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PROTECTIVE BEACHES AND HARMLESS PROTECTION: THE IMPORTANCE OF SUN EXPOSURE POLICIES IN COASTAL ENVIRONMENTS

PLAYAS QUE PROTEGEN Y PROTECCIÓN QUE NO DAÑA: LA IMPORTANCIA DE LAS POLÍTICAS DE EXPOSICIÓN SOLAR EN ENTORNOS LITORALES

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ABSTRACT

Background: Skin cancer (SC) is recognized globally as a serious public health problem, with its incidence having multiplied over the last three decades, largely due to excessive exposure to ultraviolet (UV) radiation. While SC is highly preventable (with an estimated 65% of melanomas and 90% of cutaneous carcinomas being avoidable through healthy photoprotection habits), relying solely on individualized prevention strategies has proven insufficient to curb the rising rates. The necessity for systemic change underscores the need for public policies and supportive physical-regulatory environments, mirroring successful international models like Australia's SunSmart campaign, which demonstrated significant reductions in incidence and high cost-effectiveness.

The One Health paradigm: Adopting the One Health paradigm is essential for a comprehensive and sustainable approach to SC prevention. Historically focused on zoonotic diseases, its application is crucial to addressing non-communicable diseases like SC, as it formally recognizes the interconnectedness of human health, animal health, and the environment. This framework is particularly relevant given that climate change, ozone depletion, and temperature increases—all interconnected environmental factors—amplify UV exposure risk and alter human behavior, necessitating transdisciplinary policies and practices at a systemic level to create health-promoting environments.

Coastal environments and dual risk: The beach represents a uniquely high-risk setting for photoexposure due to the cumulative effect of direct sunlight and high reflection from surfaces like sand and water, leading to elevated rates of sunburn among beachgoers and outdoor workers, such as lifeguards. Simultaneously, the widespread use of sunscreens —the most common protection measure— introduces a critical environmental concern: UV filters can harm marine ecosystems, including coral reefs, posing a dual challenge. Following the One Health mandate, effective photoprotection must not harm the environment, making the development and promotion of environmentally friendly protection alternatives imperative alongside responsible use.

The Soludable Beach model: To address these complex risks within the Spanish context, the Soludable project, initiated in Andalusia (a high-risk region for SC), promotes a multisectoral strategy. This initiative focuses on the creation of policies and infrastructures that regulate and adapt coastal spaces, including the implementation of accessible shaded areas, real-time UV index information, and the promotion of eco-sustainable protection measures. As an innovative solution, the project launched the "Soludable Beach Mention" in collaboration with the Blue Flag program, integrating SC prevention standards into quality certification criteria for coastal municipalities. This approach seeks to reduce sunburn and SC incidence in the long term, while simultaneously fostering coastal sustainability and promoting a smart, responsible, and resilient tourism model aligned with the One Health paradigm.

Keywords:

sun and beach tourism, sunburn, skin cancer, prevention strategy, Blue Flag

RESUMEN

Antecedentes: El cáncer de piel (CP), cuya incidencia se ha multiplicado a lo largo de las últimas tres décadas, es un grave problema de salud pública mundialmente, causado en gran medida por la exposición excesiva a la radiación ultravioleta (UV). Si bien el CP es altamente prevenible (se estima que el 65% de los melanomas y el 90% de los carcinomas cutáneos podrían evitarse mediante hábitos saludables de fotoprotección), la dependencia exclusiva de estrategias de prevención individualizadas ha demostrado ser insuficiente para frenar el aumento de las tasas. La necesidad de un cambio sistémico subraya la importancia de políticas públicas y entornos físico-normativos de apoyo, reflejando modelos internacionales exitosos como la campaña SunSmart de Australia, que demostró reducciones significativas en la incidencia y una alta coste-eficiencia.

El paradigma One Health: La adopción del paradigma One Health es esencial para un enfoque integral y sostenible de la prevención del CP. Históricamente centrado en las zoonosis, su aplicación es crucial para abordar enfermedades no transmisibles como el CP, ya que reconoce formalmente la interconexión de la salud humana, animal y ambiental. Este marco es particularmente relevante dado que el cambio climático, el agotamiento de la capa de ozono y el aumento de las temperaturas —todos ellos factores ambientales interconectados— amplifican el riesgo de exposición a la UV y alteran el comportamiento humano, lo que requiere políticas y prácticas transdisciplinarias a nivel sistémico para crear entornos promotores de salud.

Entornos litorales y riesgo dual: La playa representa un escenario de riesgo excepcionalmente alto para la fotoexposición debido al efecto acumulativo de la luz solar directa y la alta reflexión de superficies como la arena y el agua, lo que provoca tasas elevadas de quemaduras solares entre bañistas y trabajadores al aire libre, como los socorristas. Simultáneamente, el uso generalizado de cremas solares —la medida de protección más común— introduce una preocupación ambiental crítica: los filtros UV pueden dañar los ecosistemas marinos, incluidos los arrecifes de coral, planteando un desafío dual. Siguiendo el mandato One Health, la fotoprotección efectiva no debe dañar el medioambiente, haciendo imperativa la promoción de alternativas de protección respetuosas con el medioambiente junto con un uso responsable.

El modelo Playa Soludable: Para abordar estos complejos riesgos dentro del contexto español, el proyecto Soludable, iniciado en Andalucía (una región de alto riesgo de CP), promueve una estrategia multisectorial. Esta iniciativa se centra en la creación de políticas e infraestructuras que regulen y adapten los espacios litorales, incluyendo la implementación de zonas de sombra accesibles, información en tiempo real del índice UV, y la promoción de medidas de protección ecosostenibles. Como solución innovadora, el proyecto lanzó la “Mención Playa Soludable” en colaboración con el programa Bandera Azul, integrando estándares de prevención del CP en los criterios de certificación de calidad para los municipios costeros. Este enfoque busca reducir las quemaduras y la incidencia de CP a largo plazo, al mismo tiempo que fomenta la sostenibilidad litoral y promueve un modelo de turismo inteligente, responsable y resiliente, alineado con el paradigma One Health.

Palabras clave:

turismo de sol y playa, quemadura solar, cáncer de piel, estrategia de prevención, Bandera Azul

I. ULTRAVIOLET RADIATION AND THE PUBLIC HEALTH PROBLEM OF SKIN CANCER

Solar radiation has numerous health benefits for humans. However, it can also be a cause of illness and death[1]. Ultraviolet (UV) radiation can damage the skin, eyes, and immune system, with acute effects such as the occurrence of sunburn[2], episodes of photoconjunctivitis and photokeratitis[3], photosensitivity reactions, or the reactivation of latent infections like the herpes simplex virus. Chronic ocular effects include lesions such as pterygium[4], cataracts[5] and macular degeneration[6]. In the most exposed areas of skin, premature signs of aging (spots and wrinkles[7], can be observed, and precancerous lesions and skin cancer (SC) can develop[8].

SC is one of the most serious and concerning public health problems. Its incidence has experienced a substantial global increase over the last three decades, with rates that have doubled or tripled depending on the specific type of the disease[9]. This increase is due, among other factors, to the progressive aging of the population, the depletion of the ozone layer, and changes in beauty standards and lifestyles[10–12]. It is estimated that 1 in 5 people will eventually develop some type of SC in their lifetime[13]: basal cell carcinoma (BCC), squamous cell carcinoma (SCC), or melanoma. Melanoma is the most dangerous tumor and is responsible for over 80% of SC deaths[14].

In Spain, the age-standardized incidence rate of melanoma SC has doubled between 1990 and 2021[15]. Furthermore, statistics for our country predict an increase greater than 20% by 2040[16]. It is also estimated that the incidence of SCC is 38.16 cases/100,000 inhabitants/year, with a mortality rate of 0.90 cases/100,000 inhabitants/year. Meanwhile, the incidence of BCC is around 113.05 cases/100,000 inhabitants/year[17].

Excessive exposure to UV radiation is the main preventable cause of SC[8]. It is worth mentioning that UV radiation (UVA and UVB) was classified by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen in 1992[18]. The Sun is the primary source of UV radiation, and thus two patterns of sun exposure have been identified[8]. One acute (recreational), which induces the onset of melanoma[19] and BCC[20], and another chronic (occupational), which is related to SCC[20].

Nevertheless, SC is one of the cancers with the greatest opportunities for prevention. It is estimated that up to 65% of melanomas and 90% of cutaneous carcinomas could be avoided with healthy photoprotection habits starting from childhood[21]. Sunburn constitutes the main risk factor for SC[2]. A higher number of sunburn episodes correlates with an increased risk of developing the disease[22,23].

In this regard, the World Health Organization (WHO) recommends a set of individual precautions: avoiding the use of artificial tanning beds, limiting sun exposure at midday, seeking refuge in the shade, covering up with hats, sunglasses, loose-fitting long-sleeved clothing, and applying quality UVA/UVB sunscreen[24,25]. Adequate hydration and consumption of fruits, vegetables, and other antioxidant-rich foods are also advised[26]. Photoprotection measures should be considered when the UV radiation index reaches a value of 3 or higher, and they must be proportional to the degree of danger posed by the sun's rays at any given time. Precautions should be maximized in situations of vulnerability (childhood, individuals with skin phototypes I and II, immunocompromised individuals, those with a history of SC, genetic diseases, or those photosensitized by medication). In any case, and due to the frequency of SC presentation, regular skin examination and learning to identify the warning signs of cutaneous cancer (the ABCDE rule) are recommended for early detection and treatment of the disease.

Education in schools and informational campaigns are effective strategies for changing population lifestyles[27], but they must be accompanied by public policies and a coherent physical and regulatory environment. The involvement of governments in photoprotection policies, creating environments suitable for healthy sun exposure, is crucial[28].

The Australian experience demonstrates that investing in prevention is the most cost-effective strategy against SC, in terms of years of life gained and savings in healthcare costs[29]. SunSmart[30], active since the 1980s in media, schools, workplaces, and leisure settings, has achieved significant regulatory changes since its inception[28]: the elimination of VAT on sunscreen in 2001; tax deductions on sun-protective items in 2002; the prohibition of commercial use of sunbeds (solariums) in 2015; and the promotion of creating shaded areas in public places and schools. As a consequence, the incidence of melanoma has decreased by 11% among 15 to 49 aged population[31]. This has resulted in economic savings, estimated in Eastern Australia to be A$3.2 for every dollar invested. In Western Australia, a return of A$8.70 is estimated[32].

II. ONE HEALTH

The One Health paradigm has mainly focused on zoonotic infectious diseases[33]. However, this framework has been identified as equally relevant for Non-Communicable Diseases (NCDs)[34,35]. One of the greatest concerns regarding NCDs is the increasing incidence rates of different types of cancer[36].

In this sense, the One Health paradigm recognizes that environmental factors affect health, including in relation to NCDs[35]. Climate change amplifies these risks, altering the environmental conditions that favor the development of these diseases. Among them, the incidence of SC can be affected by climate change[37]. These environmental factors that increase the risk of SC do not act in isolation but as part of complex environmental systems. A 10% reduction in the ozone layer, for example, is estimated to lead to a 16–18% increase in SCC incidence and between 19% and 32% in melanoma[38]. Furthermore, temperature changes alter human behavior, encouraging more time outdoors and increasing sun exposure with more skin surface uncovered[37].

An innovative aspect of One Health applied to SC is the recognition that UV protection mechanisms transcend individual systems. The application of the One Health approach to SC prevention requires moving away from individualized prevention models, based solely on sun protection education, and incorporating a multisectoral vision[39], based on systemic changes, as was done in Australia[28]. Key actions include the creation of organizational plans and policies for healthy sun exposure; real-time information on UV radiation levels; the conditioning of urban spaces to offer protection against UV radiation and thermal comfort; and accessible education on SC for all population subgroups.

III. SUN AND BEACH TOURISM: THREATS AND OPPORTUNITIES

Spain is one of the sunniest countries in Europe, established as one of the most preferred destinations for holidays. In 2023, tourism accounted for 12.3% of the country's GDP[40]. 88% of visitors to Spain came from other European countries[41], with the Autonomous Communities of the Mediterranean Basin (Catalonia, Balearic Islands, Andalusia, and the Valencian Community) being the most visited in 2024[42].

Not just international tourists choose the coasts as a destination: 50% of Spaniards prefer to spend their holidays by the sea[43]. With over 2,000 km of coastline, the Mediterranean littoral has become a benchmark for sun and beach tourism[44,45]. This recreational preference, linked to sun exposure, also

coexists with occupational activities that are carried out in coastal environments.

The beach is a setting of high health risk due to its elevated solar irradiation. This is not only because of the lack of natural shade but also due to the reflection of solar rays from surfaces such as dry sand (15–18%), sea foam (25–30%), or the open sea (6%)[46]. The harm that sun exposure on the beach can cause has led to international campaigns. In February 2017, the Danish Cancer Society launched the "Help a Dane" campaign[47], with the aim of reducing the rates of sunburn suffered by Danish tourists during their holidays. To achieve this, an innovative strategy was used, targeting citizens of the five countries most visited by the northern European nation, including Spain.

At the same time, beaches represent a high opportunity for promoting healthy photoexposure and protection habits. The development of targeted interventions for SC prevention in this environment has been explored globally, demonstrating efficacy in reducing sunburn rates[48] and improving photoprotection practices[49–51].

In response to this, the Spanish Ministry of Health includes in the Strategic Plan for Health and the Environment 2002-2026 the objective to "carry out advertising campaigns to educate about the risks of UV radiation exposure, photoprotection measures, and the UV Index, and including visible information in places of interest such as beaches and swimming pools, etc."[52] The same plan proposes objectives as part of the strategy to protect people's health from the adverse effects of high UV radiation exposure.

IV. SUN EXPOSURE AND PHOTOPROTECTION ON THE BEACH: THREATS AND OPPORTUNITIES FOR SKIN AND ECOSYSTEM

Several studies provide evidence of high sunburn rates among beachgoers[53,54] people practicing sports on the beach[55], and lifeguards[56,57], with sunburn being the main risk factor for SC.

Photoprotection habits among beachgoers, mostly Spanish, are inadequate[54,58]: 58% do not avoid the central hours of the day, and only about 60% use a sun umbrella. Sunscreen application is around 80%. The use of physical measures such as hats and covering clothing is very low, practiced by barely 30% and 10% of the population, respectively. These habits lead to sunburns: between 50% and 70% report at least one sunburn during the summer.

77% of the lifeguards studied reported at least one sunburn the previous summer[56]. For outdoor workers who cannot avoid the central hours of the day, measures such as the use of covering clothing (3%), hats (33%), sunglasses (80%), and sunscreens (73%) are essential to safeguard health. These workers are exposed to 9.6 standard erythemal doses (SED), thus exceeding 7.4 times the recommended dose (1.3 SED) by competent institutions for an 8-hour workday. These worrying data are confirmed by a subsequent study conducted on Catalan beaches. It is estimated that a lifeguard working from June to September could accumulate between 230 (phototype III) and 333 (phototype II) times the dose of UV radiation capable of causing sunburn (Minimal Erythema Dose, MED) during their 750-hour work season[57].

As mentioned previously, sunscreen is the most widely used photoprotection measure by beachgoers in Spain. However, in recent years, concern has arisen regarding the environmental effects of these products[59,60]. The organic and inorganic components used in these topical formulations have been studied by both environmental professionals[61] and dermatologists [62]. The presence of the UV filters used in sunscreens in small organisms, algae, fish, and coral reefs could pose a risk to the health of

the marine ecosystem[63]. Furthermore, it should be considered that these particles may affect human health through the food chain.

Therefore, under the One Health paradigm, sunscreens should be safe for both human health and the environment[64]. Finding natural filters that are non-toxic, biodegradable, and simultaneously effective against the different wavelengths of UV radiation is the new market challenge.

However, while the feasibility of these new formulations is being studied, it must be remembered that there are other more environmentally friendly measures that do not put at risk the ecosystem. We must recall the physical and regulatory plans, practices, and policies such as: 1) avoiding the hours of greatest solar irradiance by being informed about UV radiation levels, 2) if this is not possible, using the recommendations associated with each risk level: seeking shade, wearing protective clothing that covers a large part of the skin surface, a wide-brimmed hat, and sunglasses, and applying topical products only on uncovered areas[64].

To achieve this, it is essential to consider the One Health perspective, where transdisciplinarity gains importance, respecting the balance between sectors and disciplines —such as health, tourism, and the environment in this case— and the "stewardship and the responsibility of humans to change behavior and adopt sustainable solutions"[39].

V. SOLUDABLE: A MULTISECTORAL SKIN CANCER PREVENTION STRATEGY FROM ANDALUSIA

Andalusia, being one of the sunniest regions in Spain, is the representative reference point for an outdoor lifestyle and sun and beach tourism. However, this can pose a health risk, considering that the average daily maximum UVI levels in Andalusia reach high-risk levels between April and September, and future forecasts are concerning. Furthermore, Andalusia is one of the Autonomous Communities that records the highest rates of incidence and death due to melanoma in Spain[65].

In particular, the Western Costa del Sol, with over 300 days of sunshine per year and an economic activity centered on national and international sun and beach tourism, is a geographical area of high SC risk, as demonstrated by the figures for surgical interventions and healthcare expenditure attributable to the disease in public referral hospitals[66–68].

To reverse this situation and turn the Sun into an ally for everyone's health, efficient strategies for health, photoprotection, and SC prevention are being promoted throughout our community from the University Hospital "Costa del Sol" in Marbella, through the Soludable project. The goal is to improve the population's sun exposure habits and reduce the incidence and mortality rates of SC.

With a multisectoral and multidisciplinary approach, the project encompasses multiple areas of action: education[69–71], health[72], tourism[56,58,73], work[74], sports[75–77], urban planning, and gastronomy. It also carries out multiple strategies for social awareness, training of professionals and social agents, certification of institutions and companies, research, innovation, and scientific dissemination. All this has led to its positioning as a leading health brand in Andalusia.

The Soludable Certificate (Distintivo Soludable) is a guarantee mark awarding organizations that incorporate structural and sustainable photoprotection measures to promote health and prevent SC in people, following WHO guidelines. Other certificates developed in the context of SC prevention pro-

grams include SunSmart (Australia), SunSafe School (UK), SunWise School (USA), and the Skin Cancer Foundation (USA), demonstrating their efficacy and cost-effectiveness by successfully improving population lifestyle habits and reducing SC incidence and healthcare costs.

This certification, created in Andalusia within the framework of the Soludable project, is a pioneer in our country[78]. Following a first pilot study carried out in the educational setting[69], its application is currently being tested in other target sectors of the project. A preliminary experience in the municipal sphere in Fuengirola confirms that the strategy is feasible and succeeded in making the municipality the first Soludable tourist destination.

VI. SOLUDABLE BEACH: A PROPOSAL FOR SMART AND SUSTAINABLE TOURISM

The Soludable Beach concept aims to reduce the risk of developing diseases caused by excessive sun exposure on beaches, and conversely, to transform them into an environment for health promotion, as well as a safe workplace. This involves carrying out a set of actions that must begin with the development of a health, photoprotection, and SC prevention policy; the training of beach professionals; an occupational risk prevention plan; and informative and awareness campaigns for the public. Furthermore, it requires organizational and environmental changes, such as the placement of UVI risk alert devices on beaches, shaded areas accessible to everybody, drinking water points, and sunscreen dispensers. Beach lifeguard personnel play a key role, given the opportunity to monitor the risky behavior of beach users and provide assistance and health advice in case of complications (heat stroke, sunburns, among others).

As mentioned earlier, Fuengirola obtained the Soludable Certificate in May 2024, after meeting the necessary standards of the Soludable Certificate Manual of Good Practices, aligned with the World Health Organization's sun protection recommendations. The Municipal Council has demonstrated its commitment to the health, photoprotection, and SC prevention of its residents and tourists, implementing policies and practices to improve conditions for people.

However, the beaches themselves are key environments. The Blue Flag strategy annually recognizes beaches and marinas that meet high standards of environmental quality, environmental management, safety and services, and environmental information and education. These criteria align with the health and environmental responsibility objectives of Soludable. Therefore, in July 2025, Soludable signed a collaboration agreement with Blue Flag for the creation of a special mention aimed at incentivizing the involvement of coastal governments and businesses. The first applications have been accepted since October 2025. Municipalities applying for the Soludable Beach Mention must implement sustainable and environmentally friendly measures to reduce the risk of photoexposure on beaches.

This pioneering initiative in the world naturally fits with the One Health approach, which recognizes the interdependence of human, animal, and environmental health to prevent and control health risks. The Soludable Beach Mention is not just for Andalusia. It is expected to strengthen the strategy for health promotion and SC prevention on beaches throughout Spain and other parts of the world. To this end, it has a promotion plan through communications from the certifying entity and media, and dissemination on the Soludable project's website and social media.

VII. EXPECTED IMPACT OF THE SOLUDABLE BEACH MENTION

It is anticipated that the Soludable Beach Mention will promote the implementation and improvement of measures aimed at reducing the risk of photoexposure on beaches. The introduction of changes in the physical and regulatory environments, from a public health perspective, could translate in the short term into a decrease in sunburn rates and, in the long term, into a reduction in SC incidence, with the consequent effect of lowering healthcare costs.

On the other hand, a favorable impact is expected at the environmental level. By incorporating the One Health perspective into the entire model, highlighting the relationship between human, animal, and environmental health, the Soludable Beach Mention encourages measures that preserve the sustainability of the coastal ecosystem. It is expected to improve awareness of the need to prioritize physical and regulatory policies and practices, and to promote the responsible use of sun products, as well as encouraging them to be as ecological and biodegradable as possible.

Furthermore, a positive impact is anticipated in the tourism sector. The incorporation of sustainable infrastructure and management practices that are more responsible with the coastal environment would contribute to improving the perceived quality of the beaches. These advancements could constitute a differentiating element in the tourism positioning strategies of municipalities and regions, increasing the competitiveness and attractiveness of sun and beach tourism and, consequently, its contribution to economic development.

VIII. CONCLUSIONS

The growing global incidence of SC, primarily attributable to overexposure to UV radiation, needs a prevention approach that transcends individualized strategies. The One Health paradigm is essential, as it recognizes the interconnection between human health, the environment, and the risks associated with NCDs. This approach is critical in high-risk scenarios such as sun and beach tourism, where high photoexposure accompanied by deficient protection practices is coupled with concerns about marine contamination caused by UV filters in sunscreens. Therefore, interventions must be systemic and sustainable, prioritizing physical and regulatory measures (e.g., shaded areas and UVI information) and eco-compatible solutions. Initiatives like the Soludable Beach Mention exemplify the application of this framework, seeking to reduce sunburns and SC incidence in the long term, while simultaneously fostering coastal sustainability and promoting smart and responsible tourism.

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