WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.453
Volume 15, Issue 3, 250-263. Review Article ISSN 2277–7105

IMMUNE SYSTEM MODULATION: THE ROLES OF LEUKOCYTES, VITAMIN D, PLANT EXTRACTS, NANOTECHNOLOGY, AND BIOMARKERS IN DISEASE AND HEALTH

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Article Received on 25 Dec. 2025,
Article Revised on 15 Jan. 2026,
Article Published on 01 Feb. 2026,

https://doi.org/10.5281/zenodo.18427459

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How to cite this Article: Ahmed Farhan Shallal (2026). Immune System Modulation: The Roles of Leukocytes, Vitamin D, Plant Extracts, Nanotechnology, and Biomarkers in Disease and Health. World Journal of Pharmaceutical Research, 15(3), 250–263.

ABSTRACT

This document performs a thorough examination of the processes through which various biological substances and therapeutic approaches affect the dynamics of the immune system, highlighting their essential role in disease prevention and health enhancement. The study clarifies the key correlation between white blood cells, vitamin D, plant-based chemical agents, and progress in nano-engineering for boosting immune function and health effects. The constant adaptation of harmful microbes against regular antibiotics signals an essential demand to investigate different treatment avenues, particularly those involving plant-based immunomodulatory compounds. Explorations in the field of science point to the possibilities offered by bioactive components from flora such as Quercus, Quercus gall, and Mentha in strengthening immune protections. In addition, it looks into the vital importance of preserving appropriate vitamin D amounts for the adjustment of immune activities and stresses the impact of dietary aspects on immune control. Besides, the inquiry reveals the key significance of ensuring sufficient vitamin D levels in shaping immune reactions, along with the expected ramifications of dietary adjustments on immune supervision. In addition, the field of nanotechnology is emerging as a groundbreaking advancement that holds considerable promise in both healthcare like drug administration and tissue fabrication and agricultural

chemicals. This inquiry aspires to clarify the associations between multiple lifestyle choices and their consequences for immune system resilience, factoring in things like smoking tendencies, blood thinner application, and genetic attributes. Through the unification of data sourced from different research articles, this manuscript aspires to illuminate the intricate dynamics of immunomodulatory elements contributing to stronger immune function and disease avoidance. An interaction underscores the critical necessity for collaborative efforts in augmenting our immune capabilities through the modification of our daily practices, dietary habits, and advanced knowledge.

KEYWORDS: Immune modulation, Health, leukocytes and vitamin D, plant extracts, antibacterial, genetics tools, nanoparticles

1. INTRODUCTION

An essential impact of immunological and chemical aspects in exploring health-related topics, mainly about inflammation, immune dynamics, and metabolic activities.[1] The term immunomodulators covers aspects that can change immune activity, arising from external inputs as well as internally generated substances.[2] In the field of immunology, this immunomodulator is deemed pivotal for its categorization and can be distinctly classified into immunostimulants, immunoadjuvants, or immunosuppressants. Empirical research indicates that immunostimulants have the potential to enhance the immune system's defensive mechanisms against pathogenic microorganisms, generally operating through a process that demonstrates significant efficacy. When both the innate and adaptive immune systems are triggered, these factors might produce enhanced results.[3] The organization of the human figure comprises two essential sections that support its protective frameworks: innate immunity and adaptive immunity. Besides, every main category is fragmented into distinct branches, particularly as it pertains to cellular and humoral immune relationships.[4] The immune defense system serves as a protective barrier, chiefly altering its functions to oppose the adverse consequences brought about by numerous pathogens. The body's defense mechanism operates through the collaborative efforts of leukocytes in conjunction with various auxiliary cells distributed throughout the organism, with a pronounced concentration in lymphatic regions.[5] The resistance to antibiotics grows among bacteria, pinpointing alternative antibiotic sources is imperative for managing infections effectively. Amid the countless natural entities, plants reveal striking antibacterial qualities, resulting from their bioactive elements that can obstruct bacterial growth. An examination took place on the

antibacterial capabilities of extracts taken from oak and oak galls. The study's conclusions revealed that extracts derived from oak and oak galls can significantly obstruct the development of several harmful bacterial species. Abundant in elements like flavonoids and tannins, oak demonstrates qualities that counteract bacterial activity. Traditional healing methods have incorporated these agents to address many infectious difficulties.[6] The significance of mint extract on the harmful bacteria was rigorously assessed. The mint, concentrating on its menthol feature, demonstrated considerable potency in combating numerous bacterial species. The mint was considered precious for its considerable health perks, especially tied to respiratory and gut problems. The study illuminated the properties that combat bacterial organisms, particularly in relation to Gram-negative species.[7] The considerable influence of the pandemic on the regional healthcare infrastructure is noteworthy. Findings showed a link between how often infections occur and different social and environmental influences. Although the emphasis was predominantly on prophylaxis and therapeutic interventions, the research also underscored the necessity for additional investigation into the interplay between viral and bacterial pathogens, particularly in contexts of co-infection scenarios.[8] The expanded array of evidence, the linkage of blood flow rates to the outcomes of dialysis and its concomitant complications, was assessed by means of both low- and high-flux membranes. The results suggest that a reduction in blood flow rates might raise the risk of bacterial infections resulting from toxin buildup within the vascular system, thus accentuating the immediate necessity to advance dialysis strategies to counter these risks.[9] The alterations in inflammatory indicators and biochemical parameters are associated with tobacco consumption among males. Research has demonstrated that smoking markedly boosts the levels of designated inflammatory compounds, which later impair the immune response and enhance the risk to both bacterial and viral invaders.[10] This document thoroughly explores various studies that delve into how well plant-based extracts combat bacteria. In addition, the roles played by immune system components, the alteration of immune responses, the value of nanoparticles, the imperative necessity for the reduction of smoking patterns and food choices, together with the effects of nanotechnology in both agricultural and medical fields. with a specific emphasis on their impacts on the dynamics of the immune system, advancements in tissue engineering, strategies for preventive health, and comprehensive well-being.

2. Importance and types of immunomodulation

An immunomodulator comprises several varieties such as immunostimulants, immunoadjuvants, and immunosuppressants, and is categorized within certain groups.[11] Experts suggest that immunostimulants can increase the immune response to pathogens, usually defined by their nonspecific operational mechanisms. There is an opportunity to draw on both biological and tailored immune responses to elevate their efficiency. In persons with an impaired immune system, these substances are crafted to function as treatments that adjust immune activity.[12] The function of immunoadjuvants is understood to be that of specific immune system enhancers, used to elevate the success of vaccination programs. In healthcare, pharmaceutical interventions that reduce immune system responses are chiefly intended to stop organ transplant rejection and manage autoimmune disorders. Furthermore, these agents are often administered concomitantly, akin to the principles of multidrug therapy[13] as delineated in Table 1.[1-3]

Table 1: Types and actions of immunomodulation.

No.	Type of Immunomodulator	Immunological role	Cases
1	Immunosuppressive	Suppressing immune responses	Autoimmune disease such as Rheumatoid arthritis
2	Immunostimulatory	Enhancing the immune responses	Immunotherapy
3	Mixed Immunomodulators	Modify the immune responses	Some types of cancer and autoimmune diseases.
4	Topical Immunomodulators	Reducing the immune responses	Some skin inflammations.

3. Immunomodulatory evidences

1. Immune Pathways and Biomarkers

A broad evaluation was done to explore the regulatory influences on immune pathways alongside relevant biomarkers, elucidating the effects of lifestyle choices, dietary considerations, and therapeutic methods on immune effectiveness. The analysis brought to light the principle that shifts in lifestyle, including upgraded nutrition and steady physical training, can dramatically influence immune reactions and corresponding biomarkers, thereby encouraging improved health benefits. Methods aimed at regulating immune functions are essential for influencing the ways in which the immune system tackles different health concerns.[1]

2. Leukocytes

Leukocytes are essential for overseeing and preventing viral sicknesses. The analysis indicated that encouraging the immune response to expand the leukocyte count may support the organism's effectiveness in combating infections. This instance represents a major factor in the domain of viral disorders, where the engagement of the immune mechanism is imperative for supporting useful treatments. The study reveals the potential upsides of raising leukocyte populations as a beneficial pathway for addressing certain viral infections.[14]

3. Vitamin D

Vitamin D levels have a notable link to how the immune system operates, especially for individual men. Acknowledged for its significant influence on immune function, deficiencies in vitamin D can notably diminish immune capacity. It was shown in the report that inadequate vitamin D availability resulted in lower immune resistance, making people more vulnerable to several infections. The suggestion highlights that having enough vitamin D is key for a dynamic immune system and could potentially bolster the body's ability to combat various harmful bacteria.[15]

4. Diet

The importance of food consumption styles in the governance of immune and metabolic elements is noteworthy. Sufficient nutrition is key for ensuring an effective immune response, and this research highlighted how nutritional changes can alter immune efficiency and metabolic operations. The results demonstrate that a unified nutritional strategy could improve and bolster immune responses and diminish the likelihood of metabolic disorders. Thus, substantiating the development of dietary recommendations aimed at enhancing all aspects of health.[4]

5. Anticoagulants and Immune Modulation

In addition to leukocytes and vitamin D, several variables, such as the provision of anticoagulants, can significantly alter immune capabilities. The assessment of the link between various forms of anticoagulants and the period of storage on the erythrocyte sedimentation rate (ESR), which functions as a fundamental biomarker for inflammation in the human organism, deserves comprehensive scrutiny. The report clarified that anticoagulant agents can alter immune markers and the inflammatory response, which is significant for grasping how therapeutic interventions for coagulopathies may concurrently impact immune system health.[16]

6. Smoking and Immune Health

Recognizing the importance of lifestyle influences on our immune wellness is essential. A study referenced in[17] reveals how often university students engage in hookah smoking (shisha). The findings elucidated that tobacco consumption can exert adverse influences on immune system functionality, as it is well-established that it compromises pulmonary performance and intensifies inflammatory mechanisms, thereby rendering individuals more susceptible to respiratory pathogens.

7. Genetic Factors and Hemophilia

Genetic determinants that could modulate immune responses. The investigation entailed the genotyping of intron 1 and the 22 inversion of the factor VIII gene among Kurdish patients residing in Iraq, thereby elucidating the genetic foundations of hemophilia. These revelations have important consequences for understanding how genetic anomalies could influence both blood clotting and immune responses, offering possible pathways for new therapies for genetic hematological conditions.[18]

8. Anemia and Immune System Health

Anemia represents an additional pathological condition that may profoundly influence immune functionality. A research investigation conducted by[19] examined the incidence of anemia within the pediatric population of the Ranya District located in the Kurdistan Region. The existence of anemia resulting from iron deficiency may hinder the efficacy of the immune system, consequently increasing vulnerability to infections. The analysis pointed out the essential role of fixing nutritional shortages to better immune capabilities, especially within susceptible communities, including young children.

9. Immunomodulatory Pathways in Renal Failure

People who go through extended dialysis notice changes in how well their immune system functions. Chronic kidney disease patients see pronounced transformations in blood-related figures and electrolyte readings as a consequence of dialysis. The results revealed that dialysis influences immune responses by modifying leukocyte levels and different immunological cues, underscoring the significance of evaluating immune capabilities in patients on dialysis to lower infection hazards.[20] Immunomodulatory mechanisms in patients experiencing renal insufficiency, a pathological state that profoundly influences immune functionality. The examination revealed the effect chronic kidney disease (CKD) has on immune biomarkers and the regulatory frameworks of the immune system. These revelations

emphasize the utmost necessity of assessing immune abilities in CKD individuals and probing into new therapeutic routes that aim to bring back immune balance.[2]

10. Immune Modulation during Pregnancy

The state of being pregnant involves major transformations in immune capabilities. One must take into account the transformations in immune response throughout pregnancy, especially in how hormonal variations linked to gestation can affect immune system reactions. The research underscored the imperative of comprehending these alterations to avert complications, including infections, and to safeguard the health of both the mother and the fetus.[21]

11. Immunomodulatory Effects of *Ganoderma lucidum*

An investigation mentioned in[3] delved into the immune-regulatory aspects of *Ganoderma lucidum*, a widely recognized medicinal fungus; it assessed the impact of *Ganoderma lucidum* on Natural Killer (NK) cells, essential for the immune system. The evidence shows that *Ganoderma lucidum* has substantial potential as an agent for immunotherapy, merging the old applications with new approaches in immune treatment. The analysis augments the expanding repository of evidence that illustrates the therapeutic roles of fungi in the alteration of immune responses.

12. Immunological and Biochemical Markers in Rats

The assessment of variations in immune system and biochemical metrics in Rattus norvegicus was conducted across various lifestyle scenarios. This analysis reveals important considerations regarding how lifestyle elements, like dietary practices and physical activity, can affect immune performance and disease advancement. Assessing the variations may enhance the formulation of more efficient health interventions for individuals, notably in relation to minimizing immune system impairments connected to lifestyle choices.[22]

13. Sperm DNA fragmentation and Immunological Aspects

The evaluation of sperm DNA integrity and the immunological aspects in males facing infertility. The issue of infertility is becoming more urgent, and comprehending how immune factors influence sperm quality is crucial for fostering more effective therapeutic strategies. Findings imply that ensuring the preservation of sperm DNA is essential in the fight against male infertility, with anomalies in the immune system potentially worsening the condition. Analyzing these significant indicators provides an occasion to improve our approaches

toward recognizing and addressing infertility, thereby encouraging the development of progressive practices in reproductive healthcare frameworks.[23]

14. Immuno-Physiological and Reproductive Disorders

A detailed study explored the immune and physiological characteristics of markers in individuals facing challenges with reproductive health. The analysis pointed out the vital necessity of biomarkers for the interpretation and diagnosis of immune system complications that affect reproductive health. The immunological elements that influence reproductive dysfunctions: this analysis promotes the refinement of more effective therapeutic measures and interventions for individuals suffering from infertility or various reproductive complications.[24]

15. Genetic and Epigenetic Markers and molecular tools

The epigenetic and genetic relationships pertaining to Hashimoto's thyroiditis, a situation that threatens the thyroid gland. The analysis revealed the critical nature of genetic risks and epigenetic shifts in the formation of this disease, thereby presenting original ideas about its emergence and feasible therapeutic interventions. Prompt detection of these markers might aid in refining management methods and therapeutic options for patients experiencing Hashimoto's thyroiditis.[25] In addition, a scholarly study into the realm of genetics assessed genomic approaches for the acquisition and analysis of chromosomes, emphasizing key techniques in modern genetic studies. Thus, understanding genetic hurdles and crafting personalized treatment strategies relies significantly on these methods. A review shows a crucial role of chromosome analysis in revealing genetic obstacles and adapting treatment plans tailored to individual genetic characteristics.[26]

16. Role of extended-spectrum beta-lactamases (ESBL)

The multifaceted role of extended-spectrum beta-lactamases (ESBL) in the context of bacterial resistance was examined, highlighting that ESBL-producing organisms pose a considerable challenge to antimicrobial efforts; this study revealed the manner in which the morphological features of these bacteria bolster their resistance to antibacterial substances. Recognizing these variables is fundamental for the creation of superior antibiotic treatment models and for combating infections instigated by resistant bacterial species.[27]

17. Prevalence of Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

The research furnished essential information during the initial phases of the pandemic. The examination revealed how COVID-19 propagates in the local area and accentuated the pressing necessity for health interventions to alleviate the virus. Undertaking these explorations is vital for exposing the nuances of viral infections and for measuring the success of different intervention tactics in multiple regions.[28] The incidence and contributing factors of COVID-19 within the Raparin administrative district of Iraq. This study yielded significant understanding regarding the socio-demographic and environmental variables that impacted the dissemination of the virus in this locality. By comprehending these determinants, public health interventions may be enhanced to avert prospective outbreaks and alleviate the repercussions of pandemics.[29]

18. Iron Deficiency and Female Athletes

The incidence and contributing factors of iron deficiency in female athletes within Sulaymaniyah, Kurdistan-Iraq. It has been revealed that iron shortage is a widespread challenge for athletes, notably for female athletes, which could detrimentally influence their performance and general health. This analysis underlines the vital necessity for effective nutrition tactics and persistent evaluations of iron status to aid athletes' holistic health and productivity.[30,31]

19. Chemotherapy-Induced Anemia

The concern of anemia stemming from chemotherapy, recognized as a substantial negative aspect of oncological interventions, plays a pivotal role in the decline of immune health. The research investigated the prevalence and therapeutic interventions for this ailment in the adult population, underscoring the imperative for efficacious management strategies aimed at enhancing the quality of life for patients undergoing chemotherapy. The study underscores the critical significance of tackling anemia in individuals diagnosed with cancer to facilitate improved prognoses throughout the course of therapy.[32]

4. Biomedical importance of Nanoparticles

Regarded as a revolutionary area, nanotechnology has appeared with crucial effects for multiple fields, notably agriculture and healthcare. The many developments in nanotechnology-augmented pharmaceutical distribution methods have opened up remarkable avenues for confronting both health-related and ecological concerns.[33]

1. Uses

The complexities and risks are linked to the application of nanotechnology within the agricultural sector. The innovation of nanotechnology within the agricultural sector grants several advantages, featuring enhanced pest control strategies, fortified crop safety, and efficient nutrient supply mechanisms. However, there are notable difficulties linked to its ecological ramifications, possible unfavorable results, and the demand for legal systems to ensure safe incorporation into agricultural techniques. The inquiry stresses the urgent need for additional research on these subjects to better harness the benefits of nanotechnology while minimizing the risks involved.[34]

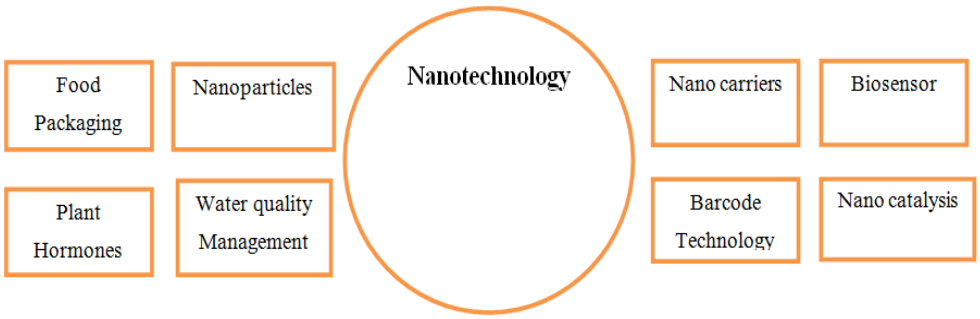

Figure 1: Utilizations of nanotechnology in the field of agriculture.

2. Nanotechnology in bone tissue engineering

The prospects of nanotechnology-driven pharmaceutical delivery mechanisms within the realm of bone tissue engineering. The innovation of nanotechnology allows for the precise application of pharmaceutical materials and healing compounds to bone tissue, which boosts the rate and success of the recovery process. This system demonstrates considerable potential for the treatment of bone injuries, osteoporosis, and various skeletal disorders. An application of nanoparticles provides practitioners with the opportunity to boost the bioactivity of bone scaffolds and enhance tissue healing, a transformation that has the potential to influence therapeutic measures for bone conditions.[35]

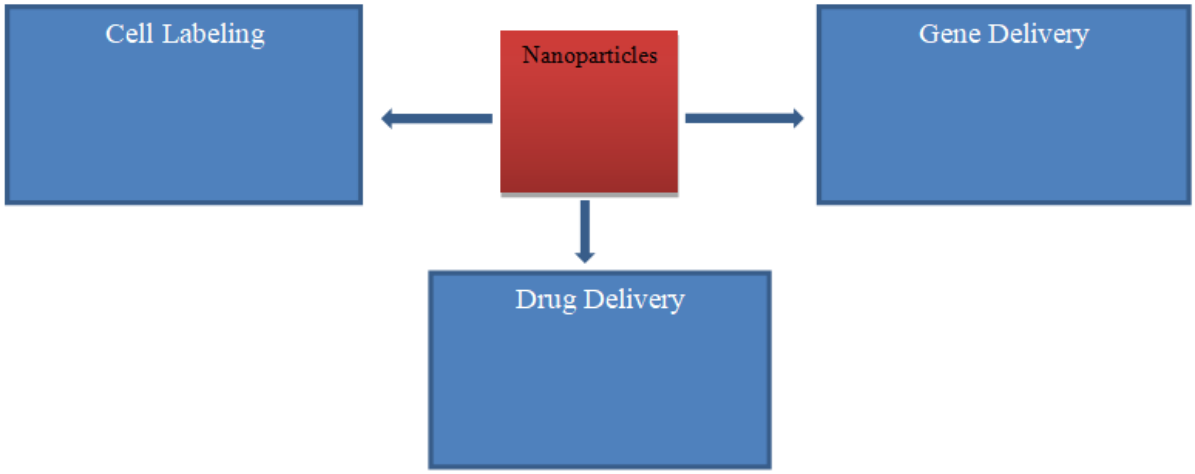

Figure 2: Applications of nanoparticles in bones.

CONCLUSION

At the conclusion, the elaborate links between immune system adjustments, pertinent influencing aspects, and therapeutic methods emphasize the essential role of related immunological and biochemical indicators in health preservation and disease prevention. The ongoing investigation of immune-modulating agents, which includes leukocytes, vitamin D, phytochemical extracts, and, importantly, nanotechnology, reveals considerable promise for augmenting immune responses and addressing infections in light of the growing issue of antibiotic resistance. Using botanical specimens, like Quercus species, oak galls, and Mentha-derived extracts, has illustrated noteworthy antibacterial agents, backing the claim that natural products may act effectively as replacements for typical antibiotics. The previously outlined components, in combination with the immune-modulating benefits of vitamin D intake and the supply of a nutritionally comprehensive diet, clarify the significance of developing a resilient immune system to address infections and several chronic ailments. The integration of nanotechnology across various sectors like drug conveyance methods, tissue production, and farming practices unveils notable chances for the progress of treatment techniques in medical science and public health. Furthermore, lifestyle-associated determinants such as tobacco usage or the administration of anticoagulant therapy, in addition to hereditary susceptibility, distinctly play a significant role in shaping individual immune responses and the progression of diseases.

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