The Immune System-Boosting Effect of Vegetables: A Nutritional Viewpoint with a Focus on Paramedics' Contributions

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Abstract

The immune system plays an essential for keeping the body healthy and protecting it from dangerous infections. Nutrition is an important driver of immunological function, with vitamins and minerals serving as necessary cofactors for immune responses. Micronutrient deficiencies, such as those in vitamins A, B, C, D, E, zinc, selenium, and iron, may impair immune responses, making them more susceptible to infections and inflammatory diseases. Paramedics, as frontline healthcare workers, have the opportunity to bridge the gap between emergency treatment and preventive health efforts by teaching patients about healthy nutrition. They may encourage immune-boosting diets, detect nutritional deficiencies, and work with public health specialists to optimize patient outcomes. However, challenges including lack of resources, insufficient nutrition expertise, and time restrictions make it difficult for them to provide useful nutritional advice. Future initiatives should include incorporating nutrition teaching into paramedic training, strengthening relationships with nutritionists, and creating community-based nutrition programs. A holistic approach to immunological health that incorporates good diet and medicinal therapies may dramatically improve illness prevention and patient resilience. This study emphasizes the relevance of paramedics in nutritional health, recommending more participation in public health education and dietary treatments to improve immune function.

Keywords: Nutrition, vegetables, immunomodulators, micronutrients, immune system, paramedics, public health.

Significance | Paramedics can enhance immune health by promoting nutrition, detecting deficiencies, and collaborating with public health experts for better patient outcomes.

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1. Introduction

Internally and externally, the human immune system provides defense against harmful microorganisms and other dangers. An immunological protection mechanism against foreign chemicals is provided by a number of anatomical and physical barriers, including the mucous blanket, mucous membranes, ciliated epithelial cells, as well as the epidermis. The immune system responds quickly to protect the body against "non-self" particles when foreign substances are able to get past these barriers. The natural immune system as well as its adaptive counterpart are the two main reactions that make up the immune system. An inherent immune reaction is elicited the more often an infectious pathogen is exposed. Pathogen-associated molecular patterns, or receptors

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that recognize foreign particles, are the foundation of innate immunity, which is instantaneous.

As a generic, flexible, and instantaneous defensive mechanism, the natural immune system is made up of leukocyte reactions towards infectious agents, cell-intrinsic reactions towards viral illnesses, and soluble mediators, such as complementary proteins. T and B cells, on the other hand, are exclusive to the adaptive immune reaction. These cells produce antibodies that fight and eliminate infections and aid in the recruitment of more immune cells that target the pathogenic factor after identifying certain antigens provided by the attacking bacterium (Pecora et al., 2020; Cai et al., 2020).

The effectiveness of immunity is significantly impacted by an individual's dietary status. The body's capacity to maintain innate immune responses may be hampered by undernutrition, which is brought on by insufficient ingestion of micronutrients; nevertheless, the consequences of nutritional status vary depending on the disease. While a person's dietary habits can predict the clinical course and outcome of many illnesses, like bacterial or viral diarrhea, tuberculosis, measles, pneumonia, and more, nutritional position has little impact on the course and outcome of many infectious diseases, including viral brain infections or tetanus, and just a slight effect on the onset of illnesses like HIV alongside influenza (Stephen et al., 2023, Figure 1).

The administration of minerals and vitamins to strengthen immune systems has so far shown encouraging results in a number of experimental trials. In animal studies and, in rare instances, in people with dietary deficiencies, the significance of certain minor nutrients, supplements, and minerals for preserving immune competency has been shown (Suksmasari, 2015). Vitamins A, B, C, D, as well as E, riboflavin, selenium, β-carotene, iron, and zinc, are important components (Widasari et al., 2020). Immune function restoration and infection resistance may be improved by supplementing or changing one's diet to include more nutrients, such as vitamins, that are lacking (Gombart et al., 2020). Carnitine, choline, coenzyme Q, as well as inositol, are examples of vitamin-like substances that are essential for immunomodulation (Sauer & Cooke, 2010; Thangasamy et al., 2008; Garcia et al., 2018; López-Pedrera et al., 2021). Furthermore, immune cells' antioxidant equilibrium has to be maintained in order to shield them from oxidation, and an abundance of micronutrients may benefit their antioxidant capacity (Elmadfa & Meyer, 2019).

The immune system is a sophisticated and highly controlled network that protects the body from infections and maintains general health. Several variables impact its efficacy, including immunomodulators, which may boost or decrease immune responses depending on therapeutic demands. These medicines include immunostimulants, which improve immunological function, and immunosuppressants, which control hyperactive immune responses. Additionally, a good diet, especially the consumption of important vitamins and minerals, is critical for immunological function. This article investigates the mechanics of immunostimulants, the therapeutic uses of immunosuppressants, and the importance of a nutrient-dense diet in maintaining immunological balance.

2. The mechanism of immunity

Allergens, inflammatory and non-pathogenic microbes, and other harmful substances may interfere with the host body's ability to maintain homeostasis. The host immunity system uses a defensive mechanism known as the immune response to combat these intrusive elements (Belkaid & Hand, 2014). The ability of the immune system to recognize an infectious agent or pathogen based on structural traits that set them apart from host cells and make them invasive is essential. For the host defenses to eliminate the invading factor without causing damage to host tissues, specificity towards foreign infections and poisons is essential (Luebke & Germolec, 2010). There are two types of mechanisms that are utilized to detect structures that are microbial, toxic, or allergic.

The natural immune system performs initial reactions, and a broad range of cell types display the identification markers that the immune system uses. When invasive infections or poisons are detected, the natural immune system may quickly become active, which is the host's first reaction to the discovery of foreign components (Carrillo et al., 2017). All multicellular creatures have an innate immune response, which is a general immune reaction that serves as the host's first line of defense against a variety of diseases. Maintaining cellular homeostasis, eliminating a variety of pathogens, and assisting in the induction of the immune system's adaptive response all depend on this reaction (Riera Romo et al., 2016). Physical as well as chemical obstacles, as well as humoral and cell-mediated elements, make up the natural immune system. The complement system, which includes neutrophils, natural killer (NK) cells, mast cells, basophils, monocytes, and macrophages, is the primary receptor of intrinsic immunity (Krensky et al., 2010).

The identification of antigens shapes the adaptive immune response, which is made up of many cells that are unique to a certain allergen, microbe, or toxin. Appropriate immune cell growth is necessary for an appropriate adaptive immune response in order to establish a successful defense against the identified poison or pathogen. Usually, the innate reaction is triggered first, followed by the adaptive reaction (Marshall et al., 2018). The B and T cells are the main constituents of the responsive immune system in this regard.

Unlike the native immune system, which uses specialized pathogen receptors to identify infectious agents, the adapted immune response has a vastly varied and randomly generated repertoire of receptors that enable it to identify a broad range of antigens. The danger of autoimmune illness, in which B and T cell-expressed receptors identify self-proteins like myelin and insulin via random gene rearrangement, is one consequence of this variety. To eradicate or control self-reactive immune cells, complex tolerance processes have to be put in place. The amount of time needed to produce an adapted immune reaction after first coming into contact with a virus is another drawback. The clonal expansion of distinct antigen-specific B and T cells may take as long as five days before the adaptive immune reaction is strong enough to eliminate infectious illness (Alpert, 2017).

Physical and chemical substances known as antigens have the power to trigger specific immunological reactions in the body. The establishment of an adaptive defense towards the infectious agent may arise from the activation of the natural immune system in response to the detection of an unknown pathogenic germ inside the host. Amongst the pattern-recognizing receptors (PRRs) employed in vertebrates to identify microbial incursions are Toll-like receptors (TLRs), Nod-like receptors (NLRs), RIG-I-like receptors (RLRs), and C-type lectin receptors (CLRs) (Hoffmann & Akira, 2013). Both the cytoplasm as well as the cell surface produce PRRs. TLRs are membrane receptors that play vital functions in both innate and adaptive immune reactions. They can recognize a broad variety of bacterial elements, including glycolipids, proteins, nucleic acids, and lipoproteins unique to microbes. On the other hand, RLRs identify viral replication-induced double-stranded RNA, CLRs identify bacterial and fungal sugar moieties, and NLRs identify bacterial elements present in the cytoplasm (Negri et al., 2013). In addition to accumulating and activating immune cells and leukocytes, non-immune cells like endothelial cells, epithelial cells, and fibroblasts can also identify pathogens and initiate innate immune defenses in infected tissues, which results in the production of a variety of cytokines and chemokines (Appay & Sauce, 2008). Antigen accuracy and adaptive immunity are established through additional immune cells that convey the primary histocompatibility antigen as well as microbe-derived peptides on their outer surfaces, besides dendritic cells (DCs), which travel from infected tissues to a local lymph node and then stimulate associated T cells (Hoffmann & Akira, 2013).

Immune control, which represents a thorough and intricate procedure within the human body, is the process of striking a balance between immune stimulation and suppression to guarantee an efficient immune response without endangering the host. Immune responses are influenced by chemokines, T regulatory cells (Tregs), antibodies, cytokines, and their receptors. Foxhead box protein P3 (FOXP3+) Tregs have been proposed to be critical participants in maintaining proper immune control and regulation of the immune response via either contact-dependent or contact-independent processes. The suppression of T responder cell growth and the generation of inflammatory cytokines are two of these processes, which are controlled by FOXP3 (Bartolucci & Piccirillo, 2017).

T4 cells, additionally referred to as stimulant, CD4, or T helper (Th) cells, and T8 cells, often referred to as cytotoxic T cells or CD8 cells, are the two kinds of T cells. The immune system uses CD4 (Th or stimulant cells) lymphocytes as a regulating function. Once an antigen has been digested, macrophages use direct cell-to-cell interaction to activate antigen-specific T4 cells. Following stimulation, the T4 cells generate cytotoxic and late sensitization T8 cells as well as IL-2, which activates more T4 cells. B cells are activated by the lymphokines produced by stimulated T4 cells. Suppressor T8 cells use suppression or adverse feedback to control the growth and activity of T4 cells (Luckheeram et al., 2012). Among other things, suppressive T8 cells additionally decrease lethal T8 cell stimulation, restrict the production of antibodies by plasma cells, and contribute to transplanted tissue resistance.

Cytokines are essential for regulating immunological reactions because they have the ability to both activate and inhibit the immune system. Extracellular vesicles are produced by immunological as well as non-immune cells, and they play important roles in immune control (Robbins & Morelli, 2014) by either activating or deactivating the immune system's functions and influencing the pathogenesis of viral, inflammatory, and autoimmune disorders. Therefore, extracellular vesicles may be used as a treatment to control the immune response.

3. Immunomodulators

Immunomodulators belong to naturally occurring substances and byproducts that the body's strong defenses create to keep things in balance. Natural or synthetic medications known as immunomodulators have the ability to either promote, hinder, or control immune system elements or disrupt the immune system's normal processes (Pecora et al., 2020). Immunostimulating drugs, immunosuppressive substances, and immunoadjuvants are the three primary groups into which immunomodulators fall in clinical application. Compounds known as immunoadjuvants increase the efficacy of vaccinations by boosting the immune system (Cai et al., 2020).

Immunostimulators, often referred to as immunostimulants, are chemicals that activate or increase the function of a number of immune system elements. Immunostimulators strengthen the body's defenses against cancer, autoimmune reactions, infections, and allergies. Levamisole serves as a manufactured anthelmintic as well as an immunomodulatory drug that may be used orally in this situation. For patients with surgically eradicated stage C colorectal cancer, levamisole, when combined with fluorouracil, lowers the chance of death and recurrence by one-third (Pecora et al., 2020). Although the exact mechanism by which levamisole affects the human immune system is complex and not completely clarified, most available in vitro and in vivo data point to levamisole's immune-restorative qualities, allowing it to boost a compromised host immune structure without overstimulating a healthy one. Granulocytopenia is a significant adverse effect linked to levamisole that clinicians need to monitor carefully.

Thalidomide is often used in the treatment of erythema nodosum leprosum and multiple myeloma. HIV-related weight loss, Kaposi sarcoma, brain tumors, mycobacterial infections, Crohn's disease, myelofibrosis, mouth ulcers, lupus, graft-versus-host disease, and leprosy are among the illnesses for which this orphan medication has received approval (Stephen et al., 2023). Because thalidomide may result in serious fetal problems, pregnant women and individuals who may become pregnant must avoid using it. Thalidomide's derivative lenalidomide has immunomodulatory and anti-angiogenic effects. Regardless of additional chromosomal abnormalities, lenalidomide has been licensed by the U.S. Food and Drug Administration (FDA) to treat transfusion-dependent anemia in patients with low- or intermediate-risk myelodysplastic syndromes (Stephen et al., 2023).

The Bacille Calmette-Guérin (BCG) vaccine is a potent immunostimulant, notably in the treatment of recurrent superficial bladder cancer, where it may also be administered topically. Its activity may involve a human leukocyte antigen (HLA)-restricted T cell response, which is aided by the expression of HLA class II antigens generated by BCG in tumor cells. Furthermore, levels of interleukin-2 (IL-2) in urine have a substantial correlation with therapy response (Pecora et al., 2020). Recent research is exploring the use of topical BCG to treat melanomas as well as head and neck malignancies. IFNs (β, α, γ) and IL-2, along with other immunostimulants, have significant immunomodulatory effects.

Immunosuppressants, on the other hand, are drugs that reduce the activity of the immune system. These medications are used to treat autoimmune illnesses, hypersensitivity reactions, and infection-related problems, as well as to regulate overactive immune responses after organ transplantation. In transplantation, common immunosuppressive medications include biologics (antibodies), calcineurin inhibitors, glucocorticoids, and antimetabolic/anti-proliferative medicines (Widasari et al., 2020).

Glucocorticoids promote lymphocyte redistribution, resulting in a fast but transitory drop in lymphocyte numbers in the peripheral circulation. Calcineurin inhibitors, such as cyclosporine, selectively reduce immunological responses by lowering IL-2 production, which inhibits the activation and proliferation of CD8+ T and CD4+ cells (Sauer & Cooke, 2010). Tacrolimus works similarly by inhibiting calcineurin, providing another method for suppressing T cell activation. Mycophenolate mofetil, a prodrug that transforms into mycophenolic acid (MPA), preferentially inhibits inosine monophosphate dehydrogenase (IMPDH), a key enzyme in the de novo production of guanine nucleotides required for B and T cell proliferation, while other cell types use salvage mechanisms. As a result, MPA predominantly inhibits lymphocyte proliferation and related activities, including cellular adhesion, migration, and antibody formation (Elmadfa & Meyer, 2019; Belkaid & Hand, 2014). FTY720 is renowned for its capacity to control immunity by selectively and reversibly sequestering host lymphocytes in lymph nodes and Peyer's patches, preventing their circulation.

Immunomodulators are becoming acknowledged as effective tools for treating a variety of immune-related illnesses by boosting immune responses in the face of major health difficulties. Immunosuppressive drugs are used in clinical settings to treat various autoimmune illnesses, including the prevention of graft rejection. Cyclosporine, for example, is often used to treat rheumatoid arthritis and psoriasis, as well as to improve the success rate of heart transplants (Stephen et al., 2023). Furthermore, monoclonal antibodies and biological response modifiers play critical roles in treating a wide range of disorders, including cancer, trauma, autoimmune diseases, cardiovascular problems, and severe infections (Pecora et al., 2020). These medicines are more effective when combined with other medications, such as antibiotics and cytokines, and are essential components of immunotherapy strategies for treating immune-related illnesses.

Proper nutrition is critical for improving immune system function, with a diet high in fruits and vegetables providing the most effective supply of key micronutrients (Thangasamy et al., 2008). Elderberries, for example, contain antioxidants and have anti-inflammatory properties, while button mushrooms are rich in selenium and B vitamins. Brazil nuts, sardines, broccoli, garlic, barley, and tuna are also high in selenium. Zinc-rich foods include wheat germ, lean meat, crabs, oysters, chickpeas, chicken, baked beans, and yogurt (López-Pedrera et al., 2021). Shellfish and lean chicken provide heme, the most absorbable iron source, while broccoli, beans, and kale offer healthy alternatives.

Folic acid, an essential vitamin that boosts immunity, is often added to bread and cereals, although natural folate may be found in peas, beans, and dark leafy greens (López-Pedrera et al., 2021; Garcia et al., 2018). Vitamin B6 is found in baked potatoes, lean poultry, chickpeas, cold-water fish such as tuna, and bananas. Green leafy vegetables and citrus fruits, notably kale and spinach, are high in vitamin C, as are strawberries, Brussels sprouts, papaya, and bell peppers (Gombart et al., 2020). Most people can meet their vitamin C requirements through diet alone since these sources are widely available. Furthermore, vitamin E is abundant in almonds, peanuts, sunflower seeds, hazelnuts, broccoli, and spinach. A broad and colorful diet promotes an appropriate intake of vitamin A (Stephen et al., 2023)

5. The Effects of Minerals and Vitamins as Immunomodulators

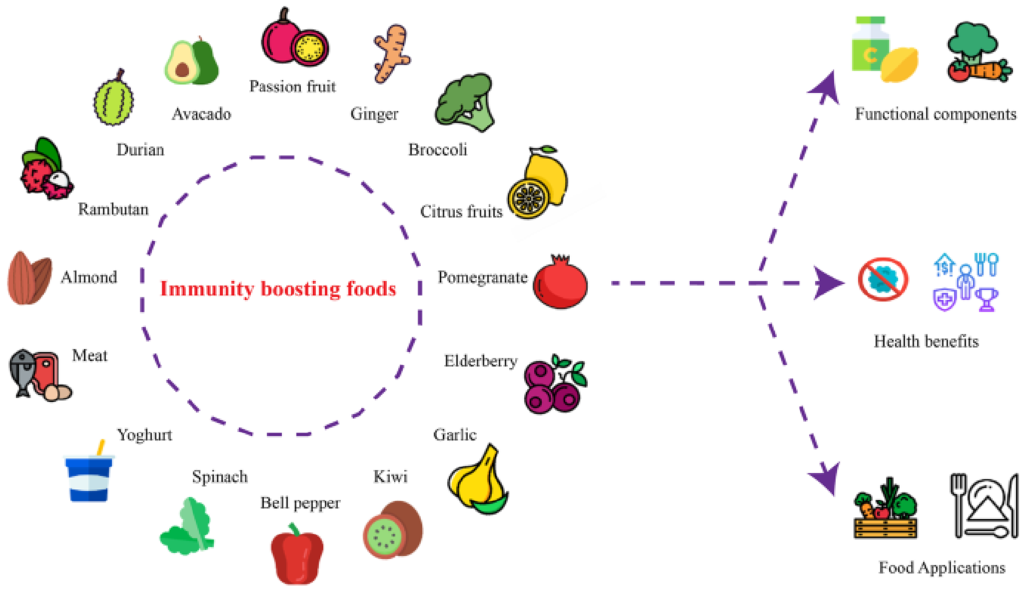
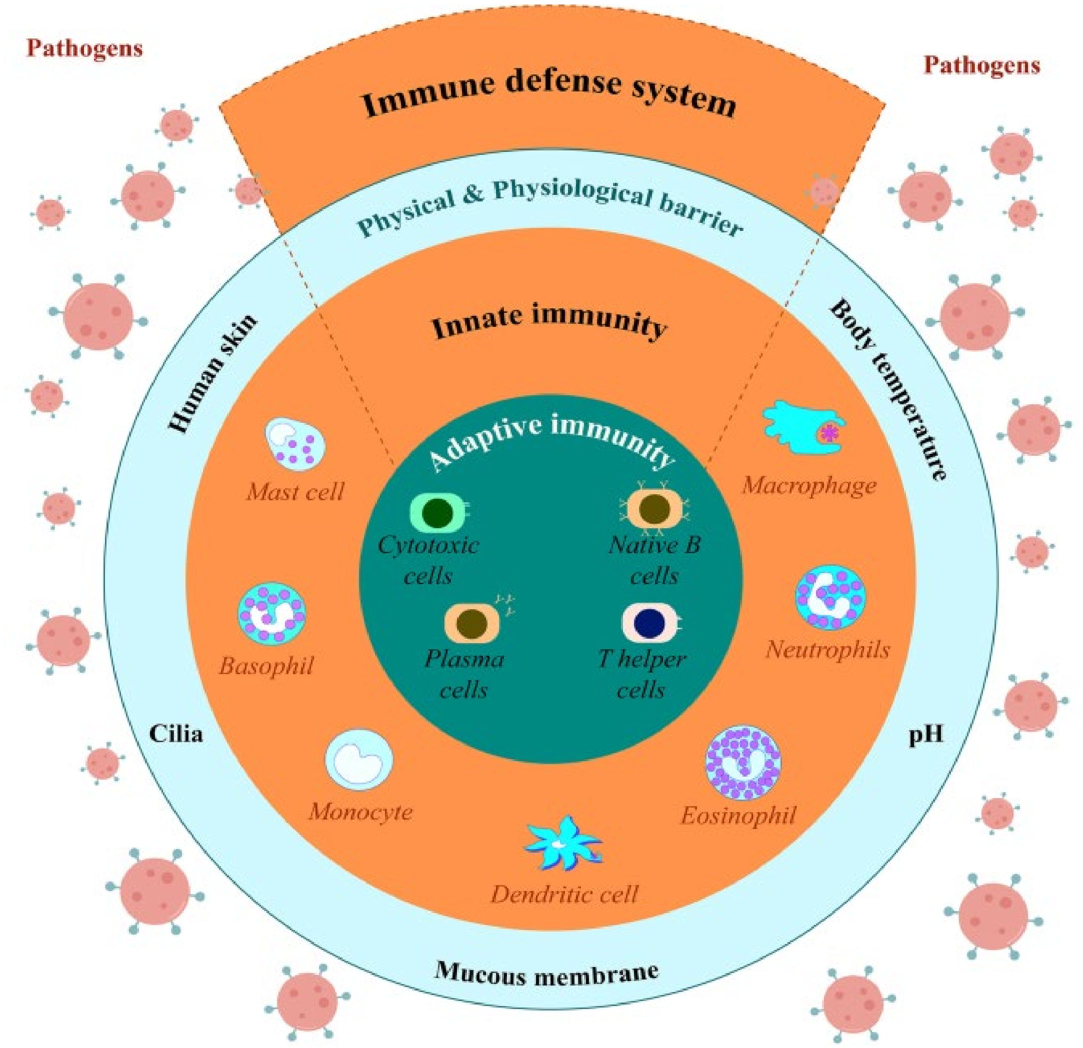


Figure 1. The effectiveness of dietary on human immunity (Stephen et al, 2023)



Defence mechanism: innate immunity (non-antigen specific) and adaptive immunity (antigen-specific)

Figure 2. The human body's innate as well as adaptive immunity (Stephen et al, 2023)

Vitamins and minerals' immunomodulatory properties are determined by their amount as well as their biological availability. Food preparation has a significant impact on nutritional absorption; varied procedures may either improve or impair nutrient bioavailability and bioactive compound storage (Sanchez-Moreno et al., 2009). Advanced processing methods aim to fulfill customer expectations for high-quality foods while preserving functional and nutritional qualities, notably via nonthermal procedures that increase shelf life without sacrificing nutrient integrity. Techniques that reduce the adverse effects of technology on vitamins and minerals are essential to achieve positive results in terms of bioaccessibility as well as durability (Cilla et al., 2018).

A balanced diet is required for good physiological performance in order to avoid negative nutritional interactions, particularly when drugs are provided at pharmacological levels. Certain nutrients may work together to improve absorption and digestion, while others may fight for absorption or need cooperation for metabolic activities, impacting many biochemical pathways (Schoendorfer & Davies, 2012). The human body's complex and interconnected systems demand careful study of both complementary and antagonistic relationships, especially in health research and clinical settings where nutrient-related factors are of relevance (Schoendorfer & Davies, 2012; Wiysonge et al., 2017).

6. The Role of Paramedics in Strengthening the Immune System

Paramedics serve a critical role in global healthcare systems, often acting as first responders in emergency circumstances. While paramedics' main role is to provide emergency medical treatment, they also make major contributions to public health efforts such as nutritional education and illness prevention. Nutrition is a critical component of immunological function, impacting the body's capacity to fight infections and recover from disease. A well-balanced diet high in key nutrients improves immune function, lowering the incidence of infections and chronic disorders (Eaton et al., 2021). Because of their frontline position, paramedics have the opportunity to educate patients on the significance of nutrition, encourage healthy dietary choices, and assist disadvantaged groups in acquiring nutritious meals.

Paramedics have direct contact with vulnerable groups such as the elderly, those suffering from chronic illnesses, and those living in low-income regions. These populations are more likely to suffer from malnutrition, which may impair immune responses and make them more vulnerable to infections and chronic disorders (Eaton et al., 2022). As frontline healthcare practitioners, paramedics may provide nutritional advice by highlighting the need to eat immune-boosting foods, including fruits, vegetables, lean meats, and whole grains. By including basic dietary guidance into patient encounters, paramedics may improve general health and immunological function in vulnerable groups (Eaton et al., 2020).

Beyond generic dietary recommendations, paramedics may actively evaluate nutritional deficits. Many patients suffer from malnutrition as a result of a poor diet, underlying health issues, or socioeconomic obstacles (Ahmed et al., 2018). Paramedics may detect vitamin deficits and offer suitable therapies by assessing the patient's history and physical state. They may also provide easy, practical, and cost-effective dietary suggestions, such as including vitamin-rich foods like citrus fruits, leafy greens, and almonds to promote general health (van Vuuren et al., 2021). Their role as first responders also enables them to work with healthcare specialists, such as dietitians and public health authorities, to create nutrition-based treatments and ensure patients get complete care (Bell et al., 2020).

7. Paramedics and Public Health Education

Aside from individual patient treatment, paramedics support community-wide health education initiatives by leading seminars, providing instructional materials, and engaging in public health campaigns. These projects encourage good eating habits and improve awareness of the role of nutrition in illness prevention. During infectious disease outbreaks, such as COVID-19 or influenza, paramedics may play an important role in teaching populations about how appropriate nutrition boosts the immune system and decreases illness severity (Morales et al., 2022). In emergency response scenarios, such as disaster-stricken regions or pandemic relief operations, paramedics might provide dietary guidance to impacted people. Access to important nutrients is crucial in these situations, as malnutrition may impair health outcomes and impede recovery (Rasku et al., 2019). Paramedics may also fight for government policies that enhance access to healthy meals, especially in underprivileged areas, by increasing awareness about food poverty and its effect on public health.

Despite their potential role in nutritional teaching and intervention, paramedics confront a number of hurdles when implementing nutrition-based initiatives into their practice. One significant challenge is time limits, since paramedics often work in fast-paced emergency settings where urgent medical treatment takes priority over nutritional talks. Furthermore, many paramedics have little nutrition training, making it difficult for them to give evidence-based nutritional advice (Juhrmann et al., 2022).

Another problem is resource scarcity, especially in low-income or rural areas where access to nutritional meals, dietary supplements, and healthcare facilities is limited. These constraints diminish the efficacy of dietary therapies, necessitating paramedics' collaboration with community groups and healthcare experts to link patients with relevant resources. To address these issues, paramedic training programs should include nutrition instruction, ensuring that first responders have the necessary knowledge and abilities to provide basic nutritional counsel. Furthermore, improved cooperation with dietitians, nutritionists, and public health authorities may help paramedics deliver more complete, evidence-based advice for improving patient health and immune function. By overcoming these limitations, paramedics may play a larger role in preventive healthcare, eventually boosting community well-being and disease resistance (Ericsson et al., 2022).

8. Conclusion

Increasing immunity is a very effective strategy for safeguarding the body against infections and other health risks. Immunostimulants and immunosuppressants influence the regulation of immune function, but an adequate diet is just as crucial. As vital cofactors for immune cell activity, vitamins and minerals either promote or control immunity during various phases of the immunological response. These micronutrients also function as antioxidants, avoiding oxidative stress, which may harm tissues and immune cells. Deficiencies in essential vitamins and minerals may decrease immune cell synthesis, antibody responses, and overall immunological function, rendering people more vulnerable to infections.

Paramedics are well-positioned to improve immune function via dietary education and intervention. While their main function is emergency treatment, they may make a substantial contribution to long-term health promotion by teaching patients about immune-boosting dietary practices. Paramedics may contribute to better community health outcomes by including nutritional assessment, dietary advice, and public health education into their practice. Future initiatives should concentrate on improving nutrition training for paramedics, incorporating nutritional methods into emergency healthcare procedures, and expanding cooperation with nutrition specialists. A holistic approach to immunological health, combining adequate diet with medical treatment, may considerably lower illness load and improve patient resistance to infection.

However, immunological responses to dietary components fluctuate across people, necessitating more clinical studies to discover appropriate doses and methods of action for various populations. Future research should concentrate on determining the specific functions of micronutrients in immune regulation and developing evidence-based dietary guidelines for disease prevention and immunological support. By improving our knowledge of nutrition-based immunomodulation, healthcare professionals may create focused therapies for autoimmune illnesses, infectious diseases, and immune-related problems, eventually leading to better public health outcomes.

Author contributions

A.M.A. and A.S.A. contributed to the conceptualization and design of the study. B.S.A., A.I.A., S.S.I.A., S.M.A., and N.S.A. were responsible for data collection and validation. B.T.A., A.A.A., and Z.H.A. conducted the formal analysis and interpretation. M.S.A., Y.M.A., and A.M.A. contributed to methodology development and software implementation. R.M.A., T.F.A.A., M.F.A., and M.R.A. assisted in drafting and reviewing the manuscript. E.S.A.A. and A.S.A. supervised the project, ensured data accuracy, and provided critical revisions. All authors read and approved the final manuscript.

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Competing financial interests

The authors have no conflict of interest.

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