



Mapping the Evolution of Sunscreen Research: A Bibliometric Analysis of the Global Literature

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Abstract

Sunscreen represents a significant consumer good with implications for public health and market dynamics. Despite extensive dermatological research, economic and market-oriented analyses of sunscreen adoption, pricing, and consumption behavior remain limited. This study conducts a bibliometric analysis of 320 peer-reviewed journal articles on sunscreen research published between 2000 and 2025, using VOSviewer to map global trends in publication growth, geographic distribution, leading authors, collaboration networks, and thematic clusters. Six key themes emerged: preventive consumption under risk, information-driven decision-making, occupational and demographic vulnerability, social norms and incentives, behavioral biases in consumption, and policy intervention effectiveness. Beyond the global mapping, a targeted review of India-focused studies examines local market structures, usage patterns, awareness levels, and economic drivers influencing sunscreen adoption. The study identifies significant gaps in the literature regarding pricing strategies, willingness to pay, consumer decision-making under uncertainty, and the impact of regulatory and marketing interventions on market expansion. By integrating global bibliometric mapping with a focused analysis of India-specific studies, this research provides a comprehensive overview of existing knowledge and highlights opportunities for future investigations in consumer economics, market development, and policy design related to sunscreen. Findings can guide both scholars and policymakers in developing evidence-based interventions to enhance market efficiency, consumer adoption, and public health outcomes.

Keywords: *Bibliometric Analysis; Consumer Behavior; Research Trends; Scopus; Sunscreen; VOSviewer*

1. Introduction

Sunscreen is extremely important in safeguarding the skin against damaging ultraviolet (UV) radiation and thus stopping sunburn, early-age skin cancer, and chronic risks such as skin cancer (Autier, 2011). Besides its dermatological benefits, the application of sunscreen has become a basic component of preventive health behavior, as it reflects the growing socio-cultural emphasis on individual health. Over the last few decades the issue of UV exposure has become acute due to climate change, urbanization, and

the changing beauty ideals, leading to an increase in the amount of attention given to sun protection (Diffey, 2002). The use of awareness campaigns, public health programs, and social media has brought further awareness that sunscreen is now part of daily life, making it a health and lifestyle product. The intensity of UV radiation depends on the geographic factors like the latitude, altitude, and seasonal variations so as to affect the extent of cutaneous risk. Sunscreens reduce cumulative photo-damage through blocking, reflecting, or scattering UV photons, thereby reducing the chances of dermatological diseases (Gordon, 2018). Nevertheless, this uptake, availability, and efficiency of sunscreens still do not cut across the demographic and geographic lines, hence creating inequalities in protective measures (Glanz, 2002).

In the past, research on sunscreens has been focused on the dermatologic and biochemical aspects, such as formulation chemistry, UV-filter composition, photostability, and clinical performance (Autier, 2011). The studies present the necessary information on the scientific foundations of sunscreen efficacy and clinical importance. However, little attention has been given to sociocultural, behavioral, and economic factors that determine the use of sunscreen. Consumer uptake and regular usage is influenced by variables like public awareness, risk perception, cultural norms, affordability, marketing strategies, and the regulatory frameworks (Rashmi, 2019). Indian empirical research has shown a high level of knowledge deficiency, uneven usage, and the lack of region-specific behavioral research, although the country has a high UV index and rising cases of dermatological diseases (Kumar, 2020).

Although the research in global sunscreen has increased over the last few years, the literature is still very sporadic and scattered in dermatology, public health, consumer psychology, and marketing areas. Bibliometric methods provide potent methods of mapping trends in research systematically, building and identifying impactful authors and institutions, following collaboration networks, and defining thematic development in scientific disciplines (Donthu, 2021). Although the scientific body of sunscreen research continues to increase, the intellectual framework, topical content, and geographical spread of the scientific study are weakly established (van Eck, 2010). The majority of the available reviews are descriptive or reviews of individual studies, and they do not provide a systematic mapping of the field. Furthermore, there is little country-specific literature, especially that of India, which limits the knowledge about the local practices, market trends, and policy-making based on evidence.

The interdisciplinary and dynamic complexity of the sunscreen scholarly state of affairs supports the importance of utilizing a method that moves past general bibliometric mapping and towards the special attention to the region-specific research. This kind of dual approach can highlight the temporal trends, thematic priorities, the patterns of collaboration, and the gaps in behavioral, social, and economic studies. It is important to consider India in particular, as this country has particular characteristics of the environment, culture, and market. The global and national viewpoint offers a comprehensive insight into sunscreen research, filling the gap between clinical effectiveness and applied use as well as shaping the health and policy approaches of the population.

This study carries out a methodical bibliometric examination of sunscreen literature regarding research evolved between 2000 and 2025. It visualizes trends of research in the world, growth of publications, geography, authors, institutional collaboration network, and thematization using VOSviewer. Complementarily, a selective review of India-based literature reveals patterns of usage, awareness deficiencies, and market-specific knowledge, as well as research deficiencies based on context. The study provides a general picture of the literature on sunscreens by combining the macro-global mapping of the world with the micro-national analysis and offers a platform to inform the direction of future research studies, societal awareness campaigns, and evidence-based public health policy. This two-fold aspect takes care of the worldwide trend of sunscreen studies as well as the locally applicable issues of adoption, knowledge sharing, and policy enforcement, thus offering practical recommendations to researchers and practitioners as well as to policymakers.

2. Methodology

2.1 Research Design

This study adopts a bibliometric approach to systematically map the academic landscape of sunscreen research. Bibliometric analysis enables identification of publication trends, influential authors and institutions, collaboration networks, and thematic clusters, providing a comprehensive overview of the evolution of the field. In addition, a targeted analysis of India-focused studies was conducted to examine local usage patterns, awareness gaps, and market-specific insights. It aimed to provide comprehensive understanding along with context-specific insights that complement the global analysis and help identify policy-relevant directions for future research.

2.2 Data Source and Search Strategy

A structured search was performed in the Scopus database to retrieve peer-reviewed journal articles. The following Boolean query was used:

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TITLE-ABS-KEY ( ( sunscreen ) AND ( use* OR usage OR growth OR awareness OR attitude OR knowledge ) ) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND ( LIMIT-TO ( SUBJAREA , "SOCI" ) OR LIMIT-TO ( SUBJAREA , "PSYC" ) OR LIMIT-TO ( SUBJAREA , "ECON" ) OR LIMIT-TO ( SUBJAREA , "BUSI" ) OR LIMIT-TO ( SUBJAREA , "ARTS" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( PUBSTAGE , "final" ) ) AND ( LIMIT-TO ( SRCTYPE , "j" ) ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )
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This search string was designed to retrieve peer-reviewed journal articles related to sunscreen usage and growth in the fields of social science, psychology, economics, arts, humanities, and business, published between 2000 and 2025. A total of 10,416 documents were initially retrieved. The following filters were applied to refine the dataset:

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Inclusions	Number of results
Year Range	2000-2025	Filtered to 9490
Subject Areas	Social Sciences Psychology Economics/Econometrics/Finance Business/Management/Accounting Arts and Humanities	400
Document Type	Journal articles only (“ar”)	355
Publication Stage	Final publication (“final”)	352
Source Type	Journals only (“j”)	329
Language	English	Final dataset: 320 articles

2.3 Bibliometric Analysis

The selected articles were analyzed using VOSviewer, a software tool for constructing and visualizing bibliometric networks. The bibliometric analysis included various critical phases that were aimed at tracing the map of the organization and development of sunscreen studies. Initially, the trends of annual publications were examined to clarify the patterns of increase and decrease of research output over time. Geographic distribution was examined to determine the contribution of countries and highlight regional differences in research activity. Citation analysis was conducted to determine which authors were the most influential, thus giving the perspective of the intellectual background and power of the field. The co-occurrences of keywords were done through mapping to identify thematic clusters, new topics, and trends in literature.

2.4 Focused Analysis of India-based Studies

A subset of journal articles specifically filtered to India was analyzed in order to explain regional trends of sunscreen use and academic engagement. The intended review examined the studies that covered the local trends in terms of awareness, attitudes, and behavioral practices regarding the use of sunscreens. It also included variables that were relevant to the market, like availability, prices, and promotion, as well as policy-related variables, including health campaigns and education initiatives in the market. Analysis was meant to shed light on the knowledge gaps present in the context, socio-cultural factors, and economic factors and thus provide a lensed image of the Indian sunscreen market that adds to the worldwide bibliometric mapping.

3. Results and Findings

The following section presents the outcomes of the bibliometric analysis and the targeted review of India-focused studies. The results are organized to provide a comprehensive understanding of global sunscreen research trends, thematic developments, collaboration patterns, and regional insights.

3.1 Global Trends in Sunscreen Research

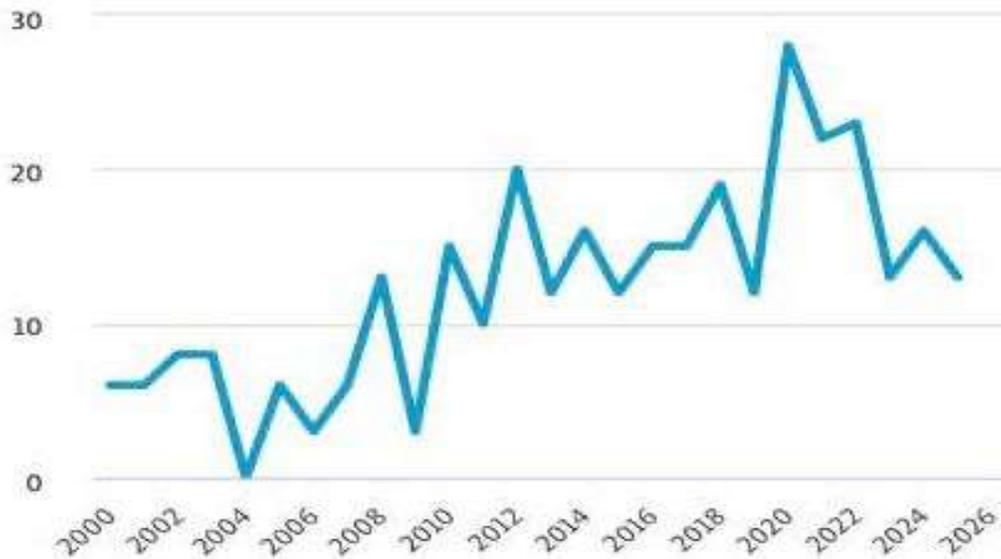


Figure 1: Year-wise Distribution of Documents

advantages of using sunscreens. Hence, these older studies, using biomedical behavioral research, acted as a base that helped bring about the evolution of the broad themes of research in this field.

The mid-phase research topics, represented by the green nodes, show an expansion into slightly broader themes relating to the usage of sunscreens. This phase shows how researchers have concentrated more on public health promotion, child health, and occupational health. Moreover, main themes included skin cancer prevention, knowledge and attitudes towards the use of sunscreens, appearance, and UV radiation. This reflects a deeper dive into biomedical research, which expands into skin cancer, radiation, and greater health concerns. It also shows a broader perspective into self-awareness through the emergence of different themes like appearance, tanning, and quantitative methods to reduce health concerns. Researchers also explored themes of knowledge and attitude for further awareness. They also integrated topics like child and adolescent health and general public health, showing that sun exposure can have various effects on different groups of people. Hence, this phase, focusing more towards health promotion, focus groups, and public health, shows how researchers have concentrated more on how use of sunscreens can be beneficial to groups of people rather than individuals.

The next stage, represented by the yellow nodes, highlights the more recent themes of studies based on sunscreens. This phase focuses more on social media, appearance-based behavior, and adolescents, revealing how adolescents' habits are often influenced by social media. It also highlights themes like indoor tanning and UV exposure, and there is an increased attention towards communication, persuasion, and interaction in promoting sun protection. This phase marks the rising discourse around sustainability, showing the public's growing interest in sustainable products and long-term photoprotection for health promotion. Therefore, this new emerging stage marks the rise of a more modern and technology-driven perspective. The evolution further shows how studies in this field are now more focused on global trends, social media influence, and environmental concerns.

Overall, this graph shows how research has evolved from more narrowly focused research, including biomedical and behavioral themes, to a broader range of ideas, combining psychology, social engagement, and media influence for deeper preventive health research. It reflects a multidimensional view and an adaptive academic landscape, which further aligns with global health trends. Hence, it reflects the modern needs of people, where health promotion is socially engaging, scientifically correct, and adapted to modern technology for easier accessibility.

3.2 Geographic Concentration

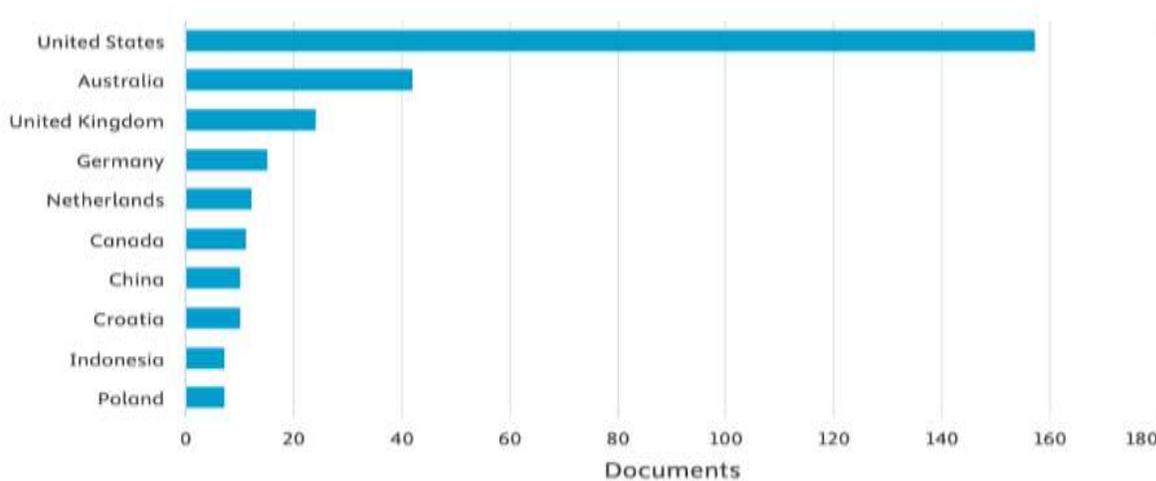


Figure 3: Geographic Concentration of Academic Output

Figure 3 above shows the geographic concentration of academic output. The discipline is currently dominated by the United States, which contributes the largest number of publications, followed by Australia and the United Kingdom. Together, these countries account for a significant majority of all indexed sunscreen-related research. This reflects strong dermatological research infrastructures, higher public awareness of skin cancer, and enough funding for cosmetic and pharmaceutical innovation. Other contributors include Germany, the Netherlands, and Canada, while Asian nations such as China and India show growing representation. The relatively lower publication output from developing regions indicates the need for more research on sunscreen use patterns.

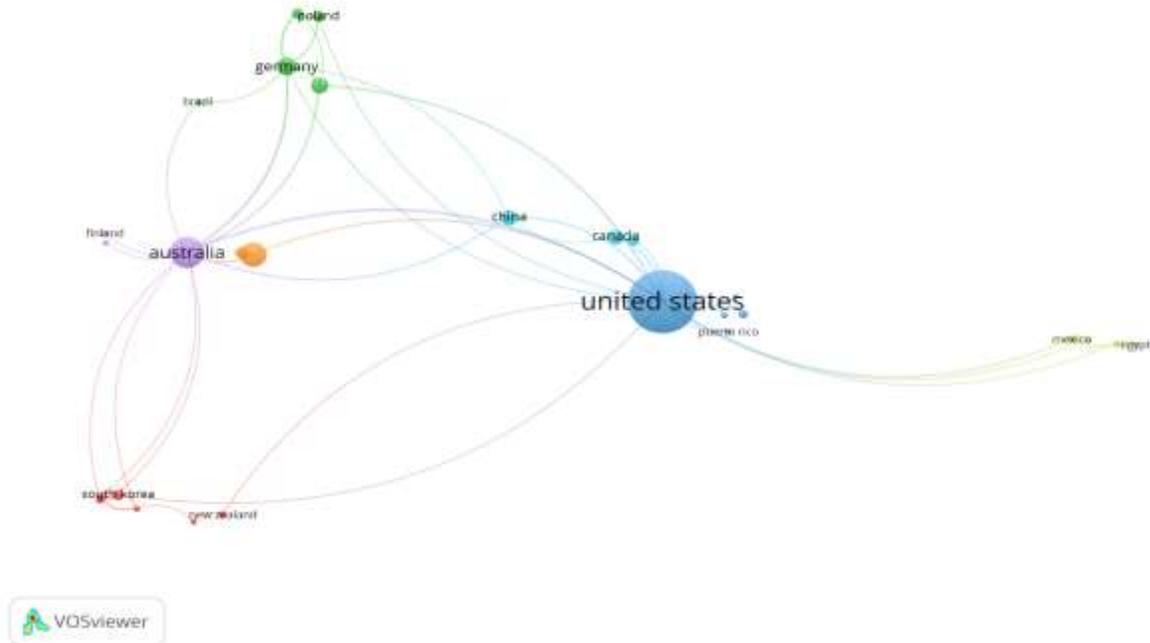


Figure 4: Country Co-Authorship Network

Based on figure 4, the country-level co-authorship network analysis has shown that the United States is the most central node in sunscreen research, which is known to have vast collaborative connections with many countries, particularly Canada, China, Australia, and Germany. Australia and Germany are also big players, which leads to regional cooperation. Smaller groups that include nations like South Korea, New Zealand, Mexico, and Egypt feature less developed or smaller partnerships. In general, the network presents a hub-and-spoke collaborative structure, thus highlighting the dominance of a handful of countries in spearheading collaborative research in the global arena.

sunscreens correctly and lacks proper consumption, thus reducing the effectiveness of sunscreens. This underscores a limitation of consumption under risk, where people try to reduce the risk of skin cancer; however, they fail to optimize the usage of sunscreen and other sun protection products. This paper also strengthens the argument that sunscreen needs to be combined with other skin protection products, along with proper compliance methods, for increased effectiveness.

The population-based cohort study *Sunscreen Use and Subsequent Melanoma Risk* examines a long-term effect on the risk of melanoma of using sunscreens (Ghiasvand et al., 2016b). This paper identifies the positive correlation between consistent use of sunscreens and decrease in risk of melanoma. The effects include people being able to stay out in the sun more and going for more sunbathing vacations, while continuing to have a decreased risk towards melanoma. Thus, this paper strengthens the argument that preventive consumption of sunscreen, especially when consistent, helps with combating melanoma risk. Lastly, the study *Regular Use of Sunscreen Can Reduce Melanoma Risk* reinforces the idea that primary methods of prevention, which include less exposure to UV radiation, are the most reliable and effective ways to reduce melanoma risk (Robins et al., 2012b). The primary methods of prevention from exposure to the sun include the use of sunscreens and protective clothing. The study shows a significant improvement in the reduction of skin cancer with consistent and proper use of sunscreens and other protective methods. Hence, this study provides us with a detailed and strong view on this theme: preventive consumption of sunscreens and various other sun protection methods helps combat risk, specifically when the products are used efficiently, consistently, and in the correct manner.

3.4.2 Information-driven decision-making

The theme reflects how information about sunscreens and other sun protection products may have various effects on the decision-making of people to use these products. Information clarity, the way it is perceived, its availability, and its reliability are some factors that shape the decisions people make, which is particularly what this theme captures. These studies, instead of only focusing on biological facts, explore how people process and interpret different forms of information, thus causing them to have different opinions and make different decisions on the preventive consumption of sunscreen. These studies also dive into how preventive methods may be often constrained due to false information, information overload, and lack of clarity. Hence, these studies highlight the importance of well-explained and clear information.

For instance, the study *Factors Influencing Anticipated Decisions about Sunscreen Use* investigates the various influences that act upon decision-making processes relating to behavior towards sun protection methods, specifically sunscreen use (Rasmussen & O'Connor, 2005b). The findings suggest that people make decisions based on how they perceive information, as well as on what information they choose to focus on at the moment of decision-making. People often tend to focus on information that is more personal to them, and they also tend to give importance to the information that is more positive than negative; thus, the type of information that individuals focus on at the time of decision-making plays an important role in the behavior of how people make decisions for the preventive consumption of sunscreens. Hence, this indicates that detailed information alone is not enough to drive preventive behavior without any personal connection attributed to individuals. Another example is the study *Decision Support System for Sunscreen Selection Based on Facial Skin Concerns Using the Analytic Network Process* (Sitorus & Fakhriza, 2025b). This study used a decision support model, which helped individuals make decisions on 9 different types of sunscreens for different skin types. The analytic network process was made to determine the best sunscreen by integrating multiple criteria like skin type, sensitivity, and other skin concerns. This decision support model helps make more efficient decisions for individuals who may not have thorough information about sun protection products. However, this study does not evaluate the behaviors of individuals towards choosing certain products for their skin type.

The paper *Empowering Patients Through Improving Clarity of Sun Protection Ratings on Sunscreen* directly highlights how important information about sun protection products is and how the way information is provided and presented may affect consumer behavior and understanding about decision-making on such products (McGowan et al., 2015b). The study emphasizes the importance of ratings and labelings of sunscreens. It provides evidence of how individuals often misunderstand the labeling, which can cause more harm than help them manage the risk of skin problems, including melanoma.

Finally, another informative study, *Sunscreens: A Narrative Review*, proved facts and expanded our knowledge on the composition, the history, the development, and the different types of sunscreens (Salih et al., 2024b). The paper also addresses the concerns and controversies relating to the use of sunscreens, including their effects and environmental concerns. The paper continues to emphasize the importance of informed decision-making based on the use of preventive products for UV exposure to help combat skin problems. Hence, this study acts as an educative review on sunscreens, providing needed information and facts about sunscreens that help individuals make a more informed decision when choosing sun protection products.

3.4.3 Occupational vulnerability

This theme reflects on and analyzes sunscreen use and sun protection behaviors amongst groups of people who are usually exposed to a larger amount of UV radiation due to the nature of their work, due to long working hours, and due to lack of access to sun protection products. This research underscores the various sun-protection problems faced by the workers in such occupations and how they attempt to take on preventive measures. This research also concentrates on how these workers are at a much higher risk for skin cancers and other skin diseases. Hence, this theme shows how, along with self-awareness and information about the sun protection products, other factors like occupational norms, access to different sun protection methods, and economic status also must be taken into consideration.

The study *Occupational Sunscreen Use Among US Hispanic Outdoor Workers* examines the frequency of sunscreen use by the workers who are largely exposed to UV radiation due to workplace norms (Day et al., 2015b). The study's findings include significantly few people using sunscreen inconsistently due to factors like lack of access to sunscreen, a low socioeconomic status, differences in geographic locations and gender, and not enough awareness about the importance of preventive methods. Hence, the study also identified that intervention to encourage the outdoor workers to use sun protection products is crucial to reduce the risk of melanoma and other skin problems. Strengthening the previous idea, the study *Sun-Related Knowledge and Practices in Irish Construction and Agricultural Workers* examined the time spent by Irish agricultural and construction workers outdoors (Hogan et al., 2024b). This study also evaluates the information and the various perceived constraints that different individuals in such occupations have about protective methods. The study found that although individuals had basic knowledge about the importance of sun protection, a large portion of the workers who spent most of their working hours outdoors had minimal and significantly inconsistent application of sunscreen along with a high rate of sunburns. The constraints faced by individuals were due to multiple factors, including insufficient knowledge and access to preventive methods for sun protection, and also various personal, cultural, and workplace characteristics. This study also identified that increased training and awareness in sun protection methods amongst the workers is crucial to help the workers and initiate a reduction in the risks of skin cancer faced by the workers.

Another example is the study *Sunscreen Use Related to UV Exposure, Age, Sex, and Occupation Based on Personal Dosimeter Readings and Sun-Exposure Behavior Diaries* (Thieden et al., 2005b). This study investigated the reasons individuals use sunscreen and the specific behaviors causing sunscreen use. The study also compared the relationship between sunscreen use by the workers and UV exposure. The

study included people's personal self-reported behaviors from their diaries, as well as dosimeters, which measure the time spent exposed to UV radiation. The findings include many disparities in the use of sunscreens. It was found that individuals used sunscreen in correlation to tanning and sunbathing instead of risk to skin cancers. This shows that individuals are not familiar with preventive behavior and may not be very well informed about the actual importance of sunscreen and other sun protection products and methods. Finally, the study *Investigation on Occupational Hazards of Ultraviolet Light, Sunscreen Awareness, and Behaviors in Wuhan City Traffic Police* evaluates the awareness and practice of sunscreen use amongst policemen in Wuhan (Yan et al., 2010b). The study finds that individuals who are exposed to UV radiation for most of their day are subject to very limited use and knowledge of sunscreens. It was also found that younger policemen, compared to older ones, show more preventive behavior towards sun protection. They were found to be more aware of the various sun protection methods and skin damage done due to exposure to UV radiation. Hence, this study shows how occupational vulnerability acts as a crucial constraint in preventive behavior for sun protection methods.

3.4.4 Social norms and incentives

This theme explores and evaluates how social incentives, various perceptions, and psychosocial norms influence and affect preventive behaviors of individuals in relation to sun protection methods. The studies relating to this theme show how decision-making is heavily influenced by societal expectations, social norms, and peer influence rather than only being influenced by risk calculation. These studies include results showing that sunscreens are often used in context to one's appearance, ongoing fashion trends, cultural norms, perceived social attitudes, and peer approval. Hence, it reinforces the idea that individuals do not solely pay attention to the use of sunscreens as a form of preventive behavior; instead, their perceptions about physical appearances and social pressure play a crucial role in their decision-making with respect to preventive behavior for protection from UV radiation.

The study *Predicting Australian Adults' Sun-Safe Behavior: Examining the Role of Personal and Social Norms* examines how individuals' beliefs highly influence behavior with respect to sunscreen use (White et al., 2014b). This study's findings show that peers' and friendship groups' support in using sunscreens is extremely influential. Additionally, this study suggests that a positive attitude, a strong personal norm to be sun-safe, and prior preventive behavior play an important role in helping individuals to practice consistent use of preventive measures to be protected from UV radiation. Overall, the study emphasizes the crucial role of social norms combined with personal responsibility for shaping consistent and correct ways of sun-protection methods. Another example of a study based on this theme is *Psychosocial Correlates of Sun Protection Behaviors Among U.S. Hispanic Adults* (Coups et al., 2014b). This study put together various factors and found how they may correlate with the use of preventive measures among a sample demographic group. According to the study, descriptive social norms, peer encouragement, individual responsibility, and worry of skin cancer were the main factors that had a positive correlation with the use of sunscreens. However, factors like perceived skin appearance, expectations based on appearance, type of sun protective clothing with respect to skin color, and sun protection barriers were concerns that led to a negative correlation with preventive behavior towards sun protection measures.

The PRISME study, *Influence of Social and Psychosocial Factors on Summer Vacationers' Sun Protection Behaviors*, strengthens the argument that social factors play a crucial role in influencing preventive behavior (Durand et al., 2022b). This study focuses its research on preventive behaviors of individuals while they are on vacation and exposed to an increased amount of UV radiation. The findings include that sunscreen use is much more when it is followed by an entire group of people and when the individuals are properly educated on the importance of sun-protection products. The findings suggest that social encouragement does boost the adherence towards preventive behavior significantly; however, education on its importance is crucial.

Finally, the study *The Social Psychology of Tanning and Sunscreen Use: Self-Presentational Motives as a Predictor of Health Risk* explores how individuals' sunscreen use might be affected due to self-presentation incentives (Leary & Jones, 1993b). According to the study, numerous individuals believe that tanning makes them look better, enhancing their appearance. This causes individuals to expose themselves to a much higher intensity of natural as well as artificial UV radiation to look better. Thus, self-presentational motives lead to individuals using sunscreen much less, thus increasing their risk of skin cancer greatly. This clearly shows how social norms, peer expectations, and general fashion trends have a huge influence on the way individuals prioritize their appearance over something so critical as skin cancer. It shows the pull social incentives have on individuals with the way they think.

3.4.5 Behavioral biases in health choices

This theme encompasses how biases—whether behavioral, cognitive, or emotional, have a strong influence on preventive behavior with respect to sunscreens. This theme contains research that shows how individuals tend to be lacking in making rational decisions. Individuals do not always make decisions based on objective understanding of sunscreens and the risks people face due to exposure to UV radiation. The research underscores how people concentrate more on their emotions, habits, and convenience to make decisions. Thus, behavioral biases may or may not facilitate preventive behavior and consistent use of sun protection methods. An example of a study based on this theme is the study *Beliefs Associated With Sunscreen Use Among Non-Hispanic White Older Adults* (Holman et al., 2022b). It examines beliefs associated with sunscreen use categorized by age, gender, geographic location, and skin cancer risk. The study found that older people who don't perceive exposure to UV radiation as a risk for skin diseases do not follow through with preventive behaviors like using sunscreens. This shows how underestimation of risk due to individual perception can play a significant role in the decision-making of individuals. Another key finding showed how older adults show more instances of preventive behavior when it is also practiced by their partners. This strengthens the argument that individuals also factor in others' opinions and practices when making their own decisions.

Another example includes a study, Kiviniemi and Ellis (2013b), that was primarily executed to navigate the correlation between perceived risk and worry in individuals to the use of sunscreen and practice of preventive behavior. In the study, researchers evaluate the reasons people begin to show preventive behavior. It is found that emotions like fear and worry in context with the perceived risk of skin cancer strongly influence individuals' behaviors to lean towards expressing preventive behavior and using sun-protection products. Thus, the study explains how distinct emotions like fear and worry bridge the link between the perception of skin cancer risk and sunscreen use. This study shows how emotional factors can also drive behavioral responses. Another review, *Consumer Behavior, Skin Phototype, Sunscreens, and Tools for Photoprotection*, is a comprehensive study that provides information on the biological aspects to successfully highlight the importance of sun protection products and methods (Reis-Mansur et al., 2023b). The study reveals various other skin abnormalities that need to be controlled using sun protection methods, like protective clothing and sun products. This study explains how infants and people with dark skin, albinism, and those who do artificial tanning may be at risk for various skin disorders like photoaging and pigmentation, as well as skin cancer. This paper also highlights how individuals tend to prioritize cosmetic elegance over their health, reflecting bias towards aesthetics over health.

Finally, the study *Interventions to Promote Sun Protection Behaviors: What Do We Know About the Efficacy of Health- and Appearance-based Messages and the Role of Cognitions and Emotions?* Examines the effectiveness of different types of interventions, cognitive and emotional, in promoting sun protection behaviors amongst individuals (Mahler, 2015b). The paper concentrates on both conscious and non-conscious intervention strategies. The study's findings include that health-based, appearance-based, and more emotional strategies prove to be more effective and successful compared to the highly

informative and cognitive strategies. Hence, this study strengthens the argument that emotional, in addition to cognitive, mechanisms strongly drive preventive behavior.

3.4.6 Policy intervention effectiveness

This theme examines studies that attempt to evaluate how intervention, through policies and formal regulations, can affect and enhance preventive behavior and sunscreen use amongst individuals. These studies try to explain how external factors like policy intervention and education can help in shaping new perceptions, incentives, and behaviors in favor of using sun-protection products. Hence, these studies essentially provide information that examines the potential of mandated policies in helping individuals to pay greater attention to the risks posed by UV exposure, thus reducing cancer risk.

The first study, a systematic review, *Skin cancer prevention: a systematic review of the efficacy of clinical trial-based interventions*, examines and explores different effective strategies that could help increase preventive behavior and sunscreen use amongst people, thereby preventing risks to skin disorders including melanoma (Chiesa, 2024b). This study finds that various external mandates, for example, education programs, providing sunscreens and a greater number of shaded areas in workplaces, and the usage of advanced sunscreens strongly enhance preventive behavior. Hence, the study establishes the need for certain obligations to help prevent the risk of melanoma. In the study *Rationale and study protocol to evaluate the SunSmart policy intervention: a cluster randomized controlled trial of a primary school-based health promotion program*, researchers investigate the effectiveness of policy interventions in younger students, specifically those in primary school, to ensure proper use of sun protection products like sunscreens (Dudley et al., 2015b). This was done with significant involvement of teachers and parents, which helped in influencing the students to use sunscreens properly. This also helps to create a more long-term effect on the students by helping facilitate habits at an early age. Thus, this paper anticipates a strong outcome through such interventions.

Another study, *Towards SunSmart School Policies in South Africa*, focuses on risks posed to students and children in South Africa (Wright et al., 2014b). According to this study, UV exposure caused high rates of melanoma and cataracts among individuals, thus requiring mandated policy intervention. This study highlights the need to introduce policy interventions to prevent such risks. This study finds that schools can significantly help students of young ages to adopt healthy sun protection habits. Hence, the study demonstrates the need for interventions to help adopt sun-safe strategies and foster sun-safe behaviors among children. Finally, the pilot study, *The SunWise Policy intervention for school-based sun protection: a pilot study*, also examines the effectiveness of school policies for using sunscreen and facilitating preventive behavior to mitigate risks of skin cancer (Emmons et al., 2008b). This study demonstrated the effectiveness of interventions with the additional help of sun-safe toolkits and technical assistance. According to the study's findings, such interventions significantly helped, enhancing preventive behavior among children at an early age, thus preventing the risk of skin disorders and melanoma.

3.5 India-Focused Insights

Although there is a body of international literature available on the use of sunscreens and associated health behavior, there are unique environmental, cultural, and market forces within the Indian market that are under-researched in the available literature. A close analysis of Indian studies in this regard therefore depicts gaps in the general knowledge, consumption trends, and consumer behavior and provides evidence of the necessity of further empirical research and policy-specific interventions. This section reviews Indian studies on sunscreen and skincare, highlighting awareness, usage patterns, effectiveness, safety, and product composition, and identifies gaps that point to the need for further research and market-focused interventions.

A study aimed to assess people's knowledge and attitudes toward sun exposure and the use of sunscreens (Agarwal et al., 2018b). Over two years, 2,037 adults completed a questionnaire about their awareness and habits related to sunscreen use. According to the results, more than half of the participants had minimal knowledge of sunscreens, especially among lower-middle-class groups. While most knew that sun exposure causes tanning, very few were aware of other harmful effects like wrinkling or skin cancer. Many used sunscreens mainly for cosmetic reasons and applied it only to the face. The study concluded by saying that public education on proper sunscreen use and better, locally suited products is needed. This shows the growing market demand for effective and affordable sun protection products in India.

Another study aimed to evaluate whether using a broad-spectrum sunscreen alone could improve melasma severity and quality of life in affected patients (Sarkar et al., 2019b). One hundred participants applied sunscreen with SPF 19 and PA+++ three times daily for 12 weeks, after which their Melasma Area Severity Index (MASI) and Melasma Quality of Life Index (Hi-MELASQOL) were assessed. Results showed a significant reduction in both MASI and Hi-MELASQOL scores, indicating that consistent sunscreen use alone led to visible improvement in melasma and enhanced patients' well-being. This suggests that sunscreen can be an effective, safe, and affordable treatment option benefiting consumers by reducing their reliance on chemical lightening agents and also by offering economic advantages through lower treatment costs and increased demand for broad-spectrum sun protection products.

Gasparro (2000b) aimed to examine the effectiveness of sunscreens in protecting the skin from ultraviolet radiation (UVR), with a focus on the need for UVA protection. It discussed how sunscreens do not fully prevent molecular damage such as DNA mutations caused by suberythemal UV exposure, while they are effective in preventing sunburn (erythema). The paper emphasized that UVA radiation can cause oxidative damage and immune changes in the skin, yet current testing methods do not measure UVA protection adequately. The author proposed improved evaluation standards, including redefining SPF as "sunburn protection factor." This highlights the need for more comprehensive and better UVA-protective products, driving innovation in sunscreen formulation and influencing market trends toward scientifically verified, higher-quality sun care solutions.

Another study aimed to analyze the ingredients of popular skin-lightening ("fairness") creams sold in India, focusing on the presence of fragrances, sunscreens, botanicals, and potential allergens (Gopinath et al., 2021b). Researchers examined 20 bestselling creams based on online and retail availability and identified components listed on their ingredient labels. Results showed that most creams contained multiple ingredients like water, fragrance, glycerin, tocopherol, and titanium dioxide, with nearly all unspecified fragrances and several known allergens. Although harmful agents were not listed, many products still carried allergenic risks. The study concluded that consumers are exposed to numerous potential allergenic compounds and called for greater regulation and transparency in cosmetic labeling. This shows the booming skin-lightening market in India is driven by beauty standards but has many health risks and needs safer, better-regulated products.

Gabhane et al. (2025b) aimed to evaluate the effectiveness and safety of a skincare regimen combining trihydroxybenzoic acid glucoside (THBG) 10% and α -arbutin 2%, applied twice daily along with a daily sunscreen, in Indian women with facial dark spots or melasma. It was conducted over 90 days with 124 participants, and the study used various measurement techniques, including the melasma area and severity index (mMASI), mexametry, and chromametry, to assess pigmentation changes. The results showed significant reductions in melanin levels and melasma severity, as well as clear improvements in skin brightness, evenness, and radiance, as well as no reported irritation or side effects. The study concluded that this combination is both safe and effective for reducing hyperpigmentation. This shows that there may be a growing demand for skincare products like sunscreen in India.

Another study by Nayak et al. (2016) aimed to explore the causes, mechanisms, and treatments of skin hyperpigmentation, with a focus on the Indian population. It discussed common pigmentation disorders such as melasma, dark circles, and post-inflammatory hyperpigmentation, emphasizing how India's diverse skin tones are particularly prone to these issues due to high UV exposure. The study emphasized preventive measures like consistent sunscreen use and medical or topical treatments for managing pigmentation. It concluded by saying that understanding molecular pathways and altering treatments for Indian skin types are needed to be more effective. This shows the growing need for dermatologist-approved, UV-protective skincare in India, which could help influence consumer preferences toward evidence-based and protective/effective skincare solutions.

Draelos et al. (2023), in his study, aimed to establish international, evidence-based recommendations for anti-aging dermocosmetics suitable for all skin types and tones. Using the RAND/UCLA appropriateness method, seven global dermatology experts evaluated key skincare ingredients across various age groups, skin concerns, and exposure conditions. Results showed universal support for high-factor broad-spectrum sunscreens, niacinamide, and topical antioxidants as essential for protection and repair. Tinted sunscreens with iron oxide were encouraged to improve compliance and visible light protection, particularly for darker skin tones. Retinols and alpha hydroxy acids were advised with caution in sensitive or darker skin types to prevent irritation and hyperpigmentation. The study concluded by talking about a way for inclusive and individualized skincare guidance. This shows a growing demand for evidence-based, diverse, and globally adaptable skincare products and for inclusive formulations that meet both dermatological and cosmetic standards.

Collectively, these studies highlight that while sunscreen awareness and use are gradually increasing in India, significant gaps remain in consumer knowledge, product safety, accessibility, and behavior across socio-economic groups. This underscores the need for further empirical research, targeted public health education, and policy-focused interventions tailored to the Indian context.

4. Discussion and Research Gap

The bibliometric research shows clusters of sunscreen research based on topics like sun protection, skin cancer prevention, sunscreen use, health behavior, social influence, and policy intervention. These are a few topics on which research seems to be most prominent, and these are densely connected to each other, showing very well-developed and vast studies in these areas. However, there are various research gaps that can be seen in the bibliometric graph. For instance, research on topics leaning towards economics, like income, prices of the products, sustainable and cost-effective alternatives, and other market-based research. Research gaps in such areas tend to limit a deep enough understanding of sunscreen to use it as a preventive product.

One obvious research gap that can be identified in the VOSviewer graph includes the pricing and affordability of sunscreens. The graph shows exhaustive research in areas like behaviors, knowledge, and health. However, it lacks studies with deep research into how the pricing of sunscreens affects consumer behavior to buy and use the product consistently. It is not sure how consumers make decisions to buy sunscreens based on their different prices. Different qualities of sunscreens are priced at different rates, forcing consumers to make choices based on their income.

There is also a significant lack of research in the price elasticity of demand. It is unknown how sensitive the change in demand and consumption of sunscreens is depending upon a change in the price of sunscreens. Therefore, it is also unsure what quality of sunscreens consumers choose to buy depending upon the different prices of the sunscreens. This gap can also be caused by a lack of research around the different income groups and what different income groups prioritize in context with sun protection

behavior. Lower-income groups might not view sunscreens as a need due to their high price and sometimes lesser information. They might purchase lower-quality sunscreens and might also be inconsistent with the use of sunscreens. On the other hand, demand for sunscreens among the higher-income groups may be inelastic due to greater affordability, causing them to purchase high-quality sun protection products and use them consistently. Hence, it is important to have more information about the elasticity or inelasticity of demand for sunscreens among the different income groups. This could help improve policy interventions and regulations to help prevent the risk of skin disorders due to exposure to UV radiation.

The visualizations, additionally, show a lack of research in the marketing of sunscreens. Marketing and advertising of different brands and different qualities of sunscreens creates a strong influence over the decision-making and perception of individuals. However, there is little research on how individuals are influenced and affected by the advertising, marketing, and differentiation in the quality of sunscreens. Hence, it is difficult to identify consumer behavior with respect to why people choose certain sunscreens of different prices.

There is plenty of research found on topics like health behavior and attitudes of individuals using sunscreens. However, research of their behavior over a long period of time seems to be missing. As individuals use sunscreens more consistently, making preventive behavior a habit, their demand for sunscreens may become more inelastic. However, there are few studies evaluating how consumers make decisions to purchase sun-protection products for long-term use. In conclusion, while research based on the biological and psychosocial aspects of sunscreen use is prominent, it is crucial to integrate a greater amount of research into more economic and price-related topics with respect to sunscreens. Knowledge about consumer behavior towards different prices and qualities of sunscreens is significant to enhance the use of sunscreens and increase interventions needed to combat risks of skin cancer.

5. Conclusion

This study aimed to map the development of sunscreen research in the world and determine thematic trends, gaps, and region-specific knowledge, especially in India. A total of 320 Scopus-indexed articles published between 2000 and 2025 were analyzed through the VOSviewer by following a bibliometric method to investigate the pattern of publications, geography, influential authors, collaboration network, and thematic clustering. In addition to this, India-based studies were qualitatively reviewed to reflect the localized usage patterns, awareness level, market dynamics, and policy-based interventions. The results indicate 6 leading international patterns in sunscreen studies, which are preventive consumption under risk, decision-making information, occupational vulnerability, social norms and incentives, biased behavior in health choices, and policy intervention effectiveness. Although these domains are well-developed, there are major gaps in research on the economical and market-focused research, such as pricing methods, readiness to pay, income-related demand fluctuation, price responsiveness, and marketing impact, as well as long-term consumer behavior. The research conducted in India shows low awareness, inconsistent use, and increasing interest in scientifically proven, safe, and affordable sunscreen products and the combination of cultural, environmental, and market forces in the context of sunscreen adoption. The research highlighted the necessity to incorporate the economic, marketing, and behavioral views with the biomedical and public health to promote preventive use of sunscreens. The findings indicate that effective public health campaigns, regulations, low-cost product development, and education on how to use the product can enhance its adoption and mitigate health hazards caused by UV. These insights can be used by scholars, policymakers, and industry players to shape interventions that will overcome gaps in knowledge, alter consumer behavior, and encourage evidence-based preventive health behaviors. One of the limitations of the research is that it was based on Scopus-indexed articles, and it could have included other databases as well. Moreover, while bibliometric

mapping does capture the trends in general, it is not able to capture the depth of individual behavioral or market mechanisms. Pricing sensitivity, affordability, marketing effectiveness, long-term adoption behaviors, and interventions based on various socio-economic and cultural settings are all topics of interest that must be studied in the future. The future studies could give a more detailed insight into the use of sunscreen and the better design of policy, marketplace procedures, and health outcomes of most people around the globe.

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