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Immunological dysregulation in psoriasis: Pathophysiology, genetic influences, and emerging therapeutic strategies

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Abstract

The persistent, immune-mediated skin condition known as psoriasis affects millions of people globally. This study aims to present a thorough examination of the basic processes that underlie psoriasis, with an emphasis on immunological dysregulation and its consequences for the treatment of the condition. The hallmarks of psoriasis are inflammation, keratinocyte hyperproliferation, and the development of distinct, scaly plaques. The main cause of psoriasis, according to recent developments in immunology, includes both the innate and adaptive immune systems and is considered an aberrant immune response. Cytokines such as TNF-α, IL-17, and IL-23, together with T cells and dendritic cells, are key players in this dysregulation, generating a feedback loop that sustains chronic inflammation in the skin. Apart from pinpointing susceptibility loci such as PSORS1, this review highlights the role of genetic and environmental factors in the pathophysiology of psoriasis. These immunological pathways are the focus of current therapy approaches, and biologics such as TNF inhibitors, IL-17 inhibitors, and IL-23 inhibitors have demonstrated exceptional effectiveness in reducing the condition. Ongoing clinical studies are used to examine emerging treatments, such as JAK inhibitors and personalized medicine strategies. According to the review, a better knowledge of immunological dysregulation in psoriasis can result in more personalized treatment plans, which could lessen the disease's burden and enhance patients' quality of life. To create more potent and long-lasting treatment plans, greater study on the immunobiology of psoriasis is essential.

Keywords: Psoriasis; Immune dysregulation; Immune response; Genetic susceptibility

1. Introduction

Psoriasis, a chronic, inflammatory skin disorder that significantly impairs quality of life, affects between 2 and 3 percent of individuals globally. It is a complicated disease caused by a combination of immune system dysregulation, environmental stressors, and genetic predisposition (1). Psoriasis can affect any region of the body, although it usually shows up as erythematous, scaly plaques on the scalp, elbows, knees, and lower back (2). In addition to its physical manifestations, psoriasis is linked to a number of comorbid conditions, such as metabolic syndrome, cardiovascular disease, and psoriatic arthritis, all of which increase the illness's total burden (3). Significant strides have been made in the last few decades in comprehending the pathophysiology of psoriasis, particularly the immune system's role (4). Once believed to be a disorder brought on by excessive keratinocyte development, psoriasis is now recognized as an immune-mediated illness (5). The primary causes of this immunological dysregulation include T cells (particularly Th17 and Th1 subsets), dendritic cells, and a network of cytokines, including tumor necrosis factor-alpha (TNF-α), interleukin-17 (IL-17), and interleukin-23 (IL-23). The severity and chronicity of the condition are exacerbated by a pro-inflammatory loop that these substances induce (6). The discovery of many susceptibility loci, the most important of which is PSORS1 (on chromosome 6p21), has highlighted the genetic component of psoriasis (7). However, the onset

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and aggravation of disease are also significantly influenced by environmental factors (8). The management of psoriasis can be made more difficult by triggers including infections (such as streptococcal infections;), psychological stress, trauma (Koebner phenomenon;), and specific drugs (9). Since immunological dysregulation plays a major role, psoriasis treatment approaches have changed significantly, especially with the introduction of biologics (10). Conventional medicines, such as topical medications (like corticosteroids and vitamin D analogs) and systemic treatments (like methotrexate and cyclosporine), have proven somewhat successful, but they sometimes have unfavorable side effects or limited effectiveness (11). Targeting particular immunological pathways, biologic medicines have completely changed the way that treatments are administered (12). Through direct modulation of important cytokines implicated in disease etiology, TNF inhibitors, IL-17 inhibitors, and IL-23 inhibitors have shown excellent efficacy and long-lasting effects in treating psoriasis symptoms (13). Despite these developments, managing psoriasis still presents difficulties. Not every patient reacts to the available treatments in the same way, and some eventually lose their effectiveness (14). Furthermore, because the disease is chronic, it necessitates long-term care, which raises questions regarding safety, adverse effects, and accessibility to expensive biologics (15). As a result, new treatments like JAK inhibitors and small molecules are becoming more popular, as are personalized medicine strategies that adjust treatment according to each patient's unique immunological profile and genetic predispositions (16).

2. Pathophysiology of psoriasis

Comprehending the pathophysiology entails investigating the intricate relationships among immune cells, hereditary factors, and environmental stimuli (17). The overreaction of the immune system at the core of psoriasis involves both the innate and adaptive immune systems, which interferes with the regular turnover of skin cells and causes psoriatic plaques (18).

2.1. Immune dysfunction

The immune system is mistakenly triggered in psoriasis, which starts with innate immune cells like dendritic cells and macrophages and sets off an inflammatory cascade (19). These cells generate pro-inflammatory cytokines, including interleukin-1 (IL-1), interferon-gamma (IFN-γ), and tumor necrosis factor-alpha (TNF-α), in response to stress signals triggered by infections, skin injuries, or other environmental stimuli (20). The adaptive immune system, in particular T cells, is activated by these stimuli and are crucial for preserving the chronic inflammation linked to psoriasis. The pathogenesis of psoriasis includes the activation of T helper (Th) cells, particularly Th1 and Th17 subtypes (21). While Th17 cells generate interleukin-17 (IL-17), a cytokine that causes keratinocyte hyperproliferation and intensifies the immune response, Th1 cells release IFN-γ, which encourages inflammation (22). The formation and maintenance of Th17 cells depend on IL-23, which is generated by dendritic cells and forms the foundation of the IL-23/IL-17 axis, which is crucial to the pathogenesis of the disease (23). These T cells move to the skin after activation and release pro-inflammatory cytokines such as TNF-α, IL-17, IL-22, and IL-23. By attracting more immune cells to the skin and sustaining chronic inflammation, these cytokines produce a positive feedback loop (24). Keratinocytes, the main cell type in the epidermis, are thus encouraged to multiply quickly. The thick, scaly plaques that define psoriasis are caused by this aberrant keratinocyte turnover, which also compromises the natural skin barrier. Furthermore, psoriatic lesions have more vascularity due to increased angiogenesis (25).

2.2. Genetic Factors

Since several susceptibility loci have been found, the most prominent of which is PSORS1 on chromosome 6p21, the genetic foundation of psoriasis has come to light (26). This locus is tightly linked to the major histocompatibility complex (MHC), namely HLA-C06:02, which is strongly linked to psoriasis (27). Additional genes that have been implicated include those that encode TNF-α, IL-23, and IL-17, which are involved in immunological control. But because psoriasis is a polygenic condition, no one gene is entirely to blame for the onset of the condition (28).

2.3. Environmental Triggers

Environmental factors frequently cause or worsen psoriasis, even while genetics provides the underlying predisposition. Infections, especially streptococcal infections, are common causes of guttate psoriasis (29). The condition can also be triggered or made worse by psychological stress, physical trauma to the skin (Koebner phenomenon), and certain drugs including beta-blockers and lithium. Other risk factors that could increase the severity of the disease and its flare-ups include smoking, obesity, and alcohol use (30)

3. The Role of Cytokines

Cytokines have a major impact on the immune response in psoriasis. Although IL-23 promotes the development and expansion of harmful Th17 cells, TNF-α and IL-17 are important mediators of inflammation (31). IL-22, which Th17 cells generate, stimulates keratinocyte growth and thickens the epidermis. Together, these cytokines cause the skin to develop a pro-inflammatory milieu that perpetuates chronic inflammation and results in the clinical signs and symptoms of psoriasis (32).

3.1. Immune Dysregulation in Psoriasis

Psoriasis, an immune-mediated disorder primarily brought on by dysregulation of the innate and adaptive immune systems, is characterized by persistent inflammation and keratinocyte hyperproliferation (33). The intricate interactions between immune cells and cytokines that sustain an inflammatory cycle are part of the immunological dysregulation in psoriasis. The formation and maintenance of psoriatic lesions are largely dependent on this abnormal immune activity (34).

3.2. Innate Immune Response

Innate immunological reactions brought on by external variables like infections, skin damage (Koebner phenomenon), or stress are frequently responsible for the onset of psoriasis (35). These stimuli cause aberrant activation of innate immune system dendritic cells (DCs), neutrophils, and keratinocytes in psoriasis (36). To activate plasmacytoid dendritic cells (pDCs), injured keratinocytes can release antimicrobial peptides like LL-37, which can then interact with self-DNA or RNA. These cells generate the potent pro-inflammatory cytokine interferon-alpha (IFN-α), which initiates the inflammatory cascade (37). After that, the region of inflammation attracts conventional myeloid dendritic cells (mDCs), which generate cytokines like TNF-α, IL-23, and IL-12. By stimulating and expanding a subset of T helper cells called Th17 cells, IL-23 in particular is essential for sustaining the chronic inflammatory state (38). By generating neutrophil extracellular traps (NETs) and producing reactive oxygen species (ROS), neutrophils are also drawn to psoriatic lesions and aid in inflammation, which in turn boosts immunological responses (39).

3.3. Adaptive Immune Response

The adaptive immune system, and specifically T cells, have a major impact on the chronic nature of psoriasis. The key players are T helper 1 (Th1) and T helper 17 (Th17) cells, which become overactivated in psoriatic skin (40). In psoriasis, the IL-12/Th1 and IL-23/Th17 axes are primarily responsible for the immunological dysregulation. The progression of the disease depends on the production of interleukin-17 (IL-17) by Th17 cells and interferon-gamma (IFN-γ) by Th1 cells (41). The Th17 cells release IL-17, IL-22, and TNF-α to promote keratinocyte hyperproliferation, epidermal thickness, and the formation of psoriatic plaques, while the Th1 cells release IFN-γ to activate macrophages and drive inflammation (42). Particularly, IL-17 is a crucial cytokine in psoriasis because it directly induces keratinocytes to generate pro-inflammatory cytokines, chemokines, and antimicrobial peptides, which further attract more immune cells to the skin (43). Th17 cells also produce IL-22, which worsens the development of plaque by inhibiting keratinocyte differentiation and encouraging their proliferation (44).

4. Cytokine Networks

Pro-inflammatory cytokine networks are one of the primary causes of the immunological dysregulation in psoriasis. In the pathophysiology of the disease, TNF-α, IL-17, and IL-23 are the most significant cytokines (45). They collaborate to form a feedback loop that sustains inflammation. TNF-α, which is produced by keratinocytes, dendritic cells, and macrophages, triggers the production of additional pro-inflammatory cytokines, thereby intensifying the inflammatory response (46). IL-23 promotes Th17 cell growth and maintenance, while IL-17 enhances keratinocyte activation and neutrophil recruitment (47). Particularly important in the pathophysiology of psoriasis is the IL-23/IL-17 axis. IL-23, which is mostly produced by dendritic cells, is necessary for the development of pathogenic Th17 cells, which secrete IL-17 (48). This cytokine is essential for psoriasis because it stimulates keratinocyte proliferation and inflammation. The significance of this pathway in the onset of disease is demonstrated by the efficacy of therapies that target IL-17 and IL-23 (49).

4.1. Chronic Inflammation and Feedback Loops

Once the inflammatory cascade is initiated, it becomes self-sustaining due to the continuous interaction between immune cells and cytokines (50). Activated T cells in the skin release cytokines that further stimulate keratinocytes,

leading to hyperproliferation and the release of additional inflammatory mediators. This creates a vicious cycle of inflammation that is difficult to break, contributing to the chronicity of the disease (51).

5. Clinical Manifestations

Symptoms that impact the systemic organs, joints, skin, and nails. Although erythematous, scaly skin plaques are the primary symptom of psoriasis, the condition also affects other body systems. A chronic immune-mediated condition, psoriasis manifests in a number of clinical body systems and is linked to serious comorbidities. For efficient treatment and better patient outcomes, it is essential to comprehend these clinical manifestations and the comorbidities that go along with them (52).

5.1. Plaque Psoriasis (Psoriasis Vulgaris)

85–90% of psoriasis patients have plaque psoriasis, which is the most common kind. Red, well-defined lesions with silvery-white scales are what set it apart. These plaques can develop anywhere on the body, although they usually appear on the scalp, lower back, knees, elbows, and trunk. The plaques are often symmetrical and come in a range of sizes. The itching, pain, and discomfort that the lesions may cause have a significant impact on the patient's quality of life (53).

5.2. Guttate Psoriasis

Guttate psoriasis, which is most commonly found in children and adolescents, is often caused by streptococcal infections. It is distinguished by small, suddenly developing lesions on the trunk and limbs that resemble drops. Compared to plaque psoriasis, these lesions are typically less scaly, more prevalent, and less chronic (54).

5.3. Inverse Psoriasis

Skin folds like the armpits, groin, and under the breasts are affected by inverse psoriasis. Because of the moist environment of skin folds, the lesions are red and glossy, unlike other types, and frequently lack the heavy scales associated with plaque psoriasis. Often, it is mistaken for a bacterial or fungal infection (55).

5.4. Pustular Psoriasis

The development of pus-filled blisters (pustules) on the skin, encircled by red, swollen skin, is a hallmark of pustular psoriasis, a more severe condition. It may manifest as palmoplantar pustulosis, which is restricted to the hands and feet, or as generalized pustular psoriasis, which could be fatal and necessitates prompt medical care (56).

5.5. Erythrodermic Psoriasis

Widespread inflammation and scaling across the body are symptoms of erythrodermic psoriasis, an uncommon but severe type of the condition. A hospital stay is frequently necessary due to the severe itching, pain, and increased risk of complications like infection and fluid loss (57).

5.6. Nail Psoriasis

Subungual hyperkeratosis, onycholysis (nail detachment), pitting, and discoloration can result from nail involvement, which affects over 50% of psoriasis sufferers. An increased risk of psoriatic arthritis is linked to nail psoriasis (58).

6. Comorbidities

6.1. Psoriatic Arthritis (PsA)

About 30% of people with psoriasis have psoriatic arthritis, which results in joint swelling, discomfort, and inflammation. If PsA is not well treated, it may result in joint injury and deformity. It frequently appears years after the first signs of psoriasis on the skin and typically affects the fingers, toes, lower back, and knees (59).

6.2. Cardiovascular Disease

An elevated risk of cardiovascular disease (CVD), which includes atherosclerosis, myocardial infarction, stroke, and hypertension, is linked to psoriasis. Psoriasis-related chronic systemic inflammation raises the risk of CVD development and causes endothelial dysfunction. Cardiovascular events are far more likely to occur in people with severe psoriasis (60).

6.3. Current Therapeutic Approaches Targeting Immune Dysregulation in Psoriasis

Treatments for psoriasis have changed significantly since it was discovered that the condition is immune-mediated. Current therapies focus on cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-17 (IL-17), and interleukin-23 (IL-23), especially targeting the dysregulated immunological pathways that lead to inflammation and keratinocyte hyperproliferation (61).

6.4. Biologic Therapies

By providing focused, efficient therapy with comparatively less adverse effects than conventional systemic treatments, biologics have completely changed the way that moderate to severe psoriasis is treated. By blocking particular cytokines or their receptors, these biologics aim to interrupt the inflammatory cycle (62).

6.4.1. TNF-α Inhibitors

TNF-α, a crucial cytokine in psoriasis inflammation, is the target of medications such as infliximab, etanercept, and adalimumab. TNF inhibitors have demonstrated notable effectiveness in lowering the severity of plaque and enhancing many patients' quality of life (63).

6.4.2. IL-23 Inhibitors

Th17 cells, which release IL-17, depend on IL-23 for survival. By interfering with the IL-23/Th17 axis, ustekinumab (which targets IL-12/IL-23) and more recent IL-23 specific inhibitors such as guselkumab, tildrakizumab, and risankizumab have shown long-term effectiveness in managing psoriasis (64).

7. Emerging Therapies and Future Directions in Psoriasis Treatment

More focused treatments for psoriasis have been developed as a result of improvements in our understanding of the immunological systems underlying the condition. Even though biologics have completely changed the therapeutic landscape, research is still being done on novel approaches that provide better long-term disease control, safety, and efficacy. Novel biologics, small compounds, and personalized medicine techniques are examples of emerging therapeutics that seek to overcome the drawbacks of current therapy and offer patients with unmet needs new options (65).

7.1. Janus Kinase (JAK) Inhibitors

Inhibitors of JAK inhibit Janus kinase enzymes, which are linked to cytokine signaling pathways that contribute to inflammation in psoriasis. Studies are being conducted to determine whether oral JAK inhibitors, such as upadacitinib and tofacitinib, can reduce psoriatic inflammation. They could serve as an alternative for those who are allergic to biologics. An increased risk of infections and cardiovascular issues are among the side effects that have prompted cautious regulatory approval and ongoing monitoring (66).

7.2. Future Directions

The development of immune-targeting treatments and the investigation of novel mechanisms of action are key to the future of psoriasis treatment. Combination treatments that target several pathways at once and use both small molecules and biologics may be more effective (67). Future treatment options are also being investigated, including gene therapy and CRISPR-based strategies. These tactics may make it possible to modify immune responses more precisely at the genetic level, potentially leading to long-term, possibly even curative, treatments (68).

8. Conclusion

Dysregulated immune responses, specifically those involving the IL-23/IL-17 axis, are the primary cause of psoriasis, a complicated immune-mediated illness. As our knowledge of its pathogenesis has grown, highly focused biologic treatments that effectively regulate inflammation and keratinocyte hyperproliferation have been developed (69). For patients with different treatment demands, emerging therapies such as small molecules and personalized medicine approaches provide potential alternatives. In order to improve patient outcomes and quality of life, ongoing research attempts to improve current medications, identify new therapeutic targets, and investigate long-term approaches to managing psoriasis (70).

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Bu J, Ding R, Zhou L, Chen X, Shen E. Epidemiology of psoriasis and comorbid diseases: a narrative review. Frontiers in immunology. 2022 Jun 10;13:880201.

[2] Singh A, Schurman SH, Bektas A, Kaileh M, Roy R, Wilson DM, Sen R, Ferrucci L. Aging and inflammation. Cold Spring Harbor Perspectives in Medicine. 2024 Jun 1;14(6):a041197.

[3] Daniel BS. The multiple comorbidities of psoriasis: The importance of a holistic approach. Australian Journal of General Practice. 2020 Jul;49(7):433-7.

[4] Lee HJ, Kim M. Challenges and future trends in the treatment of psoriasis. International journal of molecular sciences. 2023 Aug 28;24(17):13313.

[5] Vičić M, Kaštelan M, Brajac I, Sotošek V, Massari LP. Current concepts of psoriasis immunopathogenesis. International Journal of Molecular Sciences. 2021 Oct 26;22(21):11574.

[6] El-Howati A, Thornhill MH, Colley HE, Murdoch C. Immune mechanisms in oral lichen planus. Oral diseases. 2023 May;29(4):1400-15.

[7] Yang JS, Liu TY, Lu HF, Tsai SC, Liao WL, Chiu YJ, Wang YW, Tsai FJ. Genome-wide association study and polygenic risk scores predict psoriasis and its shared phenotypes in Taiwan. Molecular Medicine Reports. 2024 Jul 1;30(1):1-22.

[8] Münzel T, Hahad O, Sørensen M, Lelieveld J, Duerr GD, Nieuwenhuijsen M, Daiber A. Environmental risk factors and cardiovascular diseases: a comprehensive expert review. Cardiovascular research. 2022 Oct 1;118(14):2880-902.

[9] Mane RV, Bais SK. Psoriasis: A Comprehensive review on Clinical Features, Diagnosis and Treatment.

[10] Campanati A, Marani A, Martina E, Diotallevi F, Radi G, Offidani A. Psoriasis as an immune-mediated and inflammatory systemic disease: from pathophysiology to novel therapeutic approaches. Biomedicines. 2021 Oct 21;9(11):1511.

[11] Siboni C. *Treatment options for moderate to severe psoriasis* (Doctoral dissertation, University of Zagreb. School of Medicine).

[12] Kaur R, Bhardwaj A, Gupta S. Cancer treatment therapies: traditional to modern approaches to combat cancers. Molecular biology reports. 2023 Nov;50(11):9663-76.

[13] Sharma A, Upadhyay DK, Gupta GD, Narang RK, Rai VK. IL-23/Th17 axis: a potential therapeutic target of psoriasis. Current Drug Research Reviews Formerly: Current Drug Abuse Reviews. 2022 Mar 1;14(1):24-36.

[14] Timis TL, Florian IA, Vesa SC, Mitrea DR, Orasan RI. An updated guide in the management of psoriasis for every practitioner. International Journal of Clinical Practice. 2021 Aug;75(8):e14290.

[15] Cutroneo PM, Arzenton E, Furci F, Scapini F, Bulzomì M, Luxi N, Caminati M, Senna G, Moretti U, Trifirò G. Safety of biological therapies for severe asthma: An analysis of suspected adverse reactions reported in the WHO pharmacovigilance database. BioDrugs. 2024 May;38(3):425-48.

[16] Pinto MV, Neves JF. Precision medicine: The use of tailored therapy in primary immunodeficiencies. Frontiers in immunology. 2022 Dec 8;13:1029560.

[17] Tavakoli P, Vollmer-Conna U, Hadzi-Pavlovic D, Grimm MC. A review of inflammatory bowel disease: a model of microbial, immune and neuropsychological integration. Public health reviews. 2021 May 5;42:1603990.

[18] Boufenghour W. *Development of in vivo and in vitro models of acne inversa* (Doctoral dissertation, Université de Strasbourg).

[19] Schön MP, Wilsmann-Theis D. Current developments and perspectives in psoriasis. JDDG: Journal der Deutschen Dermatologischen Gesellschaft. 2023 Apr;21(4):363-72.

[20] Sierawska O, Małkowska P, Taskin C, Hrynkiewicz R, Mertowska P, Grywalska E, Korzeniowski T, Torres K, Surowiecka A, Niedźwiedzka-Rystwej P, Strużyna J. Innate immune system response to burn damage—focus on cytokine alteration. International journal of molecular sciences. 2022 Jan 10;23(2):716.

[21] Vičić M, Kaštelan M, Brajac I, Sotošek V, Massari LP. Current concepts of psoriasis immunopathogenesis. International Journal of Molecular Sciences. 2021 Oct 26;22(21):11574.

[22] Akhter S, Tasnin FM, Islam MN, Rauf A, Mitra S, Emran TB, Alhumaydhi FA, Ahmed Khalil A, Aljohani AS, Al Abdulmonem W, Thiruvengadam M. Role of Th17 and IL-17 Cytokines on Inflammatory and Auto-immune Diseases. Current Pharmaceutical Design. 2023 Jul 1;29(26):2078-90.

[23] Stober CB, Ellis L, Goodall JC, Veldhoen M, Gaston JH. Metabolic Stress Expands Polyfunctional, Proinflammatory Th17 Cells in Patients With Psoriatic Arthritis for Whom There is Interleukin-23–Independent Interleukin-17 Production. Arthritis & Rheumatology. 2025 Feb 8.

[24] Prados-Carmona A, Navarro-Triviño FJ, Ruiz-Villaverde R, Corell A. Role of interleukins in dermatology: Exploring the immune mechanisms in skin diseases. JEADV Clinical Practice. 2024 Dec;3(5):1381-98.

[25] Lin CY, Lin ZC, Chang YT, Lin TJ, Fang JY. Novel strategies in topical delivery for psoriasis treatment: nanocarriers and energy-driven approaches. Expert Opinion on Drug Delivery. 2025 Apr 3(just-accepted).

[26] Ramchandani M, Goyal AK. Integrating omics data for personalized medicine in treating psoriasis. Medicinal Chemistry Research. 2024 Nov 27:1-7.

[27] Luo L. Deciphering the complexity of psoriasis: non-coding RNAs and cellular interactions. Karolinska Institutet (Sweden); 2023.

[28] Khan MA. HLA-B* 27 and ankylosing spondylitis: 50 years of insights and discoveries. Current Rheumatology Reports. 2023 Dec;25(12):327-40.

[29] Liu S, He M, Jiang J, Duan X, Chai B, Zhang J, Tao Q, Chen H. Triggers for the onset and recurrence of psoriasis: a review and update. Cell Communication and Signaling. 2024 Feb 12;22(1):108.

[30] Morgan E, Delaney D, Fairchild JK. Age-Related Illnesses. Psychology of Aging: A Biopsychosocial Perspective. 2024 Oct 16:74.

[31] Akhter S, Tasnin FM, Islam MN, Rauf A, Mitra S, Emran TB, Alhumaydhi FA, Ahmed Khalil A, Aljohani AS, Al Abdulmonem W, Thiruvengadam M. Role of Th17 and IL-17 Cytokines on Inflammatory and Auto-immune Diseases. Current Pharmaceutical Design. 2023 Jul 1;29(26):2078-90.

[32] Orlando G. Molecular and Cellular Profiling of Psoriatic Scar: Exploring Early vs Late Intervention.

[33] Campanati A, Marani A, Martina E, Diotallevi F, Radi G, Offidani A. Psoriasis as an immune-mediated and inflammatory systemic disease: from pathophysiology to novel therapeutic approaches. Biomedicines. 2021 Oct 21;9(11):1511.

[34] Orsmond A, Bereza-Malcolm L, Lynch T, March L, Xue M. Skin barrier dysregulation in psoriasis. International journal of molecular sciences. 2021 Oct 7;22(19):10841.

[35] Antal D, Alimohammadi S, Bai P, Szöllősi AG, Szántó M. Antigen-presenting cells in psoriasis. Life. 2022 Feb 3;12(2):234.

[36] Wu M, Dai C, Zeng F. Cellular mechanisms of psoriasis pathogenesis: a systemic review. Clinical, cosmetic and investigational dermatology. 2023 Dec 31:2503-15.

[37] Shi W, Yao X, Fu Y, Wang Y. Interferon-α and its effects on cancer cell apoptosis. Oncology letters. 2022 May 30;24(1):235.

[38] Schinocca C, Rizzo C, Fasano S, Grasso G, La Barbera L, Ciccia F, Guggino G. Role of the IL-23/IL-17 pathway in rheumatic diseases: an overview. Frontiers in immunology. 2021 Feb 22;12:637829.

[39] Coletto LA, Rizzo C, Guggino G, Caporali R, Alivernini S, D'Agostino MA. The role of neutrophils in spondyloarthritis: A journey across the spectrum of disease manifestations. International Journal of Molecular Sciences. 2023 Feb 18;24(4):4108.

[40] Keskin S, AÇIKGÖZ E. Role of Keratinocytes and Immune Cells as Key Actors in Psoriasis. International Research and Reviews in Health Sciences. 2023 Dec:201.

[41] Rosi E, Fastame MT, Scandagli I, Di Cesare A, Ricceri F, Pimpinelli N, Prignano F. Insights into the Pathogenesis of HS and Therapeutical Approaches. Biomedicines. 2021 Sep 6;9(9):1168.

[42] Sharma A, Upadhyay DK, Gupta GD, Narang RK, Rai VK. IL-23/Th17 axis: a potential therapeutic target of psoriasis. Current Drug Research Reviews Formerly: Current Drug Abuse Reviews. 2022 Mar 1;14(1):24-36.

[43] Zhou X, Chen Y, Cui L, Shi Y, Guo C. Advances in the pathogenesis of psoriasis: from keratinocyte perspective. Cell death & disease. 2022 Jan 24;13(1):81.

[44] Jiang Q, Yang G, Xiao F, Xie J, Wang S, Lu L, Cui D. Role of Th22 cells in the pathogenesis of autoimmune diseases. Frontiers in immunology. 2021 Jul 6;12:688066.

[45] Singh R, Koppu S, Perche PO, Feldman SR. The cytokine mediated molecular pathophysiology of psoriasis and its clinical implications. International journal of molecular sciences. 2021 Nov 26;22(23):12793.

[46] Mallick S, Duttaroy AK, Bose B. A Snapshot of Cytokine Dynamics: A Fine Balance Between Health and Disease. Journal of Cellular Biochemistry. 2025 Jan;126(1):e30680.

[47] Rusiñol L, Puig L. A Narrative Review of the IL-18 and IL-37 Implications in the Pathogenesis of Atopic Dermatitis and Psoriasis: Prospective Treatment Targets. International journal of molecular sciences. 2024 Aug 2;25(15):8437.

[48] Li Y, Li Z, Nandakumar KS, Holmdahl R. Human NCF190H Variant Promotes IL-23/IL-17—Dependent Mannan-Induced Psoriasis and Psoriatic Arthritis. Antioxidants. 2023 Jun 27;12(7):1348.

[49] Mosca M, Hong J, Hadeler E, Hakimi M, Liao W, Bhutani T. The role of IL-17 cytokines in psoriasis. ImmunoTargets and therapy. 2021 Nov 24:409-18.

[50] Jarczak D, Nierhaus A. Cytokine storm—definition, causes, and implications. International journal of molecular sciences. 2022 Oct 3;23(19):11740.

[51] Sharma M, Pal P, Gupta SK. Microglial mediators in autoimmune Uveitis: Bridging neuroprotection and neurotoxicity. International immunopharmacology. 2024 Jul 30;136:112309.

[52] Li J, Zhou Y, Ma J, Zhang Q, Shao J, Liang S, Yu Y, Li W, Wang C. The long-term health outcomes, pathophysiological mechanisms and multidisciplinary management of long COVID. Signal transduction and targeted therapy. 2023 Nov 1;8(1):416.

[53] Nagar N, Poswal RK, Kumar A, Singhal K. Homoeopathic medicine Arsenic album 200C in treatment of plaque psoriasis: A case report. Indian Journal of Research in Homoeopathy. 2024;18(2):118-26.

[54] Crisan D, Crisan M. Dermatologic Concepts and Terminology. InTextbook of Dermatologic Ultrasound 2022 Dec 14 (pp. 21-72). Cham: Springer International Publishing.

[55] Crisan D, Crisan M. Dermatologic Concepts and Terminology. InTextbook of Dermatologic Ultrasound 2022 Dec 14 (pp. 21-72). Cham: Springer International Publishing.

[56] Merola JF, Amin AZ. Exploring the Clinical Presentation, Course, and Burden of Disease in Generalized Pustular Psoriasis [Podcast]. Clinical, Cosmetic and Investigational Dermatology. 2024 Dec 31:539-45.

[57] Graça A, Martins AM, Ribeiro HM, Marques Marto J. Indirect consequences of coronavirus disease 2019: skin lesions caused by the frequent hand sanitation and use of personal protective equipment and strategies for their prevention. The Journal of Dermatology. 2022 Sep;49(9):805-17.

[58] Ji C, Wang H, Bao C, Zhang L, Ruan S, Zhang J, Gong T, Cheng B. Challenge of nail psoriasis: an update review. Clinical Reviews in Allergy & Immunology. 2021 Dec 1:1-26.

[59] Kishimoto M, Deshpande GA, Fukuoka K, Kawakami T, Ikegaya N, Kawashima S, Komagata Y, Kaname S. Clinical features of psoriatic arthritis. Best Practice & Research Clinical Rheumatology. 2021 Jun 1;35(2):101670.

[60] Weber B, Merola JF, Husni ME, Di Carli M, Berger JS, Garshick MS. Psoriasis and cardiovascular disease: novel mechanisms and evolving therapeutics. Current atherosclerosis reports. 2021 Nov;23:1-1.

[61] Campanati A, Marani A, Martina E, Diotallevi F, Radi G, Offidani A. Psoriasis as an immune-mediated and inflammatory systemic disease: from pathophysiology to novel therapeutic approaches. Biomedicines. 2021 Oct 21;9(11):1511.

[62] Muth KN, Rech J, Losch FO, Hoerning A. Reversing the inflammatory process—25 years of tumor necrosis factor-α inhibitors. Journal of Clinical Medicine. 2023 Jul 31;12(15):5039.

[63] Mohd Noor AA, Azlan M, Mohd Redzwan N. Orchestrated cytokines mediated by biologics in psoriasis and its mechanisms of action. Biomedicines. 2022 Feb 20;10(2):498.

[64] Bagel J. Treatment strategies, management of comorbidities, and the role of IL-23 inhibitors in moderate to severe psoriasis. American Journal of Managed Care. 2021 Jun 3;27.

[65] Hernández AF, Calina D, Poulas K, Docea AO, Tsatsakis AM. Safety of COVID-19 vaccines administered in the EU: Should we be concerned?. Toxicology reports. 2021 Jan 1;8:871-9.

[66] Barbieri MA. Management of patients with inflammatory bowel diseases: evaluating effectiveness, safety, and drug repurposing strategies.

[67] Strzelec M, Detka J, Mieszczak P, Sobocińska MK, Majka M. Immunomodulation—a general review of the current state-of-the-art and new therapeutic strategies for targeting the immune system. Frontiers in Immunology. 2023 Mar 9;14:1127704.

[68] Engelen SE, Robinson AJ, Zurke YX, Monaco C. Therapeutic strategies targeting inflammation and immunity in atherosclerosis: how to proceed?. Nature Reviews Cardiology. 2022 Aug;19(8):522-42.

[69] Matar DY, Ng B, Darwish O, Wu M, Orgill DP, Panayi AC. Skin inflammation with a focus on wound healing. Advances in Wound Care. 2023 May 1;12(5):269-87.

[70] Lee HJ, Kim M. Challenges and future trends in the treatment of psoriasis. International journal of molecular sciences. 2023 Aug 28;24(17):13313.