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Role of Vitamin in Human Diet and its Influence on Immunity

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ABSTRACT: Vitamins such as vitamin C, vitamin D, and vitamin E are known for their immune-boosting properties. Vitamin C helps stimulate the production of white blood cells, which are responsible for fighting off infections. Vitamin D plays a vital role in regulating the immune system and reducing inflammation

KEYWORDS: vitamin, immune, infection, vital role, fight

I. INTRODUCTION

Vitamins are essential constituents of our diet that have long been known to influence the immune system. Vitamins A and D have received particular attention in recent years as these vitamins have been shown to have an unexpected and crucial effect on the immune response. We present and discuss our current understanding of the essential roles of vitamins in modulating a broad range of immune processes, such as lymphocyte activation and proliferation, T-helper-cell differentiation, tissue-specific lymphocyte homing, the production of specific antibody isotypes and regulation of the immune response. Finally, we discuss the clinical potential of vitamin A and D metabolites for modulating tissue-specific immune responses and for preventing and/or treating inflammation and autoimmunity.[1,2,3]

The statement by Albert Szent-Gyorgyi epitomizes the impact of vitamins on the body's vital organs, including the immune system. Vitamins (vital amines) are organic compounds that are required in trace amounts in the diet because they cannot be synthesized in sufficient quantities by an organism[1]. Vitamins and their metabolites are essential for a large number of physiological processes, fulfilling diverse functions as hormones and antioxidants, as regulators of tissue growth and differentiation, in embryonic development and in calcium metabolism, among others[1].

In addition, vitamins have a role in the immune system, which extends to both innate and adaptive immune responses. Although some vitamins, such as vitamins C and E and members of the B complex, can act in a relatively nonspecific manner in the immune system (for example, as antioxidants)[2–4], other vitamins, such as vitamins A and D, can influence the immune response in highly specific ways .Here we review the most important effects of vitamins on the immune system, with special emphasis on vitamins A and D, which have received particular attention owing to recent discoveries of their multi-faceted interactions with the immune system. Vitamins A and D are notably distinct from other vitamins in that their respective bioactive metabolites, retinoic acid and 1,25-dihydroxyvitamin D3 ($1,25(OH)_2VD_3$), have hormone-like properties. Both of these metabolites are synthesized from their vitamin precursors by different tissues and cells in the body and exert their effects on target cells remotely by binding to nuclear-hormone receptors.

Vitamins and minerals such as vitamin A and Zn in addition to their involvement in cell division and proliferation are involved in immune-modulation. For example, the rate of antibody synthesis can be modified by these micronutrients (20).

Vitamin A (Figure 2), which is involved in biosynthesis of carotenoids and retinyl esters, molecules well known to affect appropriate immune function (21). It can also exert a role as transcription factor if it is bound to retinoic acid receptors (RARs). As a result, it can be responsible for lipid homeostasis, cell division, growth, and specialization by regulating the expression of certain specific genes (21). Vitamin A deficiency has repercussions on immune functions, such as impaired neutrophil function, suppressing the activity of natural killer (NK) cells, as well as a decline in their number, and damaged capacity of phagocytosing of macrophages. In addition, it may affect the growth and differentiation of B cells (2). In this way, the predisposition for infection disease can increase (22).

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Zinc represents another example of the micronutrient group. The transcription factor NF-κB (23) can be inhibited by Zinc . Also, the pro-inflammatory cytokines IL-1β and tumor necrosis factor (TNF-α) production (24) may be repressed, as a result of modulation of the Toll-Like Receptor 4 (TLR4) signaling pathway. Moreover, the pro-inflammatory specific Th17 and Th9 cell differentiation pathway (25, 26) can be moderated by Zn. Treg cell population can be increased after Zinc administration (27, 28) thus Zn is considered an important factor for immune cell development. Specific effects include impaired lymphocyte proliferation, Delayed-Type Hypersensitivity (DTH) response, and natural killer (NK) cell activity (29–31). As we mentioned before, there are strong and dynamic relationships between nutrition and the immune system, which are important for maintaining good health. We will discuss further in more details the role of specific nutrients in the mediation of pro-and anti-inflammatory responses.

II. DISCUSSION

Adequate intakes of micronutrients are required for the immune system to function efficiently. Micronutrient deficiency suppresses immunity by affecting innate, T cell mediated and adaptive antibody responses, leading to dysregulation of the balanced host response. This situation increases susceptibility to infections, with increased morbidity and mortality. In turn, infections aggravate micronutrient deficiencies by reducing nutrient intake, increasing losses, and interfering with utilization by altering metabolic pathways. Insufficient intake [4,5,6]of micronutrients occurs in people with eating disorders, in smokers (active and passive), in individuals with chronic alcohol abuse, in certain diseases, during pregnancy and lactation, and in the elderly. This paper summarises the roles of selected vitamins and trace elements in immune function. Micronutrients contribute to the body's natural defences on three levels by supporting physical barriers (skin/mucosa), cellular immunity and antibody production. Vitamins A, C, E and the trace element zinc assist in enhancing the skin barrier function. The vitamins A, B_6, B_{12}, C, D, E and folic acid and the trace elements iron, zinc, copper and selenium work in synergy to support the protective activities of the immune cells. Finally, all these micronutrients, with the exception of vitamin C and iron, are essential for antibody production. Overall, inadequate intake and status of these vitamins and trace elements may lead to suppressed immunity, which predisposes to infections and aggravates malnutrition. Therefore, supplementation with these selected micronutrients can support the body's natural defence system by enhancing all three levels of immunity.

Types of vitamins and their functions

Vitamins and minerals are a form of nutrient (called micronutrients) that are needed in small amounts. Although micronutrients don’t give us energy, they are involved in the metabolic processes that enable us to get energy from carbohydrates, protein and fat, which are also known as macronutrients.

Different vitamins serve different purposes and contribute to different bodily functions. There are 13 vitamins in total and 8 of these come from the B-group of vitamins.

Vitamin A
Vitamin A is important because it:

- makes the immune system work effectively so it can fight disease and infections
- keeps our skin healthy
- supports reproduction and growth
- helps with vision.

Food sources of vitamin A

There are different compounds with vitamin A activity in animal and plant foods. Plant foods can be easy to spot as they tend to have orange/yellow pigment known as beta-carotene.
Plant sources include:

- orange and yellow fruit and vegetables – such as carrots, red capsicum, mangoes, sweet potatoes, apricots, pumpkin and cantaloupe
- leafy green vegetables – such as spinach, peas and broccoli.

Animal sources include:

- liver
- eggs

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- some fortified milk and milk products (with added vitamin A).

Vitamin A deficiency risks

Because of the various roles that vitamin A plays in the body, deficiency can have several health effects. These include:

- increased risk of infections
- night blindness and irreversible blindness (xeropthalmia)
- excessive keratin build-up of the skin.

Vitamin B

B-group vitamins help our bodies use the energy-yielding nutrients (such as carbohydrates, fat and protein) for fuel. Some B-group vitamins are needed to help cells to multiply by making new DNA.

Except for B-12 and folate which are stored by the liver, most B-group vitamins can't be stored by the body. They must be consumed regularly in a healthy diet that includes a range of wholefoods (such as lean meat, fish, wholegrains, fruit, vegetables and legumes) and limits the intake of alcohol and processed foods.

The 8 types of vitamin B are:

- thiamin (B1)
- riboflavin (B2)
- niacin (B3)
- pantothenic acid (B5)[7,8,9]
- pyridoxine (B6)
- biotin (B7)
- folate or 'folic acid' when included in supplements (B9)
- cyanocobalamin (B12).

A person who has a poor diet for a few months may end up with B-group vitamins deficiency. For this reason, it's important that adequate amounts of these vitamins be eaten regularly as part of a well-balanced, nutritious diet.

Vitamin C

Dietary intake of vitamin C (from food and drinks) is essential, because the human body cannot make this vitamin from other compounds. We also need to have vitamin C as a regular part of our diet because the body cannot store vitamin C for very long.

Vitamin C (ascorbic acid) is important for many metabolic processes, including:

- Collagen formation – collagen is used in different ways throughout the body. Its primary role is to strengthen the skin, blood vessels and bone. The body also relies on collagen to heal wounds.
- Antioxidant function– the metabolism of oxygen within the body releases molecular compounds called 'free radicals', which damage cell membranes. Antioxidants are substances that destroy free radicals, and vitamin C is a powerful antioxidant.
- Iron absorption – the process of iron absorption is aided by vitamin C, particularly non-haem iron (found in plant foods such as beans and lentils).
- Infection fighting – the immune system, particularly cells called lymphocytes, requires vitamin C for proper functioning.
- Other roles – vitamin C is used to produce other important substances in the body such as brain chemicals (neurotransmitters).

Dietary sources of vitamin C

Adults need about 45mg of vitamin C per day and any excess amount (above 200mg) is excreted.

Vitamin C is sensitive to heat, so some of its nutritional benefits can be lost during cooking. Raw foods are more beneficial as dietary sources of vitamin C. These include:

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- fruit – oranges, lemons, limes, grapefruits, blackcurrants, mangoes, kiwifruits, rock melon, tomatoes and strawberries
- vegetables – particularly green vegetables (such as cabbage, capsicum, spinach, Brussels sprouts, lettuce and broccoli), cauliflower and potatoes.

Vitamin C deficiency and scurvy

A severe lack of vitamin C can lead to scurvy. We may think of it as a disease of the past, but it does still exist. Factors or lifestyle issues that may increase your scurvy risk include:

- regularly eating unhealthy foods
- crash dieting – especially being on diets that exclude certain food groups
- being malnourished due to inadequate care
- very strict allergy diets
- having an eating disorder
- smoking – smokers need more vitamin C to cope with the extra stress on their body.

Scurvy symptoms

The onset of symptoms of scurvy depends on how long it takes for the person to use up their limited stores of vitamin C.[10,11]
Scurvy is usually easy to treat – symptoms are like many other mild complaints and may include:

- fatigue and generally feeling unwell
- loss of appetite
- nausea and diarrhoea
- fever
- painful joints and muscles
- small ‘pinpoint’ bleeding around hair follicles visible in the skin.

If you or someone you care for is at risk, please see your doctor.

Vitamin D

Vitamin D is important for strong bones, muscles and overall health. Ultraviolet (UV) radiation from the sun is necessary to produce vitamin D in the skin and is the best natural source of vitamin D.
Regular physical activity also assists with the body’s production of vitamin D.
The body can only absorb small amounts of Vitamin D.

Spending too much time in the sun may increase your risk of skin cancer. Remember to use daily sun protection, especially at times when UV index levels are at their highest (3 or above).

Food sources of vitamin D

Only a small amount (around 5-10%) of Vitamin D is sourced from our diet. Sources include:

- fatty fish (such as salmon)
- eggs
- margarine and some milks have added vitamin D.

Vitamin D deficiency

It is important to achieve a good peak bone mass early in life. Vitamin D deficiency can result in a decline in bone density in adult life, increasing the risk of:

- osteoporosis

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- falls and bone fractures (especially for older people)
- rickets (in young children) – a preventable bone disease

Treatment options include improved sunlight exposure, diet, exercise, vitamin and mineral supplements.
If you are concerned about vitamin D levels, see your GP. Your GP may recommend vitamin D supplements, which should be taken strictly as directed.

Vitamin E

Vitamin E is an antioxidant that helps protect your body against damage from free radicals, such as exposure to cigarette smoke or radiation. It is also important for our:

- vision
- immune system
- skin.

Dietary sources of vitamin E

Vitamin E is best obtained from a healthy diet that contains plenty of fresh minimally processed foods. Vitamin E is also vulnerable to heat (especially cooking methods such as deep frying.[12,13]

Dietary sources include:

- meats (e.g. liver)
- egg yolks
- leafy green vegetables – spinach, broccoli
- nuts and seeds – such as almonds, sunflower seeds, peanuts and hazelnuts
- healthy oils – such as extra virgin, sunflower, soybean
- unprocessed cereals and wholegrains – such as wheat germ.

Vitamin E deficiency

Deficiency is rare but can happen in people with diseases that cause fat malabsorption (like cystic fibrosis).
Erythrocyte haemolysis is another deficiency – it's seen in infants born before vitamin E is transferred to them from their mother prior to birth.

Vitamin K

Vitamin K is important for:

- healthy bones
- blood clotting and wound healing
- newborn babies to prevent a serious bleeding condition called haemorrhagic disease of the newborn (HDN).

Dietary sources of vitamin K

We get vitamin K from food and the bacteria in our gastrointestinal tract. Newborn babies are given a booster to increase their vitamin K levels because they are born without bacteria in their gastrointestinal tract. We get much of our vitamin K from our diet.

Food sources include:

- leafy green vegetables – spinach and kale
- fruits – such as avocado and kiwi fruit
- some vegetable oils – such as soybean oil.

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Vitamin K deficiency

Vitamin K deficiency is unlikely except when fat is not absorbed properly or when certain medications are used. For example, antibiotics can kill the gastrointestinal bacteria that produce vitamin K.
Additionally, anticoagulant drugs (or blood thinners) may cause problems with vitamin K in the body. Check with your doctor if you have any concerns.

Types of minerals and their functions

There are hundreds of minerals – they are usually classified as either major or trace minerals.

Although the amount you need differs between minerals, major (or macrominerals) are generally required in larger amounts. Some examples include calcium, phosphorus, potassium, sulphur, sodium, chloride, magnesium.
Trace minerals (microminerals), although equally important to bodily functions are required in smaller amounts. Examples include iron, zinc, copper, manganese, and iodine selenium.
Some of the important minerals to keep us healthy are listed below.
Calcium
Calcium is vital to keep our bones strong and healthy. If you don't get enough calcium, your bones will eventually become weak and brittle and can lead to conditions like osteoporosis. Calcium helps:

- strengthen bones and teeth
- regulate muscle and heart function
- blood clotting
- transmission of nervous system messages
- enzyme function.

Food sources of calcium

At different life stages, our calcium needs vary. It is better to get calcium from foods than from calcium supplements.
Good sources of calcium include dairy foods like milk, yoghurt and cheese and some plant-based foods with added calcium (for example, soymilk, tofu and breakfast cereals).[14,15]
Other sources of calcium include almonds, bok choy, kale, parsley, broccoli and watercress.
Iodine
Iodine is essential to make thyroid hormones. These hormones control your metabolic rate (the rate your body uses energy when it is resting). They also help your brain and body grow and develop.
Food sources of iodine
We only need a very small amount of iodine in our diet. Iodine is found naturally in foods such as:

- dairy products
- seafood
- seaweed (kelp)
- eggs
- some vegetables.

Iodine can also be found in iodised salt. All bought breads (except organic) in Australia are fortified with iodised salt.
You are likely to be getting enough iodine through your diet. However, if you are deficient and need to take a supplement, be guided by your doctor. Too much iodine can be harmful, especially if you have an underlying thyroid disorder.

Iron

Iron is an important mineral that is involved in various bodily functions, including the transport of oxygen in the blood the provision of energy to cells. It also vital to help our immune system function effectively to fight infection.
Food sources of iron
Iron can be found in animal and plant foods including:

- red meat and offal
- fish
- poultry
- legumes

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- eggs
- breakfast cereals with added iron.

Iron deficiency

Iron deficiency is common and can affect adults and children. Around one in 8 people do not consume enough iron to meet their needs.
Some factors such as certain foods and drinks can affect how much iron your body absorbs. Also, some groups are more at risk of iron deficiency, such as babies and young children, teenage girls, women with heavy periods, vegans and vegetarians and people with chronic conditions.

Zinc

Zinc is an important mineral involved in various bodily functions – growth and development as well as immune function.
Zinc also helps to produce the active form of vitamin A and transports it around the body.
Food sources of zinc
Zinc is highest in protein-rich foods but may also be found in some plant foods. Dietary sources include:

- red meat
- shellfish
- poultry
- milk and cheese
- whole grains
- cereals with added zinc.

Magnesium

Magnesium is important due to its many functions in the body – including maintaining bone health and using glucose for energy.
Magnesium also supports immune function and helps regulate blood pressure and lung function.
Food sources of magnesium
Dietary sources include:

- nuts (such as cashews)
- legumes
- dark green vegetables
- seafood
- whole grains
- chocolate and cocoa.

Potassium

Potassium is important for the nerves, muscles and heart to work properly. It also helps lower blood pressure.
Food sources of potassium
Our bodies are designed for a high-potassium diet, not a high-salt diet. Food processing tends to lower the potassium levels in many foods while increasing the sodium content.
It is much better to eat unprocessed foods – such as fruit, vegetables and lean meats, eggs, fish and other healthy, everyday foods.
Foods high in potassium include:

- bananas and apricots
- mushrooms and spinach
- nuts and seeds.[11,12]

Be guided by your doctor, some people with kidney disease, or who are taking some medications, need to be careful not to get too much potassium in their diet.

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Sodium

A small amount of sodium is important for good health as it helps to maintain the correct volume of circulating blood and tissue fluids in the body.
Most of us are consuming far more sodium than we need. In fact, many Australians are consuming almost double the amount required.
Too much sodium can lead to high blood pressure (hypertension) and other health conditions.
Food sources of sodium
Salt is the main source of sodium in our diet. It is a chemical compound (electrolyte) made up of sodium and chloride.
Many foods – wholegrains, meat and dairy products – naturally contain small amounts of sodium, while highly processed foods usually contain large amounts.
Vitamin and mineral deficiencies and supplements
The fat-soluble vitamins A, D, E and K can be locked away in the liver and body fat, and stored for a long time. This means that they can cause toxicity if consumed in large amounts. The water-soluble vitamins, including B-complex and vitamin C, are mostly only stored for a shorter period.

A vitamin deficiency takes weeks or months before it will affect your health. For instance, it would take months of no vitamin C before you developed scurvy.
Vitamin and mineral supplements may be recommended in certain circumstances to correct vitamin and mineral deficiencies – such as folate for women who are pregnant or planning a pregnancy. Others who may be at risk of a vitamin or mineral deficiency include:

- pregnant women and women who are breastfeeding
- people who smoke, drink alcohol in excess or use illegal drugs
- crash dieters or those on very strict diets
- the elderly (especially those who are disabled or chronically ill)
- some vegetarians or vegans
- women with heavy periods
- people with food allergies
- people with malabsorption problems (such as diarrhoea, coeliac disease, cystic fibrosis or pancreatitis).

Remember, supplements are a short-term measure and should only be taken on advice from your doctor or a dietitian. An occasional lapse in good eating will not harm you, if your usual diet consists of a wide variety of fresh foods.[12,13,14]

III. RESULTS

Smith shares some tips for some of the top vitamins and minerals your immune system needs to perform:

1. Vitamin C

Vitamin C may help prevent infections or shorten their stay. Citrus fruits are a standout, but did you know there are other good sources? It's true! Smith recommends the following:

Spinach.
Kale.
Bell peppers.
Brussels sprouts.
Strawberries.
Papaya.
Fun fact: vitamin C is in so many foods that most people may not need to take supplements unless a doctor advises it. Consult with your doctor before taking any vitamin C supplements.

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2. Vitamin E

Like vitamin C, vitamin E can be a powerful antioxidant that helps your body fight off infection. This important vitamin — part of nearly 200 biochemical reactions in your body — is critical in how your immune system functions. To get your vitamin E, think high-fat plant foods such as:

Almonds.
Peanuts/peanut butter.
Sunflower seeds.
Oils such as sunflower, safflower, and soybean oil.
Hazelnuts.

3. Vitamin A

Vitamin A is an infection-fighter and comes in two forms: preformed such as in animal foods such as fish, meat and dairy or from plant carotenoids. Tuna is a great source of preformed vitamin A. When it comes to carotenoids, go colorful:

Carrots.
Sweet potatoes.
Pumpkin.
Butternut squash.
Cantaloupe.
Dark green leafy vegetables.

4. Vitamin D

Known as the sunshine vitamin, it's one of the most important and powerful nutrients for supporting the immune system. Food sources are limited but include:

Salmon.
Mackerel.
Tuna.
Sardines.
Vitamin D fortified like milk, orange juice and cereals.
In general, it's best to get most of your vitamins from food, but vitamin D may be the exception to that rule. Talk with your doctor to find out if you need a supplement.

5. Folate/folic acid

Folate is the natural form and folic acid is the synthetic form, often added to foods because of its health benefits. To get more folate, add more beans and lentils to your plate on a regular basis, as well as leafy green vegetables. Avocado is another tasty source. You can also get folic acid in fortified foods (check the label first).

Enriched pasta.
Enriched bread.[13,14,15]
Enriched rice.

6. Iron

Iron, which helps your body carry oxygen to cells, plays a part in many of the immune system processes. It comes in different forms. Your body can more easily absorb heme iron (aka iron from animal products), which is abundant in:

Red meat (limit to smaller amounts and less often).
Chicken.
Turkey.
Canned sardines.
Oysters.

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Clams.
Mussels.
Canned light tuna.
If you're a vegetarian, have no fear. You can still find iron in:

Beans.
Broccoli.
Kale.
Iron-fortified cereals.

7. Selenium

Selenium seems to have a powerful effect on the immune system being important for preventing infections. Animal foods are the best sources, with the exception of Brazil nuts, that offer a whopping greater than 100% daily value in one nut. However, too much can be a problem, so keep to no more than one to two of these in a day. Look for selenium in:

Seafood (tuna, halibut, sardines).
Meat and liver.
Poultry.
Cottage cheese.

8. Zinc

Zinc is needed for the production of new immune system cells. It's found primarily in animal foods but can be also found in some vegetarian food like.

Oysters.
Crab.
Lean meats and poultry.
Baked beans.
Yogurt.
Chickpeas.
Choose frozen when you can't get fresh
Depending on where you live and what time of year it is, you can't always get your hands on high-quality fresh produce. Keep in mind that buying frozen is a good option and can be quite convenient in our time-crunched world. Frozen food can still boost your immune system.

"Manufacturers freeze frozen fruits and veggies at 'peak' ripeness, which means they'll pack a similar nutritional value as their fresh counterparts," she says. "Just choose plain frozen foods rather than those with added sugars or sodium."
Tissue can be damaged by pathogens or other factors such as toxins, pollutants, trauma, and extreme temperatures. This elicits an inflammatory response that removes any foreign material at the site of injury, significantly reduces the spread of pathogens to other tissues, and prepares the site for tissue repair. The fever that can accompany inflammation intensifies the effects of IFNs, inhibits some microbial growth, and speeds up the body reactions that aid repair [
Vitamin A helps to regulate the production of IL-2 and the proinflammatory TNF-α, which activates the microbial action of macrophages [8]. Administration of vitamin D reduces the expression of pro-inflammatory cytokines and increases the expression of anti-inflammatory cytokines by macrophages via upregulation of MAPK phosphatase-1 and suppression of p38 activation [24,46,47,48]. Vitamin E decreases the production of prostaglandin E2 (which has immunosuppressive activity) [8], and vitamin C modulates cytokine production and decreases histamine levels [21]. In 2229 adults enrolled in the Framingham Offspring study, those with the lowest levels of pyridoxal 5′-phosphate (PLP), the active form of vitamin B6, had the highest levels of chronic inflammation, whereas those with highest levels of PLP had the lowest inflammation scores [51]. PLP is a cofactor in more than 150 enzymatic reactions and may help regulate inflammation by acting in pathways that produce metabolites with immunomodulatory effects [52]. In vitro and in vivo studies show that an iron-rich status promotes an M2-like macrophage phenotype (which is associated with wound healing and tissue repair) and negatively regulates an M1 pro-inflammatory response (such as production of ROS) through reduced NF-kB p65 nuclear translocation [33]. Zinc is an anti-inflammatory agent [8], while copper is important for the production and response of IL-2 to adaptive immune cells and accumulates at the sites of inflammation [2].

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IV. CONCLUSION

Antibody-mediated (humoral) immunity mainly works against extracellular pathogens in extracellular body fluids, such as blood and lymph. During this process, B cells break down the antigen, combine it with MHC-II self-antigens, and move the resulting complex into the B-cell plasma membrane. Th cells recognize the antigen-MHC-II complex and produce IL-2 and other cytokines to activate the B cells. Once activated, the B cell undergoes clonal selection and expansion into plasma cells and memory B cells. Plasma cells synthesize and secrete antibodies, which bind to a specific antigen, while memory B cells do not secrete antibodies but instead quickly proliferate and differentiate into more plasma cells and memory B cells if the antigen reappears in the future. Antibodies (and cytokines) are synthesized from amino acids; thus, like all proteins, they require vitamins B6 and B12 and folate during their endogenous synthesis and metabolism [7,8,35]. In patients with B12 deficiency, decreased CD8+ cells levels were observed, as was a high CD4/CD8 ratio and suppressed NK cell activity [103]. B12 is necessary for cell replication and cell division and this may explain the effect it has on rapidly proliferating B cells. Vitamin C increases serum levels of antibodies [7,21], and both copper and selenium have roles in antibody production [9,35]. Magnesium also acts as a cofactor for the synthesis of antibodies [38]. Calcitriol has an inhibitory effect, and suppresses IL-2 driven B-cell antibody production [15].

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