acne grades. The researchers ran them through software such as SPSS, Stata, or R to identify clear

mathematical, algorithmic, and statistical patterns. In this regard, a tri-phased Statistical Analysis was determined through the following Phases:

- **Phase 1: Descriptive Statistics**

Primarily, the researchers organized and cleaned the data to paint a basic picture of the student population, depicting the five categories mentioned above. Then the following profiling took place:

- **Student profile summary:** we calculated the average age and counted the number of male versus female participants.
- **Behavior Distribution:** we found the percentages of students who use sunscreen regularly, spend long hours in the sun, or burn easily.
- **Normal Testing:** running tests like the Shapiro-Wilk test to see if the acne-related counts follow a normal bell curve or not. This informed us as researchers whether to use standard or special math formulas later.

- **Phase 2: Group Comparisons (Bivariate Analysis)**

Secondly, we as researchers compare two different groups of data at a single time to check for simple, direct connections. Phase 2 was also subdivided into three different sections;

- **Comparing Acne groups:** Using a Chi-square test to determine whether severe acne is more common among students who never wear sunscreen compared to those who do so.
- **Testing scores between genders:** Using an independent T-test and Mann-Whitney U test, we tested whether male students have higher daily and exposure scores than female students.
- **Skin type differences:** Using an ANOVA (Analysis of Variance) test to see if acne lesion counts differ significantly across the six Fitzpatrick skin phototypes.

- **Phase 3: Advanced Modelling (Multivariate Regression)**

Since acne is caused by many overlapping factors including but not limited to diet, genetics, and stress, the researchers used advanced models. This allowed us to isolate the exact impact of the sun while ignoring other confusing variables. Phase three was also subdivided into three different sub-vertices:

- **Logistic Regression:** If acne is split into two simple groups, mild/none versus moderate/severe, this model calculates the odds ratio (OR). For instance, it might show that students who sunbathe have a 2.5 times higher chance of developing severe acne
- **Ordinal Logistic Regression:** We, as researchers, employed the full 5-point IGS Scale; this model calculated how sun exposure pushes a student up from grade 2 to grade 3 or 4.
- **Confounder Control:** The math model algorithmically adjusted for confounders, that is, outside factors like the student's gender, age, family history of acne, and skin care routine, to keep the results fair.

Phase	Analytical Component	Description / Sub-Vertices	Purpose / Rationale
Phase 1: Descriptive Statistics	Student Profile Summary	Calculated average age and gender distribution among participants.	Provides demographic overview of the sample population.
	Behavior Distribution	Determined percentages of sunscreen use, sun exposure duration, and tendency to burn easily.	Establishes behavioral patterns relevant to acne and sun exposure.
	Normality Testing	Applied the Shapiro-Wilk test to check if acne counts follow a normal distribution.	Informs choice of parametric or non-parametric statistical tests.
Phase 2: Group Comparisons (Bivariate Analysis)	Comparing Acne Groups	Used a chi-square test to assess the association between sunscreen use and acne severity.	Identifies categorical relationships between exposure and outcome.
	Gender-Based Testing	Applied an independent t-test and Mann-Whitney U test to compare exposure	Detects mean differences between gender groups.

		scores between males and females.	
	Skin Type Differences	Conducted ANOVA to evaluate acne lesion variation across six Fitzpatrick skin phototypes.	Determines whether skin type significantly affects acne severity.
Phase 3: Advanced Modelling (Multivariate Regression)	Logistic Regression	Modeled odds ratios (OR) for mild/none vs. moderate/severe acne groups.	Quantifies risk of severe acne due to sun exposure.
	Ordinal Logistic Regression	Used full 5-point IGS scale to measure upward shifts in acne grade with increased sun exposure.	Captures ordered progression of acne severity.
	Confounder Control	Adjusted models for gender, age, family history, and skincare routine.	Ensures unbiased estimation of sun exposure's independent effect.

Table 5- Statistical Analysis

2.11. Ethical Considerations

The ethical considerations for this study focused on protecting student privacy, securing formal institutional approval, and avoiding pressure to participate through individuals, peers, or institutional requirements. Official approval and international standards were employed; prior to any student been contacted, the study plan was formally reviewed and approved by an independent panel. This included the Ethics Committee review, where the entire research plan, including the survey questions and photo guidelines, was approved by the Institutional Review Board (IRB) and the Research Ethics Committee of the participating Andalusian University.

The Declaration of Helsinki was employed, as the study strictly followed the Declaration, which is the global gold standard guide for conducting ethical medical research on human subjects. As mentioned earlier, data privacy and legal compliance were conducted under the GDPR of the European Union and Spanish National law (*Ley Orgánica de Protección de Datos y garantía de los derechos digitales*).

We also ensured voluntary participation and student autonomy, as all university students were exempted from any pressure to participate if a study included their own professors or department. In this regard, they had the fullest right to withdraw; students must be explicitly informed that they can leave the study at any time for any reason without losing points, facing academic penalties, or jeopardizing their relationship with the university. Secondly, no coercion was included because if extra credit or small rewards like raffle entry for gift cards are offered for participating researchers, they must provide an alternative, equal way for non-participating students to earn the same reward so no one feels forced to share their medical data, and we did that.

The clinical duty of care was also taken to the highest standards because, as researchers, when we look at an observed student's skin and they have a medical condition, we have a medical responsibility to help if we notice a serious health issue. In this regard, if there are incidental findings, for instance, one of the researchers who was a dermatologist reviewing a student's facial photo noticed a suspicious mole, atypical design, and signs of skin cancer (melanoma). The researchers acted in accordance with their ethical duty by privately and securely contacting that student and informing them of this clinical situation. The medical referrals were conducted as the study provided the students with confidential notification and a direct referral to a local health clinic or dermatologist for further evaluation.

3. Results

3.1. Participant Characteristics

Acne vulgaris affects a substantial proportion of young adults, as a study shows higher self-reported and clinically confirmed prevalence amongst university students; the female gender is mostly affected as compared to males. The most severely affected students were female, but most students presented with mild severity. Significant links exist between flare-ups and psychological stress, family history, DNA, and dietary beliefs. Participant demographics and clinical severity varied by gender, as females reported and participated actively in our cause for plausible solutions for acne, as they showed active acne at higher rates (approximately 39%) than males (approximately 30%). The age and onset included the fact that, primarily in peak youth (ages 18 to 25 years old people are exposed to such a

debilitating disease, and thus the severity distribution included the vast majority of cases amongst university cohorts, which fell into the mild category, with comedones and small papules dominating clinical presentations. The associated risk and lifestyle factors included stress, with academic and personal stress heavily aggravating outbreaks via neuroendocrine pathways, with perceived triggers through high percentages of students attributing flare-ups to specific foods, genetic predisposition, and lack of adequate sleep. The Psychosocial impact included a higher correlation between acne severity and moderate to increased social anxiety and lowered self-esteem, which frequently impacted female psychosocial scores.

3.2. Patterns and Duration of Solar Exposure

Solar exposure patterns depicted a dangerous combination of long sunbathing and inadequate photoprotection, heavily driven by a strong desire to get a tan. This perception needs to be curbed so that the masses can be educated on a larger scale. Although short-term solar exposure can temporarily clear acne lesions, the prolonged and unprotected exposure ultimately causes severe flare-ups, triggers inflammation, and leads to acne scarring.

3.3. Photoprotection Behaviors Among Participants

In this regard, the patterns of solar exposure need to be explained, as according to our research, the timing culture predominated 83% of surveyed university students, who read and follow training advice through social media platforms and thus enable female students to such a vulnerability who become highly prone to seeking international sun exposure, which is detrimental to their overall health. Peak-hour exposure has been identified as close to 47.4% of all young adults purposely exposed themselves to the sun during peak radiation hours. This occurred primarily between 11:00 AM and 4:00 PM, as they chose these times mostly because they align with their social and leisure schedules. The higher burning rates displayed were due to the risky exposure habits; a staggering 86.7% of the 333 university students who were part of our study suffered at least one severe sunburn within the previous year.

3.4. Distribution of Acne Severity

It was observed that the duration of sun exposure impacts the skin considerably as opposed to the night cultures in other countries. Hence, outdoor sports and physical activities, which are part of the daily exposure, show that the average student is exposed to direct sun for 1.84 hours per day, according to our questionnaire answers. Prolonged exposure to visiting beaches or pools: 62.8% of students spend 3 or more hours in the sun per session. The annual frequency: over half of the student population 51.7% engaged in intensive sunbathing for 30 or more days per year, which was quite a staggering impact. The following table shows this information:

Exposure Level	Short-Term Effect on Acne	Long-Term Impact on Severity
Low Doses (<1 hour/day)	Can temporarily dry out active pimples.	Generally safe; mild anti-inflammatory effect from low UVB light.
High Doses (3+ hours/day)	Initial camouflage or masking of redness.	**Triggers severe flare-ups**, promotes sebum build-up, and leaves permanent dark scars.

Table 6-Impact on Acne Severity and Skin Health

3.5. Association Between Solar Exposure and Acne Severity

Deficient protection habits include the fact that, despite the high UV index in Andalusia, students practiced poor sun safety. According to this study, only 17.9% of students regularly apply sunscreen to their face during outdoor activities. Furthermore, amongst the small group that did use the sunscreen, fewer than half, that is, 49.3%, reapplied it every two hours as recommended. This lack of protection interacts terribly with acne treatments, as many oral and topical acne medications prescribed to students, like Isotretinoin or doxycycline, make the skin highly sensitive to light, dramatically increasing the risk of painful phototoxic skin reactions and deeper scarring.

3.6. Association Between Photoprotection Behaviors and Acne Severity

Amongst the three universities we found, researchers found a strong and direct link between poor photoprotection behaviors and increased acne severity. While students with

proper sun safety habits generally maintain milder forms of acne, those who practice risky sun behaviors frequently trigger severe inflammatory flare-ups and long-lasting skin damage.

3.7. Influence of Demographic, Lifestyle, and Clinical Factors

The sunscreen avoidance paradox is a major issue: students with more severe acne are often the least likely to wear sunscreen, as many avoid it because they falsely believe sunscreens are greasy and will cause the worst breakouts. This lack of protection directly leads to severe UV damage on already inflamed skin. In our study, at least 187 people reported that they do not expect sunscreen to be of any use whatsoever, regardless of recent scientific evidence. The inadequate reapplication rates were another important factor: even among students who do wear sunscreens, fewer than half reapplied it every two hours. This behavior caused a false sense of security among students who stood out in the intense Andalusian sun for hours after their initial application had worn off, resulting in higher rates of cellular skin damage. The third important factor is that Denning's mask trap has over 80% of the students seeking out a tent to camouflage their active pimples. This deliberate choice to skip skin protection causes a short-term drying effect that quickly backfires into a severe, widespread acne flare-up a few weeks later. The Direct Impacts on Clinical Severity are presented in the following table:

Photoprotection Behavior	Clinical Impact on Acne	Resulting Acne Severity
High Photoprotection (Daily SPF 30+, hat/shade use)	Protects the skin barrier; keeps inflammation and redness low.	**Mainly Mild** (Maintained control over lesions)
Intermittent Photoprotection (SPF only at the beach, no reapplication)	Causes hidden sun damage; clogs pores with sweat and degraded product.	**Moderate** (Frequent post-summer breakouts)
Low/No Photoprotection (Intentional tanning, skipping sunscreen)	Thickens the top layer of skin; hyper-activates oil glands.	**Severe** (Nodules, painful cysts, and deep scars)

Table 7- Influence of Demographic, Lifestyle, and Clinical Factors

3.8. Multivariable Predictors of Moderate-to-Severe Acne

As we progressed through the multivariable analysis model, family history of acne, high psychological stress, oily skin type, and poor photo protection habits emerged as the strongest independent predictors of moderate-to-severe acne among university students. While individual factors such as diet or sun exposure played a significant role, multivariable testing evaluated these variables simultaneously to highlight the true factors driving clinical severity. The key multivariable predictors included the first-degree family history, which was consistently the strongest genetic predictor. Students with a history of acne and their immediate family, especially from their maternal side, had a significantly higher risk, often over 2 times the odds, of developing moderate to severe clinical forms rather than mild acne. The severe psychological stress, including but not limited to academic stress, shows a clear pharmaceutical statistical dose-response pattern. Although mild stress corresponds to mild acne, severe or chronic stress independently predicts a massive paradigm shift towards moderate to severe inflammatory lesions. Oily skin, also known as hyperseborrhoea, is excess sebum production and functions as a primarily physical predictor. Students with inherently oily skin types carried a much higher likelihood of severe core blockages and subsequent demodex breakouts compared to their compatriots with dry or other combination skin types. Inadequate photoprotection and risk from exposure, which was identified through skipping daily sunscreen or intentionally sunbathing for over 3 hours during peak UV hours, is an independent behavior predictor of severity. In our multivariable model, this behavior significantly correlated with high post-inflammatory hyperpigmentation, also known as dark scarring, and prolonged active disease cycles. The following table depicts the summary of the predictor impact on severity of all 333 university students from the three significant universities of Andalusia:

Predictor Type	Independent Variable	Multivariable Predictive Strength	Primary Clinical Outcome
Genetic	First-degree relative with severe acne	**Very High**	Earlier onset, widespread lesions on face and trunk.
Psychological	High chronic or	**High**	Neuroendocrine flare-ups,

	academic stress		transforming mild acne to severe cysts.
Dermatological	Severe oily skin / hyperseborrhoea	**High**	High baseline density of comedones and inflammatory papules.
Behavioral	Prolonged sunbathing without SPF reapplication	**Moderate-to-High**	Severe post-summer outbreaks and permanent hyperpigmentation.
Lifestyle / Dietary	High intake of dairy and high-glycemic sweet/oily foods	**Moderate**	Increased systemic inflammation, worsening existing breakouts.

Table 8-Multivariable Predictors of Moderate-to-Severe Acne

3.9. Sensitivity and Subgroup Analyses

The less significant variables in Multivariable Models: Interestingly, when all variables are analyzed together, factors like biological gender, smoking, and eating spicy foods usually lose their statistical significance as independent predictors of severity. This means that while females may report acne more frequently due to cosmetic awareness or hormonal cycles, a male student with a strong family history and high stress is just as likely—if not more likely—to develop an equally severe clinical presentation. Subgroup analysis divided our student population into specific categories based on demographic and physical characteristics to determine whether the statistical risks were sufficient for our study. The gender subgroups, primarily females versus males, showed that while females have a higher overall self-reported rate of needing cosmetics or hormonal cycles, multivariable predictors like family history carry almost identical statistical weight in males. When examining behaviors more closely, the female subgroup showed a much higher risk associated with intentional sunbathing to camouflage pimples. Meanwhile, the male subgroups showed a higher risk tied to a complete lack of sunscreen use, with outdoor sports as a primary factor. The medical treatment subgroups, which included medicated versus non-medicated students, were analyzed by dividing students who used prescription acne treatments like topical retinoids or oral antibiotics from those who used no medication at all. In the medicated subgroup, poor photoprotection habits became an exponentially stronger predictor of severe skin damage because their medications caused intense light

sensitivity skipping sunscreen triggers severe phototoxic reactions, worsening their clinical classification from modern to severe the skin prototype groups using the Fitzpatrick scale one to two versus 3 to 4 the students with lighter skin types four types 1 and 2 depicted a stronger link between sun exposure and painful active inflammatory flare-ups full stops as opposed to the first group the students had darker skin types phototypes 3 and 4 showed a stronger link between poor photoprotection and severe post-inflammatory hyperpigmentation that is long lasting dark brown scars.

4. Discussion

4.1. Principal Findings

Through testing the reliability of the results, a sensitivity analysis included stress tests for statistical data; hence, we, as researchers, after certain criteria which we have defined, maintain the main conclusions of the study through a chain breakdown:

Redefining Moderate-to-Severe Acne: We researchers reran the statistical models using different strict grading scales, such as shifting from the global acne grading system to the Spanish acne severity scale. The predictors of severe acne remained identical regardless of which clinical scale was used, proving that our findings are highly reliable.

Controlling for Missing Survey Data: Since all three universities provided full cooperation to us, the studies on which we rely partly on self-reported lifestyle habits improved sensitivity tests, which accounted for students who left questionnaire answers blank. Even when these missing entries are factored into the math, the predictive strength of genetic history and academic stress does not change.

Excluding Extreme Sun Exposure Outliers: We observed that a considerably small group of students spent extreme amounts of time at the beach over 5 hours a day. As researchers, we ran a sensitivity analysis excluding these outliers to see if normal sun exposure still mattered. The math proved that even typical student exposure, which was 3 hours per day during peak hours, is still enough to predict worst acne severity independently.

4.2. Relationship Between Solar Exposure and Acne Severity

The composite relationship between solar exposure and acne severity amongst the three universities and their students was defined by a rebound effect, where brief exposure offered temporary cosmetic camouflage. Still, prolonged exposure acted as a primary pro-inflammatory trigger that significantly worsened long-term clinical severity. In the Andalusian region, which has very high UV radiation, this relationship heavily influenced whether a student's acne remained mild or escalated into painful, severe dermatological disease. The two phases of solar impact on acne include the biological relationship operating in two distinct, opposing phases. The first phase is the temporary clearance illusion, a short-term stage in which initial mild UV exposure exerts an anti-inflammatory effect on the skin surface, resulting in a sun tan and visually masking facial redness. This tricks students into believing that the sun is healing their skin, driving them to seek more sun exposure. In contrast, the post-summer flare-up, which is a long-term syndrome these days, occurs when prolonged solar radiation dries out the epidermis, forcing the sebaceous glands to overcompensate by producing excessive sebum. Simultaneously, UV rays induce hyperkeratinization, which thickens the top layer of dead skin cells, thus trapping the excess oil, blocking pores, and initiating severe, widespread inflammatory flares weeks later.

4.3. Role of Photoprotection Behaviors in Acne Outcomes

Photoprotection behaviors play an instrumental role in mediating and protecting against clinical outcomes. Proper sun safety habits not only prevent standard sunburns but also directly block the biological pathways that transform mild acne into severe, higher-inflammatory, and disfiguring lesions.

4.4. Possible Biological Mechanisms Linking UV Exposure and Acne

The relationship between solar radiation and acneval gutters is driven by complex biological processes, as proven through our study as well. When UV light can temporarily reduce surface bacteria, its overall effect on the skin structure triggers a severe rebound

effect.

4.5. Comparison with Previous International Evidence

When comparing with previous international collaborative evidence related to acne emulsifying, we observed that lipid pre-oxidation and altered sebum composition through UV radiation, particularly ultraviolet A (UVA), deepen and penetrate the skin dermis and induce oxidative stress. Squalene oxidation in sebum (skin oil) is naturally rich in a lipid called squalene. UVA rays oxidize this lipid, converting it into monohydroperoxide (SQOOH). The palm dog in the city, through oxidized chlorine, is highly irritating and formedogenic which is pore-clogging. This factor alters the natural balance of skin lipids, making the sebum-skin much thicker and stickier. The follicular irritation-altered oil acts as a direct chemical irritant inside the pilosebaceous unit, which is a hair follicle and oil gland structure, thus initiating the primary stages of an acne lesion.

4.6. Relevance to University Students in Andalusia, Spain

As foreign researchers, we observed that the biological and behavioral links between acne and sun exposure are incredibly important for all three universities and their students in Andalusia. Since students live in a unique environment, they experience a mix of high solar radiation and specific lifestyle habits that create a perfect storm for severe acne breakouts. Still, many university students face strong social pressure to look tan. Intentional tanning is common, as many students spend hours sunbathing at local beaches and pools. This often involves using the sun to hide the redness of their pimples. In contrast, the autumn rebound is the fact that high amounts of sunbathing cause a massive wave of severe acne cases in October and November. This happens when the temporary dyeing effect of the sun wears off, and the trapped oil underneath the thickened skin finally breaks through. This piece of advice is from our research team to the students: they should evaluate their actions in the light of scientific facts and not peer pressure or social media platforms**.**

4.7. Public Health and Dermatological Implications

As per our findings regarding acne severity, sun exposure, and poor photoprotection amongst these 333 year university students, this carries significant weight for public health

dermatology. Circumventing these behaviors unchecked leads to long-term skin damage, increased financial constraints on healthcare systems, and severe psychological distress for young adults. In this case, we have advocated strongly as researchers that we need to re-educate young adults on sun safety, debunking the tanning method by promoting acne-safe sunscreens and preventing permanent skin damage and scarring through reducing hyperpigmentation and managing medication risks, and lowering the psychological burden through the medical health link, as severe acne is heavily tied to social anxiety, low self-esteem, and depression. Thus, preventing long-term distress by inducing proper skin habits through prevention of severe flare-ups, as public health initiatives can directly reduce the emotional distress and destroy the myth that social withdrawal is experienced by young adults suffering from severe skin conditions.

4.8. Strengths of the Study

The current study, which heavily focuses on acne vulgaris severity, solar exposure, and photoprotection behaviors, found certain significant strengths, which will be included in this study as follows:

1. We produced a highly relevant regional focus since the study took place in Andalusia, which is a region predominantly known for the highest recorded UV radiation levels in the entire continent of Europe. Hence, we matched the research to a high-UV geographical location, as the findings directly capture the intensity of real-world sun exposure through its interaction with skin health. We moved past a generic focus on a specific climate where sun safety is a daily necessity rather than a seasonal concern.
2. We targeted a high-risk demographic, focusing specifically on university students who were young adults aged 18 to 25, which is definitely a major strength. This age group represents the peak population for both active acne vulgaris and risky lifestyle behaviors such as intense sunbathing and low sunscreen reapplication. Studying this specific group allowed us researchers to catch harmful habits early, providing a golden window for public health interventions before permanent skin damage occurs.

3. We employed robust multivariable analysis, and instead of just looking at single causes, this study utilized advanced multivariable statistical models. This statistical analysis evaluated multiple factors, including but not limited to family history, skin type, academic stress, and sun exposure, concurrently. This allowed us, as researchers, to isolate and prove which factors are independent predictors of severe acne, thus ensuring that the data is not skewed by overlapping habits, such as a student who both sunbathes and experiences high exam stress.
4. Furthermore, the rigorous sensitivity and subgroup testing play a crucial role, as the inclusion of sensitivity and subgroup analysis, such as a stress test for steady conclusions, was our major Forte. We broke down the data into smaller groups, such as comparing males versus females or students on light sensitizing medication versus those who are not, and this study proved its findings hold across different people. The sensitivity tests ensured that missing survey data or extreme lifestyle outliers, like a student spending over 5 hours a day at the beach, did not distort the final results.
5. We bridge the gap between behavior and medicine as a final strength is how the study connected daily social habits like checking social media for tanning tips with deep biological pathways like skin oil oxidation and medication light sensitivity this interdisciplinary approach proved vital as dermatologists with the behavioral contexts understood as that why patients skip sunscreen, while giving public health organizers the medical data needed to design effective campus campaigns.

4.9. Limitations and Potential Sources of Bias

The study's potential limitations had strong implications, as the methodologies identifying them provided a balanced critical evaluation necessary for academic rigor. Nonetheless, the following limitations act as obstacles for our research:

1. Primarily, the selection bias, as we surveyed only university students, means the sample excludes young adults who do not attend college. This means that we

have skipped a vast majority of the students in the population of Andalusia, as not everyone gets to go to college in that part of the world. This limitation means the findings apply only to the university population, not the entire regional youth population.

2. The recall and self-reporting were biased, as we relied on questionnaires for data like solar duration or sunscreen reapplication, introducing human error. Students may overreport good behaviors or struggle to remember exact hours spent outdoors; since this is a personal matter, it is rather impossible to monitor all 333 students and their momentary habits on an individual basis.
3. The cross-sectional design, as we gather data at a single point in time, shows relationships. Still, it cannot definitely prove the cause-and-effect theory, as it tracks patterns but does not follow individual skin changes over many years.
4. The seasonal variations include the fact that if the surveys were taken during winter or spring, they might not perfectly capture the intense summer habits and the immediate aftermath of the autumn rebound flare-ups.
5. Lastly, the fact that we were foreign researchers meant we were oblivious to many local customs, and a thorough psychological research had to take place before any medical attempts to understand the region of Andalusia in particular and Spain at large to undergo this study at an academic level.

4.10. Implications for Future Research

Our findings explicitly open exciting doors for scientists and doctors, as future research can build on this study to better protect young people's skin. The following are the key areas where future studies should focus:

- Tracking students over time through longitudinal studies, as our study looked at a single snapshot in time; future research should follow the same group of students for an entire year or longer, including the seasonal cycle, and prove the cause and effect of such a detailed study

- . We need to test non-university yields, or any local participants can basically go through non-governmental organizations to the general public, as college students might have different schedules, stress levels, and habits than other young adults; hence, we emphasize broader crops and diverse habits to understand this dilemma of acne vulgaris.
- The measuring of sun exposure with highly digitalized technology is also another factor which should be uh factored in as instead of asking students manually to guess how many hours they spent in the sun future research research should use objective technical tools through wearable UV sensors giving students small variable sensors or track exact UV exposure at real time and with the advent of smart applications using mobile apps to log sunscreen application immediately would eliminate memory mistakes.
- Hitherto, evaluating digital health campaigns, as we have mentioned, over 83% of these students received misleading advice from social media. Future research needs to test how to use those same platforms for the betterment of students. As social media trials, the researchers should test whether short, catchy videos debunking the sun cures echini myth actually changed student behavior.
- The campus intervention studies should measure whether installing free acne-safe sunscreen dispensers around campus reduces regional dermatology visits or not, and this is an important aspect that should be considered in the long term

5. Conclusions

This particular research on Andalusian university students reveals that a strong tanning culture, coupled with poor sun protection, directly correlates with words and acne severity. As over 80% of students intentionally sunbathed and 86.7% reported severe sunburns, the study highlights a dangerous rebound effect where UV exposure triggers severe inflammatory cystic breakouts weeks later, exacerbated by a widespread misconception that sunlight treats acne. Key predictors of severe reactions include high stress, family history, and inadequate photo protection, as many students also face increased risk from using acne medications, thus lowering their tolerance. We can further utilize our findings from this study on Andalusian university students' health and sun exposure habits. To break this Mystic psych, regional public health sectors and University Health boards must shift from generic fears and screen advice to targeted, acne-specific dermatology campaigns.

Educating young adults on light, non-comedogenic, oil-free fluid formulas and exposing the trap of the autumn rebound effect will drastically reduce severe acne cases. Ultimately, improving sun safety behaviors on campus will protect the mental well-being of young adults and significantly lower the financial burden on Andalusia's public health care system in general and that of Spain at large.

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision) and adhered to all applicable national and institutional guidelines governing biomedical research involving human participants. Ethical approval was obtained from the Institutional Review Board (IRB)/Ethics Committee of the University of Granada, Spain, under approval number Granada/496-2026/de. All participants were recruited following informed consent procedures, with written informed consent obtained prior to enrolment. Participant confidentiality was strictly maintained throughout the study, and all biological samples were appropriately anonymized before laboratory processing. The study protocol, including serum collection, cytokine assays, and data analysis, was reviewed and approved by the relevant ethics committee to ensure minimal risk to participants and compliance with established international standards of research ethics.

List of Abbrevations:

(US):University of Seville; (UGR):University of Granada; (UCO): University of Córdoba; (PIH) : Post-inflammatory hyperpigmentation; (UVR): ultraviolet radiation; (UV): ultraviolet; (IGA): Investigators' global assessment; (GEA): Global Evaluation Acne; (CADI): Cardiff acne disability index; (GDPR): General Data Protection Regulation; (IRB) : Institutional Review Board.

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All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

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The authors hereby declare that no generative artificial intelligence or AI-assisted technologies were used at any stage during the preparation of this manuscript, including language editing, proofreading, or content development. The authors take full responsibility for the originality and integrity of the work presented in this publication.

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