

Review

The Epidemiology of Acne in the Current Era: Trends and Clinical Implications

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Abstract: Acne is an inflammatory dermatosis of the pilosebaceous unit that remains highly prevalent worldwide. In recent decades, the epidemiological profile of acne has evolved, with a rising incidence observed not only among adolescents but also in adult populations, particularly adult women. The current global prevalence is approximately 9.4%, reflecting its continued relevance as a public health concern. While early epidemiological studies were predominantly conducted in the United States and United Kingdom, recent data from diverse geographic regions highlight the need for updated, globally representative research. The Global Burden of Disease (GBD) initiative has recognized acne as a condition with a substantial impact on disability-adjusted life years (DALYs), underscoring its contribution to both physical and psychological morbidity. This review aims to synthesize current epidemiological findings, identify high-risk populations, and explore intrinsic and extrinsic factors influencing disease distribution and progression. A deeper understanding of acne’s epidemiology is essential to inform prevention strategies and improve outcomes in dermatological care.

Keywords: acne; epidemiology; global burden; DALYs; population studies; prevalence trends



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1. Introduction

Acne vulgaris is among the most frequently encountered dermatologic conditions, with its prevalence rising globally, including in Europe. Although the incidence of this dermatosis is significant in the young population, the prevalence remains high in the adult population as well [1,2]. Acne has a negative psychosocial impact on patients, due to the fact that this dermatosis occurs on exposed areas, often on the face, but it can also be localized in other parts of the body that are not so visible, such as the anterior and posterior thorax [1]. The psychological discomfort that acne causes in patients is often linked with physical pain as well, as inflammatory papules and nodules are often associated with aching symptoms. Currently, a particular emphasis is being placed on the negative psychosocial implications which this dermatosis brings. It is found that acne patients are often stigmatized and have major professional and social difficulties, and all these lead to increased school absenteeism in adolescents and decreased professional performance at work in adults [1,2].

The global prevalence of acne is estimated at approximately 9.4%, based on GBD data [2]. It is one of the most widespread dermatologic conditions and is classified as acne

vulgaris and adult acne. Acne vulgaris is a dermatosis of adolescents and adults up to 24 years of age and is found in up to 57.8% [3]. If adolescent acne is not treated until the age of 25 years, or if its onset is after this age, we refer to adult acne. Estimates of the annual prevalence of acne vulgaris in the population generally range between 3% and 4%, depending on the study [4–6].

According to the Global Burden of Disease (GBD) study, acne vulgaris affects approximately 85% of young adults aged 12–25 years. Acne consistently ranks among the top three most prevalent skin conditions in the general population, as found in large studies from the UK, France, and the U.S. [7]. In the past, this dermatosis was considered a strictly adolescent disease due to the high peak of incidence in the 15–20 age group. Nowadays, this hypothesis is no longer supported because the prevalence of acne in adult patients is steadily increasing [8,9].

This review aims to provide an up-to-date overview of the epidemiology of acne vulgaris and adult acne, focusing on current global trends, regional variations, and the clinical implications of these patterns. By synthesizing recent data from population studies and burden of disease assessments, the article highlights the shifting age distribution, the rising prevalence in adult women, and the psychosocial and healthcare consequences of this disease.

2. Relevant Sections

2.1. Epidemiology

At first, studies on the epidemiology of acne were mainly conducted in the United States and the United Kingdom, but in recent decades, this field has started to develop in other countries of the world. Taking this into account, it can be stated that dermatology-epidemiology remains a topic of great interest for both dermatologists and epidemiologists, as there is a lack of current data on the epidemiology of dermatologic diseases [9,10]. We want to expand the knowledge within this domain because it concerns the study of certain risk groups and can make the physician aware of intrinsic and extrinsic factors that may influence the evolution and outcome of the patients' disease. Dermatologic diseases are of general interest, given that they are the third most common in the world, and the research in this field must always be endorsed by up-to-date epidemiologic studies [10].

According to recent statistics, more than 3.5 million people are diagnosed with acne every year. It is worth mentioning that most patients first go to a general practitioner's office rather than to a dermatologist's office. Accordingly, it can be seen that the incidence of this disease is extremely high and poorly quantified, but it is estimated that it affects 80% of people at some point in their lives between the ages of 11 and 30. During adolescence, sex differences are noticed, probably due to androgen hormones, and acne is more common in male patients [8]. An increased frequency is also reported in adult patients, especially in women, with up to 20% of women and 8% of men suffering from the disease. Of those who suffer from acne, 20% have a severe form. This percentage should raise alarm bells for both the physician and the patient, as early and prompt treatment is necessary because severe forms of the disease often lead to post-acne scarring [11].

"The Global Burden of Disease" (GBD) is a global research initiative that assesses the impact of diseases and conditions on public health. In this context, acne is one of the conditions which were analyzed, having a significant burden due to its high prevalence and negative impact on quality of life [12].

According to GBD, the global burden of acne is related to its high prevalence, as it is generally acknowledged that acne vulgaris affects millions of people worldwide [2]. It is one of the most common dermatologic diseases and is a significant public health burden. Quality of life is affected as a result and all these factors can cause anxiety, depression,

social isolation, and decreased self-esteem. The psychosocial burden is often ignored but is in fact a major component of the overall problem. Acne generates significant economic costs to healthcare systems through medical treatments, dermatologic consultations, and dermato-cosmetic products used with or without medical advice [13]. Furthermore, it should be stated that it can also affect productivity and work opportunities, especially in severe cases. Regional differences are significant; in developed regions, acne has a higher prevalence, probably due to lifestyle, diet, and access to cosmetic products that can aggravate and maintain the disease [14]. Another aspect that has been noticed is an increasing incidence of acne in developing regions with the adoption of Western diets and lifestyles [13–15].

Epidemiologic Burden and Psychosocial Impact of Acne

In the assessment of the global burden of acne vulgaris, the Global Burden of Disease (GBD) study commonly uses epidemiological indicators such as disability-adjusted life years (DALYs) and Years Lived with Disability (YLDs) [15,16]. Although acne is not a life-threatening disease, its significant psychosocial impact—particularly among adolescents and young adults—can lead to a substantial impairment in mental well-being and social functioning. As a result, acne contributes substantially to DALYs by affecting individuals' quality of life and psychological health [13–16].

YLDs quantify the number of years spent living with a disease or health condition that reduces quality of life, adjusted for the severity of the condition. In the case of acne, YLDs are notably high among young people, as this dermatosis often affects social confidence, academic performance, and early career development [16]. DALYs are calculated as the sum of YLDs and Years of Life Lost (YLLs), the latter referring to premature mortality. While YLLs may be less relevant for acne compared to other diseases, they remain an essential component of the DALY metric [13–16]. The formula used to calculate YLLs is: $YLLs = N \times L$, where N represents the number of deaths due to a specific condition and L is the number of years lost per death, based on the difference between the age at death and the standard life expectancy [16].

Recent GBD reports highlight a notable rise in the global burden of acne. The 2021 study estimated that acne vulgaris was responsible for 5.13 million YLDs (95% CI: 3.22–8.06), with 3.43 million YLDs (95% CI: 2.14–5.41) occurring among individuals aged 15–49 years. In a separate 2019 analysis, acne accounted for 4.96 million DALYs (95% CI: 2.98–7.85), of which 3.52 million were observed in the same age group. Acne ranked as the 27th most common cause of DALYs globally in 1990 (UI: 1.1), rising to the 19th position by 2019 (UI: 1.6), underscoring its growing epidemiological and clinical relevance [17,18].

Moreover, the 2010 Global Burden of Disease Study found that acne vulgaris is the eighth most common dermatologic disease, with an estimated global prevalence of approximately 9.4% (for all ages). In different countries and among different age groups, acne prevalence varies, with estimates ranging from 35% to almost 100% in adolescents who had the disease at some point in time [19,20].

Western Europe, North America, and Latin America are reported to have the highest prevalence of acne. It is likely that these high values are associated with Western diets high in processed foods, carbohydrates, and unhealthy fats and sugars. According to Zaenglein et al., acne affects about 50 million people in the United States [7]. Despite its occurrence in most age groups, it reportedly affects an estimated 85% of US adolescents [20,21].

Although it is not associated with significant mortality, acne is associated with significant physical and mental morbidity. Therefore, it is extremely important to pay attention to both the inflammatory and sequelae phases, when post-acne scarring forms as a result of

the inflammatory response and a lack of treatment, or even its ignorance. This may further contribute to depression and social stigmatization during the active disease period [22].

In the context of the Global Burden of Disease study, acne vulgaris is recognized as a condition with a significant impact, not in terms of mortality but in terms of morbidity and its long-term impact on life and mental health. Although acne is a common disease and most cases are treatable, demographic, genetic, and environmental factors influence the prevalence and treatment approaches in Europe. The global epidemiology of acne emphasizes its universal prevalence, but also its variability across age, gender, genetic factors and environmental influences [23] (Table 1).

Table 1. Epidemiologic data related to acne (all age groups) [24,25].

Epidemiologic Aspect	Details
Prevalence	Over 85% of teenagers are affected by some form of acne (absolute differences)
Age distribution	Most common between 12 and 24 years of age; may persist in adults (absolute differences 15–20% of cases)
Gender distribution	More common in men in adolescence (due to androgen hormones); more common in women in adulthood
Geographical factors	More common in industrialized countries; lower incidence in non-Westernized populations (difficulty in access to dermatological care)
Genetic impact	Significant family predisposition (if one or both parents had severe acne)
Ethnic factors	Severity may vary: Caucasians tend to develop inflammatory forms more often. People of color may have hypertrophic or keloid scars more often
Hormonal factors	Acne is frequently associated with hormonal changes (puberty, pregnancy, polycystic ovary syndrome)
Severe forms	Acne conglobata and fulminans are rarer but predominantly affect men
Psychological impact	Affects quality of life and is associated with anxiety, depression, and low self-esteem

Even though this skin condition has no lethal potential, its psychological effects can be significant, and the relationship between this dermatosis and other systemic manifestations might represent a point of interest for other medical specialties [26]. In addition to the inflammatory lesions present in acne, post-acne scarring is also relevant, as it can be a real challenge for both the dermatologist and the patient [26]. We often observe poor adherence to treatment, arising from a lack of understanding of the pathophysiology, the relatively long period of time needed for clinically evident improvements to be observed, and most importantly from the side effects of the prescribed anti-acne treatment [27]. Nowadays, given the access to social networks and the uninformed opinions of people on the internet, it is extremely important to empathize with the patient and explain each step of the prescribed treatment [28].

The social burden of acne remains an extremely sensitive topic, as most of the time this pathology is regarded as mild, with no systemic implications, by other medical professionals [28]. For the patient, on the other hand, the psychosocial burden of acne is extremely high. Patients face daily social stigmatization, anxiety, and depression and are given unsolicited advice on personal hygiene and proper skin care. For the dermatologist, a patient with acne is not an “easy to treat” patient because it is imperative to pay attention to both the local aspect and, more importantly, to the mental state of the patient [29,30].

Patients with acne should be assessed by the physician by using questionnaires on quality of life; this aspect is crucial in understanding the patient’s perception of their illness to prevent major psychiatric disorders such as depression, anxiety–depressive syndrome, and even suicidal tendencies in severe cases [31]. Understanding the patient’s mental state is also important given that the treatment may also be affected. Some acne patients tend to abandon the prescribed treatment and to approach alternative treatment methods without medical advice, which may further worsen the recovery prospects. Such practices generally lead to a decreased adherence to dermatologic treatment, delays in therapeutic success, and the development of post-acne scars [30]. To measure the quality of life of patients with acne, the Dermatologic Life Quality Index (DLQI) and the Cardiff Acne Disability Index (CADI) are used [31–34]. The DLQI and CADI are two scales used to assess the impact of acne on patients’ quality of life [32].

The DLQI (Dermatology Life Quality Index) is a general questionnaire for dermatological diseases. It contains 10 questions about the impact of the disease on daily activities, social relationships, symptoms, emotions, and work/school. The score ranges from 0 to 30, where a higher score indicates a more severe negative impact [34].

The CADI (Cardiff Acne Disability Index) is a questionnaire specific to acne. It has 5 questions, each with a score from 0 to 3, regarding the patient’s perception of the severity of acne, emotional and social impact. The total score ranges from 0 to 15 (the higher the score, the stronger the impact of acne on quality of life). It is faster to apply and more specific for patients with acne than the DLQI [29–31].

Both are useful for assessing the psychological impact of acne and for monitoring the response to treatment. The CADI is preferred in clinical trials and dermatological practice for acne because it is more specific for this condition [31–33].

Psychodermatology seems to be a new area of scientific interest because cutaneous pathology predisposes the patient to the development of secondary psychiatric pathologies, such as depression and social anxiety [34]. It should be mentioned that acne lesions are visible, with a tendency for chronicization, and are often associated with subjective symptoms such as local pain, pruritus, and irritative/allergic contact dermatitis in patients due to treatments not adapted to the patients’ skin type [35–37].

Many cutaneous pathologies are triggered by stress, which can exacerbate the underlying pathology, thus creating a vicious circle that is quite difficult to break and manage. Even if skin pathology, especially acne, does not pose life-threatening problems, this pathology contributes significantly to increased morbidity by reducing the patient’s quality of life [38].

2.2. Pathophysiology

The pathophysiology of acne focuses on four major factors: 1. hyperseborrhea, 2. hyperkeratinization of the pilosebaceous follicle, 3. colonization with *Cutibacterium acnes* (*C. acnes*), and last but not least, 4. the follicular inflammatory process [26]. During local clinical examinations, performed in the dermatologic office, we identify both inflammatory lesions such as papules, pustules, nodules, and cysts, but also noninflammatory lesions such as closed and open comedones, which clinically classify acne into two forms: inflammatory acne and noninflammatory acne [39,40].

Considering the frequency of this skin pathology in the general population, the pathogenesis of acne is of great interest and has been intensively studied, although the topic has not been completely explored by scientists and there are clear gaps in the research on the matter. A multitude of factors seem to be involved in acne, in addition to those already known, such as hyperseborrhea, which is always present, and follicular hyperkeratinization, but also colonization and the immune and inflammatory response produced by *C. acnes* [41] (Table 2).

The local inflammatory response is initiated by CD 4-positive lymphocytes, which will induce an increased production of proinflammatory cytokines, one of which is Interleukin 6 (IL-6) [41]. Acne is a multifactorial condition that, in the pathophysiological circle, centers on the inflammatory component, which can also be triggered by follicular obstruction produced by an abnormal follicular hyperkeratinization of keratinocytes [42]. Furthermore, the quantity and quality of sebum and the diversity of the cutaneous microbiome may represent the actual key factors of acne, while understanding these aspects may improve therapeutic perspectives and, more importantly, contribute to the preservation of the physiologic cutaneous microenvironment [43].

Table 2. Pathophysiologic mechanisms and future perspectives [44,45].

Pathophysiologic Mechanism	Details	Future Perspectives
Sebum overproduction	Increased sebaceous gland activity under the influence of androgen hormones	Development of molecules that directly inhibit sebum production or target specific androgen receptors
Follicular hyperkeratinization	Blockage of pilosebaceous follicles due to keratinocyte obstruction	Use of more selective topical retinoids or gene therapies to regulate keratinocyte differentiation
<i>Cutibacterium acnes</i> colonization	Overgrowth of <i>C. acnes</i> bacteria, exacerbating inflammation	Development of bacteriophages or microbiome therapies to restore bacterial balance in the skin
Inflammation	Local inflammatory response with formation of pustules, papules, and nodules	Introduction of anti-inflammatory biologic therapies (IL-1, IL-6, IL-17 inhibitors) for severe inflammatory acne
Role of the skin microbiome	Imbalance of the skin microbiome can contribute to the development and worsening of skin lesions	Research on topical probiotics and prebiotics to optimize microbiome health
Genetic factors	Genetic polymorphisms influence acne sensitivity and susceptibility	Gene editing technologies (CRISPR-Cas9) to correct mutations involved in acne predisposition
Dietary and metabolic influence	Diet high in simple carbohydrates and dairy may exacerbate acne	Development of personalized dietary guidelines and use of metabolic biomarkers for prevention and treatment

2.3. Microbiome

The human skin microbiome consists of the community of microorganisms colonizing the tegument, and it is composed of bacteria, fungi, viruses, and mites [45,46]. Bacteria of the commensal flora structure commonly colonize the tegument, digestive tract, upper respiratory tract, and genital organs, and they play an important role in protecting the body from the pathogens with which they come into contact [45]. The microenvironment of the

tegument is grouped into three main categories, which are directly related to the number of sweat and sebaceous glands in the area; therefore, we distinguish the following:

- “Seborrheic” areas (forehead, scalp, chest, back);
- “Wet” areas (armpit, cubital fossa, groin, inguinal fold, popliteal fossa, umbilicus (navel), buttock fold, soles, inner finger spaces);
- “Dry” areas (upper and lower limbs, except folds) [47,48].

The skin is the second organ, after the intestine, with the second most numerous microorganisms that make up the microbiome, so we believe that it is important to know more about this subject and that studies in this field of research should be expanded [49]. Concerning the skin microbiome, bacterial species are the most abundant, and they are classified into four major bacterial categories (phyla), namely, Actinobacteria, Bacteroidetes, Firmicutes, and Proteobacteria [49,50].

Even if we are talking about the same individual, the composition of the microflora at the tegumentary level may differ over time, which emphasizes that the cutaneous topography is not the only thing of interest, but that there are a variety of factors that can influence the cutaneous microenvironment in the same person [48]. Apart from intrinsic host factors such as gender, age, and certain associated pathologies, we can also discuss an important external contribution when it comes to antibiotic treatments, the cosmetics used, environmental temperature and humidity, UV exposure, occupation, and clothing [51].

The study of the microbiome is a subject of great contemporary interest, not only in dermatology but also in other medical fields [50]. Currently, we do not have sufficient data on the overall microorganism populations that are part of the tegument microbiome, and some of them may be involved in dermatologic diseases. Culture-based studies and 16S rRNA methods have shown that in healthy body areas rich in sebaceous glands, the skin microbiome is mainly composed of *Cutibacterium*, followed by *Staphylococcus* species and *Malassezia* [52]. It is already proven that the commensal bacterium *Cutibacterium acnes* (*C. acnes*) plays a key role in the pathogenesis of acne vulgaris. It virtually closes the pathophysiologic circle of acne through the inflammation and the immunologic mechanisms it produces in the pilosebaceous follicle [53].

Certain *C. acnes* phylotypes may increase the local inflammatory response by activating the innate cellular response and releasing proinflammatory cytokines such as tumor necrosis factor- α (TNF- α) and interleukin (IL)-6, IL-8, and IL-12, partly through Toll-like receptor 2 (TLR2) signaling [54]. It may also induce the secretion of IL-1 β by monocytes through NOD-like receptor signaling and, in particular, the NLRP3 inflammasome. *C. acnes* increases the T lymphocyte response, in particular Th17/Th1, and thus promotes the production of the proinflammatory interleukins IL-17A and interferon gamma [55,56].

Staphylococcus epidermidis (*S. epidermidis*) is a commensal of human skin and a coagulase-negative staphylococcus (CoNS) that plays an extremely important role in skin homeostasis. It can act as a tegument protector when an individual comes into contact with a pathogenic microorganism, such as *Staphylococcus aureus* [57,58].

In this review, we can draw attention to the importance of the cutaneous microbiome and emphasize the importance of its maintenance during anti-acne treatments and procedures. An excessive use of antibiotics and acids to treat this dermatosis may affect the skin and gut microbiome and increase the incidence of treatment resistance [58]. We currently aim to promote and preserve the skin microbiome with treatments that are gentle and tailored to the needs of the patients and also to maintain skin and gut balance through a healthy lifestyle [59–61].

2.4. Genetic Predisposition

In practice, it has been observed that the descendants of acne patients have an increased predisposition to develop this condition. The hereditary factor plays an essential role in triggering acne, especially in severe forms, characterized by nodules, cysts, and scars [60].

A study conducted on twins in the United Kingdom concluded that in 81% of cases, acne has a genetic cause and is influenced by family history. This aspect emphasizes the importance of genetic inheritance in the onset of the disease. Likewise, an Italian observational study highlighted a close link between the severity of acne (from moderate to severe) and the family history of first-degree relatives [62,63].

Studies from China and Europe have reached similar conclusions, confirming that family history not only favors the early onset of acne but is also associated with more aggressive forms, which are difficult to treat (He et al.) [64]. They conducted a cohort study in the Han population and found two genetic segments involved in the susceptibility to severe acne—11p11.2 (associated with DNA-binding proteins involved in wound repair) and 1q24.2 (L-selectin, with a role in androgen metabolism, inflammation, and scarring) [63,64].

2.5. Economic Factors

Depending on family income and regional characteristics, urban residents can be classified into several categories: low-income, middle-income, upper-middle-income, and wealthy groups. Studies have highlighted differences in access to medical services according to these economic categories, which may in turn influence the frequency of acne [63–65].

According to a study conducted in Canada, only 17% of people with incomes under CAD 20,000 had visited a dermatologist, compared to 24% of those earning over CAD 80,000 who had consulted a dermatologist. There were also differences in the frequency of acne in urban versus rural areas. The study, conducted by Dreno and his collaborators, showed that people suffering from acne were more frequently found in urban areas with high socio-economic status [65].

2.6. Diet

We all know that diet plays a major role in an individual's overall health, and a healthy lifestyle and a diet rich in healthy nutrients is to be encouraged, but current data on the relationship between diet and acne are limited, uncertain, and sometimes conflicting [56].

It is well known that some foods can have a proinflammatory effect in the body, and these foods are generally the “ultra” processed ones, with an increased content of sugar, salt, fats, and additives. The foods and drinks that fall into this category can be considered unhealthy and may increase systemic inflammation [56,57]. This category may include ice cream, potato chips, cereals, cereals biscuits, carbonated drinks, fast food (burger, French fries, high fat sauces), yogurts with sugar and flavorings, instant soup, or alcoholic drinks [65].

Dos Santos and his collaborators showcased the relationship between ultra-processed foods and increased IL-6 concentration in the body in a 2023 study. Unhealthy foods were associated with substantial weight gain but also with an intensification of the systemic inflammatory process, and also with a substantial increase in IL-6 in the blood [66,67].

Adolescents of the current generation adopt an unhealthy lifestyle, based on Western influences, with high carbohydrate content and a high glycemic index in the diet, which triggers increased production of insulin and IGF-1. These hormones cause mTORC1 signaling, which has an anabolic effect, resulting in increased body weight and thus insulin resistance [68].

The Western diet is commonly found in developed countries, and there is now an increasing trend towards its adoption in developing countries, making an awareness of its

physical and mental health consequences critically important. This diet is mainly reliant on the ingestion of large quantities of foods and beverages with high sugar content, refined cereals, processed foods, convenience foods, and foods cooked in oil [69].

Current studies classify foods that trigger and maintain acne lesions into three categories: (1) hyperglycemic carbohydrates, (2) milk and dairy products, and (3) saturated fats, including trans fats and ω -3 polyunsaturated fatty acid (PUFA) deficiency [70].

Changes in sebum production under the influence of diet can be seen both quantitatively, through hyperseborrhea, and compositionally, through dysseborrhea, due to biofilm formation and an increased virulence factor of *C. acnes*, leading to increased follicular levels of palmitate and free oleate. Free palmitate acts as a “danger signal” and causes follicular hyperkeratinization mediated by interleukin-6 and 17 [71,72].

2.7. Environmental Factors

The skin is an essential organ and is in direct contact with the external environment. It constitutes the first line of defense against the influence of outside factors and has the role of protecting internal tissues and organs from harmful physical, chemical, and biological agents. The skin also contributes to maintaining the balance of the entire organism and facilitates adaptation to external conditions [73].

Air pollution is one of the most challenging environmental problems, especially for urban areas and for developed countries overall. In recent decades, researchers have been increasingly concerned about the risks that air pollution brings in large cities, in connection with the increase in asPM (aerosol particulate matter) and PM (particulate matter) [73,74]. PM refers to particulate matter, that is, the solid and liquid particles in the air, and asPM is not a globally standardized term, but it refers to the particulate matter that is part of aerosols: suspensions of solid or liquid particles in the air [73]. Clinical studies report that air pollution has a detrimental effect on the skin by increasing oxidative stress, which considerably alters skin functions through changes in lipids, proteins, and deoxyribonucleic acid at this level. Two comparative clinical studies that evaluated subjects from highly polluted areas with those from less polluted areas in Shanghai and Mexico demonstrated that skin quality decreased with chronic exposure to a polluting environment [74]. This is illustrated in Figure 1, which highlights the main environmental factors contributing to acne.

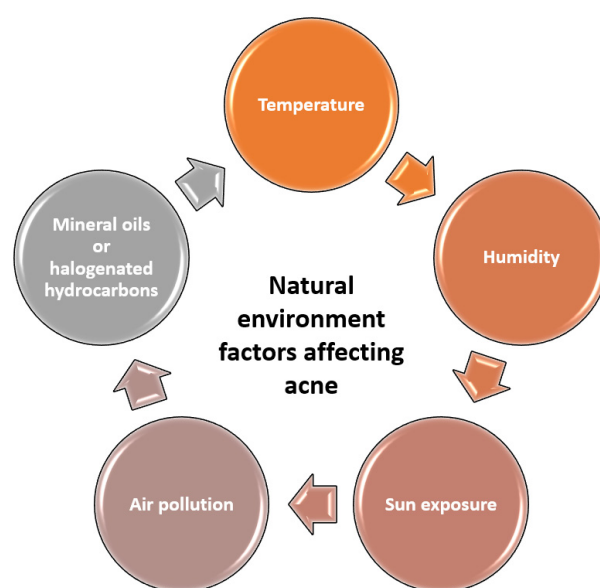


Figure 1. Factors in the natural environment affecting acne [62].

2.8. Cytokines Involved in Acne Pathogenesis

Several cytokines have been identified as key contributors to the inflammatory processes underlying acne pathogenesis. Among them, interleukin-1 (IL-1) plays a central role as a proinflammatory cytokine that initiates and amplifies the immune response. IL-1 promotes the production of additional inflammatory mediators and exerts a direct effect on keratinocytes and immune cells in the skin, thereby intensifying local inflammation and contributing to the formation of acne lesions [74,75].

Another critical cytokine is interleukin-17 (IL-17), primarily produced by T helper 17 (Th17) lymphocytes. IL-17 is strongly associated with inflammatory acne due to its involvement in recruiting and activating neutrophils and other immune cells at the site of inflammation. It also stimulates sebum production in the sebaceous glands, which further aggravates acne appearance [74–76].

The role of interleukin-23 (IL-23) is equally important, as it supports the development and maintenance of the Th17 response. By promoting IL-17 synthesis, IL-23 indirectly sustains the inflammatory cascade that characterizes many acne lesions [75].

Tumor necrosis factor-alpha (TNF- α) is another major proinflammatory cytokine implicated in acne. It activates a variety of intracellular signaling pathways that enhance inflammation, increase sebum production, and may lead to further obstruction within the pilosebaceous unit [74–76].

Although adiponectin is not a cytokine in the strict sense, it plays a significant role in the modulation of inflammatory acne. This protein, secreted by adipose tissue, possesses anti-inflammatory properties and may influence acne severity, particularly in the context of hormonal dysregulation and chronic low-grade inflammation [74].

Among the cytokines directly involved in acne pathogenesis, interleukin-8 (IL-8) acts as a potent chemoattractant that recruits inflammatory cells such as neutrophils to the site of inflammation in the skin. This process intensifies the local immune response, potentially contributing to the progression and aggravation of acne lesions, especially in the development of pustules and papules [73,74].

Interleukin-6 (IL-6) also plays a dual role in acne inflammation. It functions as both a cytokine and a myokine, capable of triggering inflammatory responses while also modulating them under certain conditions. IL-6 is produced by various cells, including osteoblasts, and has been shown to participate in the regulation of immune responses that contribute to the chronicity of acne [44].

Smooth muscle cells produce IL-6 as a cytokine that triggers inflammation. The role that IL-6 has as an inflammation-relieving myokine is carried out by inhibiting the effects of TNF-alpha and IL-1 and by activating IL-1ra and IL-10 [63,64]. IL-6 correlates with inflammatory markers such as C-reactive protein, which can increase the value of IL-6 as an inflammatory mediator. The 572 C allele of the IL-6 gene plays a role in the production of IL-6 in acne vulgaris, and it is further argued that acne severity and certain cytokine gene polymorphisms correlate [76].

In studies, keratinocytes and sebocytes have been shown to secrete IL-6, which may suggest that IL-6 has a role in acne vulgaris. Considering that IL-6 is a proinflammatory cytokine, it is known that its production may be influenced by a variety of aspects [75]. Besides the involvement of genetic factors in the development of acne, it is evident that both inflammatory processes and the effects of oxidative stress are involved in this pathology. The cytokine IL-6 facilitates the production of neutrophils, various cytokines, proteases, and free radicals. Cytokine IL-6 can also induce T cell differentiation, B cell maturation, and immunoglobulin production [77,78]. Acne vulgaris is a dermatosis that requires special attention and appropriate and personalized treatment. Considering that IL-6 levels could provide information about the degree of inflammation in the body, we find it useful to

dose it by laboratory tests [44]. Its relationship with other inflammatory markers, such as fibrinogen and C-reactive protein, and their relationship with the severity of acne can also be studied. Acne vulgaris can be considered a tegumentary inflammatory process, occurring on the face or body, with varying degrees of severity [79,80].

3. Discussion

Acne's epidemiology is influenced by genetic, hormonal, environmental, and lifestyle factors. The rising prevalence of adult acne may be linked to chronic stress, Western diets (increasing insulin and IGF-1), hormonal imbalances, and occlusive cosmetics. Microbiome dysbiosis also plays a role, with emerging treatments focusing on probiotics and prebiotics. Anti-inflammatory diets rich in omega-3 and antioxidants may help reduce severity by modulating inflammation. These biological, environmental, and lifestyle factors influencing acne development are illustrated in Figure 2.

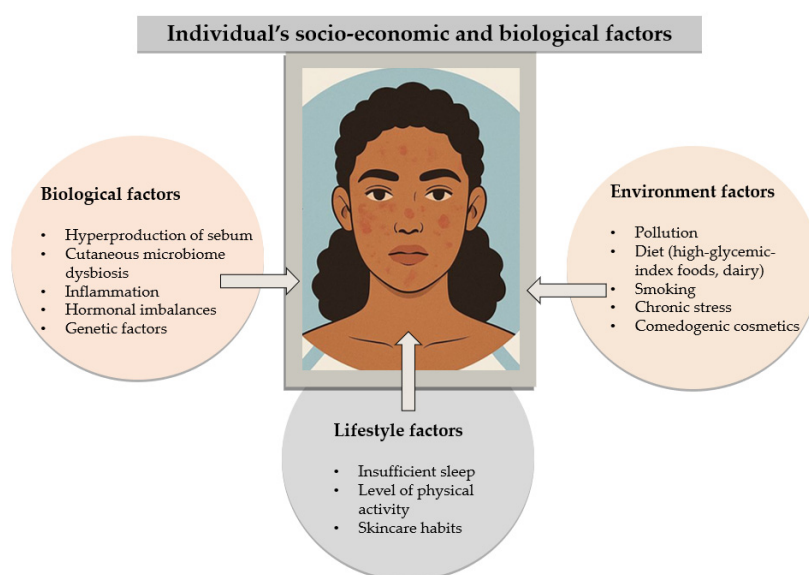


Figure 2. Socio-economic and biological factors affecting the individual [74].

However, there are research gaps regarding the impact of pollution on acne, the precise role of dietary factors beyond high glycemic load and dairy, and the complex interplay between genetic predisposition and environmental triggers.

Acne remains one of the most common dermatological conditions globally, and recent changes in the epidemiological profile, with a significant increase in prevalence among adults, especially women, highlight the need for updated studies that take into account genetic, hormonal, dietary, and environmental factors.

The absence of globally standardized and updated epidemiological data constitutes a major limitation to the full understanding of the phenomenon. Consequently, the need to consolidate epidemiological approaches in dermatology through interdisciplinary studies is critical.

4. Conclusions

The epidemiology of acne reflects a complex interplay between biological and environmental factors. Ultimately, the need for more epidemiological studies, taking into account changes in risk factors and ongoing therapeutic evolution, may expand the understanding of pathophysiological mechanisms and optimize prevention and treatment strategies.

Acne is a complex global disorder with both biological and environmental risk factors. Dermato-epidemiological studies emphasize that although acne may have similarities

globally, each region has particularities related to lifestyle, diet, access to treatment, and cultural perceptions.

5. Future Directions

The future prospects of acne research involve a focus on the study of epidemiology in different regions of the world, considering that in developed countries, the consumption of high-fat foods and refined carbohydrates is higher compared to that in developing countries [81,82].

Besides easy access to unhealthy foods in urban areas in developed countries, there is also an increased exposure to cosmetic products, which are used without medical advice. It is likely that urbanization, modern diets, and daily stress may be triggers of acne lesions, and they are certainly factors that contribute to them. Studying these factors and establishing causality relationships may be breakthroughs in acne management [82].

Current data on the role of nutrition in acne vulgaris are unclear, but there is growing interest in this topic. There is a relationship between the severity of acne and patients' eating habits, and the current trend in people's diets nowadays is to replace healthy nutrition, based on fruits, vegetables, and unsaturated fats, by those with an increased content of saturated and trans fats, namely, semi-processed, high-glycemic-index foods and fast food products [81,82]. This unhealthy diet may increase the risk of obesity and may induce hyperinsulinemia, which comes along with increased insulin resistance and implicitly increased serum levels of androgenic hormones, which have been shown to have direct implications in the pathophysiology of acne [83–86].

Another hypothesis researched these days relates to the contribution of emotional stress to the pathophysiologic circle of acne; it is able to stimulate androgenic hormones and even to increase serum cortisol levels. The latter can eventually trigger and even maintain a local and systemic proinflammatory status [87,88].

Considering that the role of interleukins TNF, IL-6, IL-10, IL-7, IL-19, IL-31, IL-36, and IL-38 in dermatologic diseases is seen as major, benefiting, in some cases, from certain treatments that block their action, it is worth studying their possible role in the pathogenesis of acne [89–91].

Another future direction that is gaining considerable weight nowadays are AI systems, which are already integrated in some dermatologic clinics and mobile applications, and their future looks promising [92–94]. Regardless of this fact, we should not forget that these applications may have some limitations, such as the need for an extensive and diverse database (AI needs to be trained on images from multiple skin groups and skin types); the quality of the photographs needs to be extremely high, as poor lighting or certain distortions may affect diagnosis and treatment recommendations [95,96]. However, even if technology is important and AI systems are oftentimes of great help, we cannot argue that AI has the potential to replace the dermatologist; rather, it assists and guides them in certain diagnostic and treatment matters [96,97].

Finally, the study of the cutaneous microbiome before and after the treatment of certain dermatologic diseases may be a new approach in the future, as the alteration of the human microbiome may point at a “weakening” of the immune system and may implicitly lead to the development of other imbalances and even diseases [98].

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