

Boosting Immunity in Stressful Times: Strategies and Considerations

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Abstract

In times of heightened stress, the delicate interplay between psychological stressors and the immune system assumes paramount importance in maintaining overall health and well-being. This comprehensive review delves into the intricate relationship between stress and the immune system, highlighting strategies and considerations for enhancing immune resilience during challenging periods. The paper synthesizes current literature on the physiological mechanisms through which stress impacts immune function, elucidating the pathways by which stress mediates immune responses and potentially compromises their effectiveness. Building upon this understanding, the paper delineates multifaceted strategies aimed at fortifying the immune system amidst stress-induced challenges. The paper encompasses lifestyle modifications, emphasizing the pivotal roles of nutrition, exercise, and sleep in bolstering immune function during stress. Additionally, it scrutinizes the efficacy of stress-reducing techniques, such as mindfulness practices, meditation, and social support networks, in augmenting immune resilience. Furthermore, the review assesses the impact of nutritional interventions and pharmacological approaches, presenting evidence-based insights into their potential contributions to immune health during stressful periods. Behavioral and psychological interventions are also evaluated, elucidating their role in ameliorating the effects of stress on immune function. Amidst the elucidation of strategies, the paper considers the limitations, challenges, and ethical considerations associated with interventions aimed at boosting immunity during stressful times. It advocates for an integrative approach that accounts for individual differences, ethical implications, and potential risks. In conclusion, this review provides a comprehensive compendium of evidence-based strategies and considerations to fortify the immune system amidst stressful circumstances.

Keywords: *immune cells, stress, immunity, inflammation, exercise, diets*

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Introduction

In the modern era, the omnipresence of stress has become an inescapable facet of daily life.¹ From personal challenges to global crises, the manifestations of stress exert profound influences on human health and well-being.² Amidst these stressors, the intricate relationship between psychological stress and the immune system has garnered heightened attention for its profound implications on overall health resilience.³ The immune system, a remarkable defense network, is intricately intertwined with stress pathways, making its functionality susceptible to the effects of psychological stress.⁴ Understanding this dynamic interplay is pivotal, as stress-induced alterations in immune function can render individuals more susceptible to infections, exacerbate inflammatory responses, and impede the body's ability to maintain optimal health.

This paper aims to elucidate the complex relationship between stress and the immune system while exploring a spectrum of strategies and considerations essential for bolstering immunity in times of heightened stress. By synthesizing existing research and insights across various disciplines, this review endeavors to offer a comprehensive understanding of the multifaceted approaches available to fortify the immune system amidst challenging and stressful circumstances. The exploration of strategies encompasses lifestyle modifications, nutritional interventions, pharmacological approaches, behavioral and psychological techniques, and social support mechanisms. Recognizing the significance of these strategies not only in mitigating the deleterious effects of stress on immunity but also in fostering resilience against various health challenges becomes imperative in our current societal landscape. Moreover, this paper aims to shed light on the limitations, controversies, and ethical considerations surrounding interventions aimed at augmenting immune function during stressful times. Recognizing these intricacies is crucial in devising a nuanced approach that not only enhances immune resilience but also considers individual differences and potential risks associated with different interventions.⁵ This paper sets the stage for a comprehensive analysis of the interconnectedness between stress and the immune system. By exploring diverse strategies and considerations, it aims to provide a roadmap for individuals, practitioners, and researchers seeking to navigate the terrain of stress-induced immune modulation, thereby promoting holistic health in the face of adversity.

Stress and Immune System Interaction

The interaction between stress and the immune system is a complex and bidirectional relationship that involves various physiological pathways and responses.⁶ Stress, whether acute or chronic, has been found to significantly impact the immune system's functionality, influencing its ability to defend the body against pathogens, regulate inflammation, and maintain overall health.⁷ When the body perceives stress, the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic-adrenal-medullary (SAM) axis are activated.⁸ This leads to the release of stress hormones such as cortisol, adrenaline, and noradrenaline, which can modulate immune responses.⁹ Stress can trigger an increase in pro-inflammatory cytokines and other molecules that promote inflammation.¹⁰ Chronic stress may lead to a sustained inflammatory state, contributing to various health issues linked to inflammation.¹¹ Stress can impact the distribution and activity of immune cells.¹² For instance,

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chronic stress has been associated with alterations in the number and function of immune cells like lymphocytes, natural killer cells, and macrophages, affecting their ability to mount effective immune responses.

Effects of Stress on Immune Function

Prolonged stress has been linked to a higher susceptibility to viral and bacterial infections.¹³ This susceptibility may result from compromised immune responses and decreased immune cell activity. Chronic stress may impair the body's ability to heal wounds and injuries due to altered immune cell function and prolonged inflammation.¹⁴ Stress can exacerbate existing inflammatory conditions such as asthma, arthritis, and autoimmune disorders by intensifying inflammatory responses.¹⁵ Chronic stress might accelerate aspects of immune aging, potentially affecting the body's ability to respond effectively to pathogens and vaccines, particularly in older individuals.¹⁶ Interestingly, the relationship between stress and the immune system is bidirectional.¹⁷ While stress can suppress immune function, the immune system, in turn, can influence stress responses. Immune cells produce signaling molecules that communicate with the brain, impacting stress perception and the body's stress response systems.¹⁸ Understanding the intricate interplay between stress and the immune system is crucial for developing strategies to mitigate the adverse effects of stress on health. Lifestyle modifications, stress management techniques, adequate nutrition, regular exercise, and social support are among the approaches that may help in maintaining a balanced immune response during stressful periods.

Strategies to Boost Immunity

Boosting immunity involves a multifaceted approach that encompasses various strategies aimed at supporting and strengthening the body's immune system.¹⁹ High in vitamins, minerals, and antioxidants that support immune function. Omega-3 fatty acids found in fish, nuts, and seeds can aid immune responses.²⁰ Lean meats, legumes, and dairy provide essential amino acids necessary for immune cell production.²¹ Moderate physical activity can enhance immune function by improving circulation and promoting the production of immune cells.²² Aim for 7-9 hours of quality sleep per night to support immune system repair and function. Practices like meditation, mindfulness, yoga, and deep breathing exercises can help manage stress, thereby positively impacting immune responses.²³ Limiting excessive alcohol consumption and avoiding smoking or exposure to secondhand smoke can prevent immune system suppression.²⁴ Regular handwashing and proper hygiene practices can reduce the risk of infections and support immune health.²⁵ Ensuring vaccinations are up-to-date helps the immune system recognize and fight off specific pathogens efficiently.²⁶

Strong social connections and supportive relationships contribute to overall well-being, potentially bolstering immune function.²⁷ Consultation with a healthcare professional may be beneficial for identifying potential deficiencies and determining the need for supplements such as vitamin D, vitamin C, or zinc, which can support immune health.²⁸ Obesity or being underweight can impact immune function.²⁹ Maintaining a healthy weight through balanced nutrition and exercise is

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important for immune health.³⁰ Employ stress management techniques to reduce chronic stress levels, as chronic stress can significantly impair immune function.³¹ Combining these strategies forms a holistic approach to supporting and strengthening the immune system. It's essential to adopt these practices as part of a long-term lifestyle rather than as quick fixes to enhance immune function.³² Consulting with healthcare professionals or registered dietitians can provide personalized guidance on implementing these strategies effectively.

Nutritional Interventions

Nutritional interventions play a crucial role in supporting and optimizing the immune system's function.³³ Found in citrus fruits, bell peppers, strawberries, and broccoli, vitamin C is an antioxidant that supports immune cell function.³⁴ Sunlight exposure, fortified foods, and supplements can help maintain adequate vitamin D levels, crucial for immune regulation.³⁵ Present in nuts, seeds, and spinach, vitamin E acts as an antioxidant, protecting cells from damage.³⁶ Present in meat, shellfish, nuts, and seeds, zinc supports immune cell function and helps with wound healing.³⁷ Found in Brazil nuts, fish, and whole grains, selenium is vital for immune function and acts as an antioxidant.³⁸ Found in fatty fish (salmon, mackerel), flaxseeds, and walnuts, omega-3s have anti-inflammatory properties that can support immune health.³⁹

Found in yogurt, kefir, and fermented foods, probiotics support gut health, which is closely linked to immune function.⁴⁰ Foods like garlic, onions, bananas, and whole grains contain prebiotic fibers that nourish beneficial gut bacteria.⁵¹ Foods rich in antioxidants like fruits (berries, citrus), vegetables (spinach, kale), and nuts combat oxidative stress and support immune function.⁴² Adequate protein intake from sources like lean meats, poultry, fish, legumes, and dairy is essential for the production of immune cells.⁴³ Certain herbs and spices, such as turmeric, ginger, garlic, and echinacea, possess immune-boosting properties and can be included in the diet.⁴⁴ Water and fluids support overall health and assist in proper immune function and circulation.⁴⁵ It's important to emphasize a well-balanced diet that incorporates a variety of nutrients rather than focusing solely on individual supplements.⁴⁶ A diverse and colorful plate consisting of fruits, vegetables, lean proteins, healthy fats, and whole grains ensures a broad spectrum of nutrients necessary for optimal immune health.⁴⁷ For individuals with specific dietary concerns, deficiencies, or medical conditions impacting nutrient absorption, consulting a healthcare provider or registered dietitian is recommended.⁴⁸ They can provide personalized advice on dietary adjustments or supplements to support immune health while considering individual needs and potential interactions with medications or conditions.

Pharmacological Approaches

Pharmacological approaches aimed at supporting immune health during times of stress involve the use of medications or supplements that may have a direct or indirect impact on immune function.⁴⁹ It's important to note that while certain pharmaceutical interventions may support immune responses, their use should be carefully considered under the guidance of a healthcare professional, as they may have potential side effects or interactions with other medications. Vitamin C, vitamin

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D, vitamin E, and multivitamin formulations are commonly used to bolster immune function.⁵⁰ These supplements are available over the counter and may support immune health, especially in cases of deficiencies. Zinc and selenium supplements may be used to address deficiencies and support immune cell function.⁵¹ Widely used as an herbal remedy, echinacea is believed to enhance the immune system's response to infections. Known for its potential immune-boosting properties, garlic supplements are used to support immune health. These contain live beneficial bacteria that support gut health, potentially impacting immune responses positively.⁵²

Certain medications or compounds might modulate the immune system, such as cytokine inhibitors or immune-modulating drugs used in specific autoimmune conditions.⁵³ However, these are typically prescribed for diagnosed medical conditions and not for general immune enhancement. Supplements containing antioxidants like glutathione, coenzyme Q10, or N-acetylcysteine (NAC) might be used to reduce oxidative stress and support immune health.⁵⁴ It's crucial to approach pharmacological interventions for immune support with caution. While some supplements or medications may have promising effects on immune function, their efficacy, safety, and appropriate dosages need to be carefully evaluated.⁵⁵ Moreover, individual responses and potential interactions with existing medications or underlying health conditions should be considered before initiating any pharmacological intervention. Consultation with a healthcare professional, preferably a doctor or a healthcare provider specializing in integrative or functional medicine, is recommended to assess individual needs, potential deficiencies, and the suitability of specific supplements or medications for supporting immune health during stressful periods.

Behavioral and Psychological Interventions

Behavioral and psychological interventions play a significant role in supporting immune health during stressful times.⁵⁶ These approaches focus on managing stress, improving mental well-being, and fostering a positive mindset, which can positively impact the immune system. MBSR involves mindfulness meditation, yoga, and awareness practices to reduce stress, enhance self-awareness, and promote relaxation.⁵⁷ Studies suggest that MBSR can positively influence immune function. CBT is a therapeutic approach that helps individuals recognize and modify negative thought patterns and behaviors.⁵⁸ It's effective in managing stress, anxiety, and depression, which can impact immune function. Techniques like deep breathing exercises, progressive muscle relaxation, guided imagery, and biofeedback can lower stress levels and enhance immune responses.

Strong social connections and supportive relationships have been linked to improved immune function and overall well-being.⁵⁹ Engaging with friends, family, or support groups can reduce stress and boost immunity. Practices focusing on gratitude, optimism, and resilience-building can positively affect mental health, thereby supporting immune function indirectly.⁶⁰ Participating in stress management programs or workshops that teach coping skills and relaxation techniques can improve overall resilience and immune health.⁶¹ Regular physical activity not only supports physical health but also positively impacts mental well-being, reducing stress and promoting a healthy immune system.⁶² Improving sleep quality and adopting good sleep hygiene practices can significantly impact stress levels and support immune function.⁶³ Engaging in enjoyable activities,

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hobbies, or creative pursuits can act as stress-relievers and positively impact mental health, indirectly influencing immune responses.⁶⁴ Seeking professional mental health support through counseling, therapy, or support groups can provide strategies to cope with stress and improve overall mental well-being.⁶⁵ By managing stress, improving mental health, and fostering a positive mindset through these behavioral and psychological interventions, individuals may experience a positive impact on their immune system.⁶⁶ Integrating these practices into daily life can contribute to overall resilience and support immune function during stressful times.

Considerations and Challenges

When exploring strategies to bolster immunity during stressful times, several considerations and challenges should be acknowledged and addressed to create effective interventions.⁶⁷ These considerations encompass various aspects, including limitations, ethical concerns, conflicting evidence, and potential challenges. Individuals respond differently to interventions aimed at boosting immunity. Genetic factors, existing health conditions, age, and lifestyle variations contribute to diverse responses.⁶⁸ Tailoring interventions to individual needs are essential.

Despite ongoing research, certain interventions' efficacy in enhancing immunity during stress might lack strong empirical evidence or have conflicting study results. Distinguishing between scientifically validated strategies and speculative interventions is crucial. Ethical concerns arise regarding the promotion and use of certain interventions, supplements, or treatments that lack sufficient evidence or may have potential risks. Ensuring interventions are safe, evidence-based, and ethically sound is paramount. Some interventions, especially pharmacological approaches or high-dose supplementation, may pose risks or side effects. Evaluating the safety profiles, potential interactions, and adverse effects is essential before recommending any intervention.⁶⁹

Emphasizing holistic lifestyle modifications over quick-fix solutions is vital.⁷⁰ A balanced approach that integrates nutrition, stress management, exercise, and mental well-being is more sustainable and effective than relying solely on supplements or singular interventions.⁷¹ Accessibility to certain interventions, healthy foods, supplements, or healthcare services might pose challenges for some populations. Addressing disparities in access to resources is essential for equitable immune support.⁷²⁻⁷⁶ Psychological stress and social determinants significantly impact immune health. Socioeconomic status, living conditions, and access to healthcare can influence an individual's ability to adopt immune-boosting strategies.⁷³ Misleading claims and marketing of products or interventions as "immune-boosting" without substantial evidence can lead to misconceptions and potentially harmful practices.⁷⁴ Critical evaluation of information sources is crucial. Addressing these considerations and challenges involves fostering evidence-based practices, promoting health equity, ensuring ethical guidelines are followed, and encouraging a balanced understanding of immune health interventions. Collaborative efforts between healthcare providers, researchers, policymakers, and the community are essential for developing comprehensive strategies that effectively support immune health during stressful periods.⁷⁷⁻⁸⁵

Future Directions

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Advancements in personalized medicine can lead to tailored interventions considering individual genetics, microbiome, and lifestyle factors influencing immune health.⁷⁵ Exploring the link between metabolism and immune function could unveil novel strategies targeting metabolic pathways to enhance immunity during stress. Research into immune-modulating therapies, such as immunotherapies and immune-based treatments, might offer innovative approaches to strengthen immune responses. Leveraging technology, such as wearables and digital health platforms, could facilitate monitoring stress levels and immune markers, aiding in personalized interventions.⁷⁶ Further understanding the intricate relationship between diet, gut health, and immune function could lead to refined dietary strategies for immune support. Advancements in understanding the mind-body connection could pave the way for more targeted and effective stress-reduction techniques for immune enhancement.

Conclusion

The relationship between stress and the immune system underscores the significance of adopting holistic approaches to support immune health during challenging periods. Strategies encompassing lifestyle modifications, stress management, nutritional interventions, and psychological well-being play pivotal roles in fortifying immunity. Acknowledging the complexities and individual variabilities involved, a multidisciplinary approach is warranted. Integrating evidence-based practices, ethical considerations, and acknowledging limitations while pursuing innovative research avenues will pave the way for more effective immune-boosting strategies.

References

1. Hutmacher F. On the Janus-facedness of stress and modern life. *Journal of Theoretical and Philosophical Psychology*. 2019;39(3):181.
2. Delcea C, Rad D, Gyorgy M, Runcan R, Breaz A, Gavrilă-Ardelean M, Bululoi AS. A Network Analysis Approach to Romanian Resilience-Coping Mechanisms in the Covid-19 Era. *Pharmacophore*. 2023;14(4):57-63.
3. Johnson S. Focus: The Science of Stress: In Times of Adversity: A Neuroscience Perspective on Stress, Health, and Implications for Society Post-pandemic. *The Yale Journal of Biology and Medicine*. 2022;95(1):165.
4. Jiang J, Yang M, Tian M, Chen Z, Xiao L, Gong Y. Intertwined associations between oxytocin, immune system and major depressive disorder. *Biomedicine & Pharmacotherapy*. 2023; 163:114852.
5. Saceleanu VM, Toader C, Ples H, Covache-Busuioc RA, Costin HP, Bratu BG, Dumitrascu DI, Bordeianu A, Corlatescu AD, Ciurea AV. Integrative Approaches in Acute Ischemic Stroke: From Symptom Recognition to Future Innovations. *Biomedicines*. 2023;11(10):2617.
6. Haykin H, Rolls A. The neuroimmune response during stress: A physiological perspective. *Immunity*. 2021;54(9):1933-47.

Citation: Obeagu EI, Obeagu GU. Boosting Immunity in Stressful Times: Strategies and Considerations. *Elite Journal of Immunology*, 2024; 2(2): 60-72

7. Seiler A, Fagundes CP, Christian LM. The impact of everyday stressors on the immune system and health. *Stress challenges and immunity in space: From mechanisms to monitoring and preventive strategies*. 2020;71-92.
8. Schommer NC, Hellhammer DH, Kirschbaum C. Dissociation between reactivity of the hypothalamus-pituitary-adrenal axis and the sympathetic-adrenal-medullary system to repeated psychosocial stress. *Psychosomatic medicine*. 2003;65(3):450-60.
9. Pondeljak N, Lugović-Mihić L. Stress-induced interaction of skin immune cells, hormones, and neurotransmitters. *Clinical therapeutics*. 2020;42(5):757-70.
10. Tian R, Hou G, Li D, Yuan TF. A possible change process of inflammatory cytokines in the prolonged chronic stress and its ultimate implications for health. *The Scientific World Journal*. 2014.
11. Liu YZ, Wang YX, Jiang CL. Inflammation: the common pathway of stress-related diseases. *Frontiers in human neuroscience*. 2017; 11:316.
12. Dhabhar FS. Effects of stress on immune function: the good, the bad, and the beautiful. *Immunologic research*. 2014; 58:193-210.
13. Biondi M, Zannino LG. Psychological stress, neuroimmunomodulation, and susceptibility to infectious diseases in animals and man: a review. *Psychotherapy and psychosomatics*. 1997;66(1):3-26.
14. Yaribeygi H, Panahi Y, Sahraei H, Johnston TP, Sahebkar A. The impact of stress on body function: A review. *EXCLI journal*. 2017; 16:1057.
15. Calcagni E, Elenkov I. Stress system activity, innate and T helper cytokines, and susceptibility to immune-related diseases. *Annals of the New York Academy of Sciences*. 2006;1069(1):62-76.
16. Vitlic A, Lord JM, Phillips AC. Stress, ageing and their influence on functional, cellular and molecular aspects of the immune system. *Age*. 2014; 36:1169-85.
17. Rabin BS, Cohen S, Ganguli R, Lysle DT, Cunnick JE. Bidirectional interaction between the central nervous system and the immune system. *Crit Rev Immunol*. 1989;9(4):279-312.
18. Pondeljak N, Lugović-Mihić L. Stress-induced interaction of skin immune cells, hormones, and neurotransmitters. *Clinical therapeutics*. 2020;42(5):757-70.
19. Shao T, Verma HK, Pande B, Costanzo V, Ye W, Cai Y, Bhaskar LV. Physical activity and nutritional influence on immune function: an important strategy to improve immunity and health status. *Frontiers in Physiology*. 2021:1702.
20. Kumar N, Chandan NK, Gupta SK, Bhushan S, Patole PB. Omega-3 fatty acids effectively modulate growth performance, immune response, and disease resistance in fish against multiple stresses. *Aquaculture*. 2022; 547:737506.
21. Mariotti F, Gardner CD. Dietary protein and amino acids in vegetarian diets—A review. *Nutrients*. 2019;11(11):2661.
22. Simpson RJ, Kunz H, Agha N, Graff R. Exercise and the regulation of immune functions. *Progress in molecular biology and translational science*. 2015; 135:355-80.
23. Gleeson M. Effects of exercise on immune function. *Sports Science Exchange*. 2015;28(151):1-6.
24. Arcavi L, Benowitz NL. Cigarette smoking and infection. *Archives of internal medicine*. 2004;164(20):2206-16.

Citation: Obeagu EI, Obeagu GU. Boosting Immunity in Stressful Times: Strategies and Considerations. *Elite Journal of Immunology*, 2024; 2(2): 60-72

25. Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *American journal of infection control*. 2007;35(10): S27-64.
26. Laupèze B, Del Giudice G, Doherty MT, Van der Most R. Vaccination as a preventative measure contributing to immune fitness. *npj Vaccines*. 2021;6(1):93.
27. Kansky J. Benefits of well-being: Health, social relationships, work, and resilience. *Journal of Positive Psychology and Wellbeing*. 2017;1(2):129-69.
28. Godswill AG, Somtochukwu IV, Ikechukwu AO, Kate EC. Health benefits of micronutrients (vitamins and minerals) and their associated deficiency diseases: A systematic review. *International Journal of Food Sciences*. 2020;3(1):1-32.
29. Samartín S, Chandra RK. Obesity, overnutrition and the immune system. *Nutrition Research*. 2001;21(1-2):243-62.
30. Patil AP, Patil TM, Shinde AR, Vakhariya RR, Mohite SK, Magdum CS. Nutrition, lifestyle & immunity: Maintaining optimal immune function & boost our immunity. *Asian Journal of Pharmaceutical Research and Development*. 2021;9(3):129-36.
31. Dhabhar FS. Effects of stress on immune function: the good, the bad, and the beautiful. *Immunologic research*. 2014:193-210.
32. Bodai BI, Nakata TE, Wong WT, Clark DR, Lawenda S, Tsou C, Liu R, Shiue L, Cooper N, Rehbein M, Ha BP. Lifestyle medicine: a brief review of its dramatic impact on health and survival. *The Permanente Journal*. 2018;22.
33. Calder PC, Carr AC, Gombart AF, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*. 2020;12(4):1181.
34. Stephen J, Manoharan D, Radhakrishnan M. Immune boosting functional components of natural foods and its health benefits. *Food Production, Processing and Nutrition*. 2023;5(1):61.
35. Bendik I, Friedel A, Roos FF, Weber P, Eggersdorfer M. Vitamin D: a critical and essential micronutrient for human health. *Frontiers in physiology*. 2014; 5:248.
36. Singh L, Kaur N, Kumar P. Reactive Oxygen Species (ROS), Oxidative Damage AND Antioxidative Defence Systems with Emphasis on Herbal Antioxidants and Human and Cattle Health. *Biochemical and Cellular Archives*. 2009;9(2):135-44.
37. Lakra P, Gahlawat IN. The role of Nutrition in the Immune system functions. *Integrated Journal of Social Sciences*. 2016;3(1):30-3.
38. Thomson CD, Chisholm A, McLachlan SK, Campbell JM. Brazil nuts: an effective way to improve selenium status. *The American journal of clinical nutrition*. 2008;87(2):379-84.
39. Zivkovic AM, Telis N, German JB, Hammock BD. Dietary omega-3 fatty acids aid in the modulation of inflammation and metabolic health. *California agriculture*. 2011;65(3):106.
40. Parvez S, Malik KA, Ah Kang S, Kim HY. Probiotics and their fermented food products are beneficial for health. *Journal of applied microbiology*. 2006;100(6):1171-85.
41. Praznik W, Loeppert R, Viernstein H, Haslberger AG, Unger FM. Dietary fiber and prebiotics. *Polysaccharides: Bioactivity and Biotechnology*; Ramawat, KG, Mérillon, J.-M., Eds. 2015:1-30.

Citation: Obeagu EI, Obeagu GU. Boosting Immunity in Stressful Times: Strategies and Considerations. *Elite Journal of Immunology*, 2024; 2(2): 60-72

42. Stephen J, Manoharan D, Radhakrishnan M. Immune boosting functional components of natural foods and its health benefits. *Food Production, Processing and Nutrition*. 2023;5(1):61.
43. Schonfeldt HC, Hall N. “Fish, chicken, lean meat and eggs can be eaten daily”: a food-based dietary guideline for South Africa. *South African Journal of clinical nutrition*. 2013;26: S66-76.
44. Tiwari R, Latheef SK, Ahmed I, Iqbal H, Bule MH, Dhama K, Samad HA, Karthik K, Alagawany M, El-Hack ME, Yattoo MI. Herbal immunomodulators-a remedial panacea for designing and developing effective drugs and medicines: current scenario and future prospects. *Current drug metabolism*. 2018;19(3):264-301.
45. Rutkowski JM, Davis KE, Scherer PE. Mechanisms of obesity and related pathologies: the macro-and microcirculation of adipose tissue. *The FEBS journal*. 2009;276(20):5738-46.
46. Rautiainen S, Manson JE, Lichtenstein AH, Sesso HD. Dietary supplements and disease prevention—a global overview. *Nature Reviews Endocrinology*. 2016;12(7):407-20.
47. Loux R. *The Balanced Plate: The Essential Elements of Whole Foods and Good Health*. Rodale; 2006.
48. Ptomey LT, Wittenbrook W. Position of the Academy of Nutrition and Dietetics: nutrition services for individuals with intellectual and developmental disabilities and special health care needs. *Journal of the Academy of Nutrition and Dietetics*. 2015;115(4):593-608.
49. Crucian BE, Choukèr A, Simpson RJ, Mehta S, Marshall G, Smith SM, Zwart SR, Heer M, Ponomarev S, Whitmire A, Frippiat JP. Immune system dysregulation during spaceflight: potential countermeasures for deep space exploration missions. *Frontiers in immunology*. 2018; 9:1437.
50. Fantacone ML, Lowry MB, Uesugi SL, Michels AJ, Choi J, Leonard SW, Gombart SK, Gombart JS, Bobe G, Gombart AF. The effect of a multivitamin and mineral supplement on immune function in healthy older adults: a double-blind, randomized, controlled trial. *Nutrients*. 2020;12(8):2447.
51. Elmadfa I, Meyer AL. The role of the status of selected micronutrients in shaping the immune function. *Endocrine, Metabolic & Immune Disorders-Drug Targets (Formerly Current Drug Targets-Immune, Endocrine & Metabolic Disorders)*. 2019;19(8):1100-15.
52. Goel V, Lovlin R, Chang C, Slama JV, Barton R, Gahler R, Bauer R, Goonewardene L, Basu TK. A proprietary extract from the Echinacea plant (*Echinacea purpurea*) enhances systemic immune response during a common cold. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*. 2005;19(8):689-94.
53. Nelson Jr RP, Ballow M. 26. Immunomodulation and immunotherapy: drugs, cytokines, cytokine receptors, and antibodies. *Journal of allergy and clinical immunology*. 2003;111(2): S720-32.
54. De Andrade KQ, Moura FA, Dos Santos JM, De Araújo OR, de Farias Santos JC, Goulart MO. Oxidative stress and inflammation in hepatic diseases: therapeutic possibilities of N-acetylcysteine. *International journal of molecular sciences*. 2015;16(12):30269-308.

Citation: Obeagu EI, Obeagu GU. Boosting Immunity in Stressful Times: Strategies and Considerations. *Elite Journal of Immunology*, 2024; 2(2): 60-72

55. Muller PY, Brennan FR. Safety assessment and dose selection for first-in-human clinical trials with immunomodulatory monoclonal antibodies. *Clinical Pharmacology & Therapeutics*. 2009;85(3):247-58.
56. Kiecolt-Glaser JK, McGuire L, Robles TF, Glaser R. Psychoneuroimmunology: psychological influences on immune function and health. *Journal of consulting and clinical psychology*. 2002;70(3):537.
57. Nehra DK, Sharma N, Kumar P, Nehra S. Mindfulness based stress reduction (MBSR) program: An overview. *Mental Health: Risks and Resources*. 2013:197-230.
58. Forman EM, Herbert JD. New directions in cognitive behavior therapy: Acceptance-based therapies. General principles and empirically supported techniques of cognitive behavior therapy. 2009; 52009:77-101.
59. Graham JE, Christian LM, Kiecolt-Glaser JK. Close relationships and immunity. *Psychoneuroimmunology*. 2007; 4:781-98.
60. Shastri PC. Resilience: Building immunity in psychiatry. *Indian Journal of Psychiatry*. 2013;55(3):224.
61. Rose RD, Buckley Jr JC, Zbozinek TD, Motivala SJ, Glenn DE, Cartreine JA, Craske MG. A randomized controlled trial of a self-guided, multimedia, stress management and resilience training program. *Behaviour research and therapy*. 2013;51(2):106-12.
62. Silverman MN, Deuster PA. Biological mechanisms underlying the role of physical fitness in health and resilience. *Interface focus*. 2014;4(5):20140040.
63. Chen PH, Kuo HY, Chueh KH. Sleep hygiene education: efficacy on sleep quality in working women. *Journal of Nursing Research*. 2010;18(4):283-9.
64. Forster N. Maximum performance: A practical guide to leading and managing people at work. Edward Elgar Publishing; 2005.
65. Mahomed NJ, Johari KS, Mahmud MI. Coping strategies and psychological well-being of guidance and counselling teachers in schools. *Creative Education*. 2019;10(12):3028.
66. Kobau R, Seligman ME, Peterson C, Diener E, Zack MM, Chapman D, Thompson W. Mental health promotion in public health: Perspectives and strategies from positive psychology. *American journal of public health*. 2011;101(8): e1-9.
67. Bennett JM, Reeves G, Billman GE, Sturmberg JP. Inflammation–nature's way to efficiently respond to all types of challenges: implications for understanding and managing “the epidemic” of chronic diseases. *Frontiers in medicine*. 2018; 5:316.
68. Olsson T, Barcellos LF, Alfredsson L. Interactions between genetic, lifestyle and environmental risk factors for multiple sclerosis. *Nature Reviews Neurology*. 2017;13(1):25-36.
69. Antoni MH. Stress management effects on psychological, endocrinological, and immune functioning in men with HIV infection: empirical support for a psychoneuroimmunological model. *Stress*. 2003;6(3):173-88.
70. Groven KS. They think surgery is just a quick fix. *International Journal of Qualitative Studies on Health and Well-being*. 2014;9(1):24378.
71. Ahmed F, Zuk AM, Tsuji LJ. The impact of land-based physical activity interventions on self-reported health and well-being of Indigenous adults: A systematic review. *International journal of environmental research and public health*. 2021;18(13):7099.

Citation: Obeagu EI, Obeagu GU. Boosting Immunity in Stressful Times: Strategies and Considerations. *Elite Journal of Immunology*, 2024; 2(2): 60-72

72. Osarogiagbon RU, Sineshaw HM, Unger JM, Acuña-Villaorduña A, Goel S. Immune-based cancer treatment: addressing disparities in access and outcomes. American Society of Clinical Oncology Educational Book. 2021; 41:66-78.
73. Davis MD, Lohm D, Flowers P, Whittaker A. The immune self, hygiene and performative virtue in general public narratives on antibiotics and antimicrobial resistance. Health. 2023;27(4):491-507.
74. Caulfield T, Marcon AR, Murdoch B. Injecting doubt: responding to the naturopathic anti-vaccination rhetoric. Journal of Law and the Biosciences. 2017;4(2):229-49.
75. Doestzada M, Vila AV, Zhernakova A, Koonen DP, Weersma RK, Touw DJ, Kuipers F, Wijmenga C, Fu J. Pharmacomicrobiomics: a novel route towards personalized medicine? Protein & cell. 2018;9(5):432-45.
76. Anikwe CV, Nweke HF, Ikegwu AC, Egwuonwu CA, Onu FU, Alo UR, Teh YW. Mobile and wearable sensors for data-driven health monitoring system: State-of-the-art and future prospect. Expert Systems with Applications. 2022; 202:117362.
77. Obeagu EI, Ubosi NI, Obeagu GU, Obeagu AA. Nutritional Strategies for Enhancing Immune Resilience in HIV: A Review. Int. J. Curr. Res. Chem. Pharm. Sci. 2024;11(2):41-51.
78. Alum EU, Obeagu EI, Ugwu OP, Samson AO, Adepoju AO, Amusa MO. Inclusion of nutritional counseling and mental health services in HIV/AIDS management: A paradigm shift. Medicine. 2023;102(41):e35673.
79. Hassan AO, Oso OV, Obeagu EI, Adeyemo AT. Malaria vaccine: prospects and challenges. Madonna University journal of Medicine and Health Sciences. 2022;2(2):22-40.
80. Etido A, Obeagu EI, Okafor CJ, Chijioke UO, Vincent CC, Mojo-Eyes GC. The Dynamics of Innate and Adaptive Immune Response to Sars Cov-2 Infection and Its Limitations in Human Beings. Journal of Pharmaceutical Research International. 2021;33(45A):10-25.
81. Obeagu EI, Babar Q, Vincent CC, Anyanwu CO. Infants Immunization: Challenges of Other Vaccines Due to Covid-19 Pandemic. Journal of Bioinnovation. 2021;10(4):1056-66.
82. Obeagu EI, Obeagu GU, Odo E. A Review on exercise and blood cells. Int. J. Adv. Multidiscip. Res. 2016;3(11):70-5.
83. Obeagu EI, Obeagu GU. Maternal Influence on Infant Immunological Responses to HIV: A Review. Elite Journal of Laboratory Medicine. 2024;2(1):46-58.
84. Obeagu EI, Obeagu GU. Breastfeeding's protective role in alleviating breast cancer burden: A comprehensive review. Annals of Medicine and Surgery.:10-97.
85. Obeagu EI, Obeagu GU. Immune Checkpoint Inhibitors in Type 1 Diabetes: A New Frontier in Therapy. Elite Journal of Medicine. 2024;2(2):26-41.

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