Research Article

COVID-19 like Viral Disease and Nutritional Based Preventions

Rizwan Shaukat[1*], Sana Sadaf[2], Musarrat Jahan[3], Hadiya Hassan[4], Bushra Munir[5], Syeda Nayab Bukhari[5], Saba Sehar[6]

[1]Department of Biochemistry, University of Okara, Renala Khurd Okara, Pakistan; [2]Department of Biochemistry, Faculty of Health and Medical Sciences, Hamdard University, Karachi- 74600, Pakistan; [3]College of Human Nutrition and Dietetics, Ziauddun University, Karachi- 74600, Pakistan; [4]Department of Biochemistry, University of Karachi, Pakistan; [5]Institute of Chemistry, University of Sargodha, Pakistan; [6]Department of Biochemistry, University of Agriculture Faisalabad, Faisalabad, Pakistan.

Abstract | COVID-19, which originated from China, resulted in a global pandemic across many countries when it spread through close contact. Upon studying it appeared to be a crown shaped RNA virus with a spike protein. As COVID-19 enters the body, B cells make antibodies and T cells directly attack it. COVID-19 affects the production and normal working of these cells. It attacks the respiratory pathways causing breathing problems. Older people develop more serious form of the disease that can be fatal whereas healthy people can recover and their immune system becomes stronger towards any future COVID-19 infection. Vaccines have been developed to provide immunity to the body prior to actual contact with the virus. Diet including immune-boosting foods, nutraceuticals, phytochemical and micronutrients (vitamins like A, C, D, E) which can help boost the immune system have been explained in detail. Diet is important because it can determine the system's stability against COVID-19 infection.

Editor | Muhammad Abubakar, National Veterinary Laboratories, Park Road, Islamabad, Pakistan.
Received | September 09, 2025; **Accepted** | November 07, 2025; **Published** | December 18, 2025
***Correspondence** | Rizwan Shaukat, Department of Biochemistry, University of Okara, Renala Khurd Okara, Pakistan; **Email:** rizwankhan36201@gmail.com
Citation | Shaukat, R., S. Sadaf, M. Jahan, H. Hassan, B. Munir, S.N. Bukhari, S. Sehar. 2026. COVID-19 like viral disease and nutritional based preventions. *Veterinary Sciences: Research and Reviews*, 12(1): 12-22.
DOI | https://dx.doi.org/10.17582/journal.vsrr/2026/12.1.12.22
Keywords | COVID-19, Characterization, Genome structure, Symptom, Boosting immunity, Treatment

Introduction

Since the peak of the COVID-19 pandemic, SARS-CoV-2 infectivity and associated mortality rates have decreased. However, society is still at risk from the growing number of new SARS-CoV-2 variants, such as KP.2, KP.3, and LB.1. Furthermore, a considerable number of individuals are now experiencing prolonged COVID-19 symptoms even after they have recovered from the acute phase of the disease. As a result, COVID-19 remains a public health problem (Gao *et al.*, 2020). But in 2019 from these families of viruses' new species arose that spread respiratory diseases in Asia (Chowdhury *et al.*, 2020). The infection of coronavirus virus was first of all identified in humans in 1931 but in 2019 the species of virus that spread is known as COVID-19 (Alagawany *et al.*, 2021).

The chain continued and another form of coronavirus appeared in 2019 in Wuhan, China (Yan-Rong *et al.*, 2020). In 2019 some countries Thailand, Japan, Korea confirmed the human infection which is COVID-19 that had basically started from China. The latest type of coronavirus caught the world by storm. It was necessary to identify the viral agent that was responsible for causing the COVID-19. SARS-CoV-2 was identified to be the viral agent (Chowdhury *et al.*, 2020). Strains of SARS-CoV-2 are divided into four types till now, including alpha, beta, gamma, delta. New type of corona virus is omicron which has large number of mutation due to its region generate transmissibility (Hossain *et al.*, 2021). Omicron and delta virus show same mutation. This mutated variant shows great resemblance to wuhan-Hu-1 variant. Out of 46 most frequent mutations, 23 mutations are in the spike and other 23 mutations are in structural protein like in membrane envelop and nucleocapsid (Wang *et al.*, 2020). Omicron cases are found in 26 countries and it is spreading rapidly. Hydrogen- bonding of sub-molecules of spike glycoprotein is backbone in these mutations. The omicron has co-indication with HIV (Brown *et al.*, 2021). These enhance the mutational ability of coronavirus. Most recent mutations in SARS CoV-2 are quite dominating just as delmicron. Delmicron is a blend of omicron and delta strains of corona. According to Chinese researchers the detectable viral loads of delta variant is thousand times elevated than other strains (Shiehzadegan *et al.*, 2021).

Flurona is a combined form of corona and influenza virus. It was diagnosed in a non-vaccinated young female patient of Israel. WHO said it is common to have coinfections in an individual (Pawlowski *et al.*, 2022). Flurona and delmicron have similar majority of symptoms as seen in previous variants, perhaps flurona symptoms are much alike influenza such as severe flue accompanied by cough, fever and throat itching.

COVID-19 does not require any specific mode of transmission and is easily transmitted during close contact. Old aged people are at the most risk of getting the COVID-19. Coronavirus infects animals and humans and can cross the species barrier to cause zoonotic infections in humans (Mishra *et al.*, 2021). Their zoonotic nature helps them to spread the disease and become a reason for epidemics and pandemics. Earlier when epidemic broke through, there wasn't any vaccine or treatment available and people suffered a lot. After receiving the virus, patients were initially treated with hydroxychloroquine and chloroquine as immediate aid, as US Food and Drug Administration had permitted the use of these (Pilkington *et al.*, 2020). In China, another antiviral drug which is known as Favilavir has been introduced for treating the patients of corona virus and has proved to be very efficient. Its use has been checked through 70 patients in Shenzhen, in Guangdong province (Byléhn *et al.*, 2021). Any type of drug that proved to be useful was used on globally for the treatment of patients. Some worked on locating the causes, while others worked on understanding the virus. It was really difficult to tackle the situation when virus had infected the whole world and immediate actions were required. However, as the virus shook the whole world, it had to go through barriers like physical barriers and body's natural defense. In this article we have discussed the reports from recent observations about body's natural defensive capabilities towards the coronavirus as the virus attacks the body and enters the host system. Some symptoms of the patients affected by the virus along with nutritional aspects have also been discussed.

Genome structure COVID-19

After a lot of study on this virus much is known to this day. Inspections have revealed that it is a RNA virus and its shape is like a crown with a diameter of about 60nm to 140 nm (Mertens *et al.*, 2021). There is a concave surface with a ridge on a side. This helps it in easier contacts with the ACE2 which is infecting the main receptor of COVID-19 in human body. ACE2 is Angiotensin-converting enzyme 2 (Yan *et al.*, 2020). The spike protein present on the virus can pinch inside the cell once that host cell is in contact with the virus. The entire genome of COVID-19 virus has been sequenced comprising of the 29,881 base pairs (Kousathanas *et al.*, 2022). A structural representation of COVID-19 virus is displayed in the Figure 1. The long polymeric chains of RNA are tightly packed up inside the center and the whole structure is protected by capsid which is formed of caspid proteins, called nucleocapsids. Another outer covering is made of fats or lipids with some proteins inserted into them. This is also known as an envelope (Ota, 2020). So, all these structures tend to provide protection to the viral RNA.

After getting into contact with the body, COVID-19

begins its processes of making its way into it. The virus can travel through air, not necessarily dependent on direct contact which makes it terrifying. It enters our nasal cavity when we inhale and proceeds to replicate there. It can make contact with ACE2 very easily because of its concave shape having a ridge that is very suitable for it (Kousathanas *et al.*, 2022). After having made contact with the host cell, it can begin its process of propagation and is then detected by the nasal swabs as an innate immune response. Continuing its path it reaches respiratory tract where immune response is more serious. Disease is also detected at this stage due to the production of cytokine (Panigrahy *et al.*, 2020). There is other type of infections as well. Beta and lambda infections were mainly caused by the epithelial cells that were infected with the virus. The disease however, is mild for nearly 80% of the people and is concerned with upper part of the body, more specifically; conducting airways. Remaining 20% patients have the risk of facing very severe disease that is fatal (Chowdhury *et al.*, 2020).

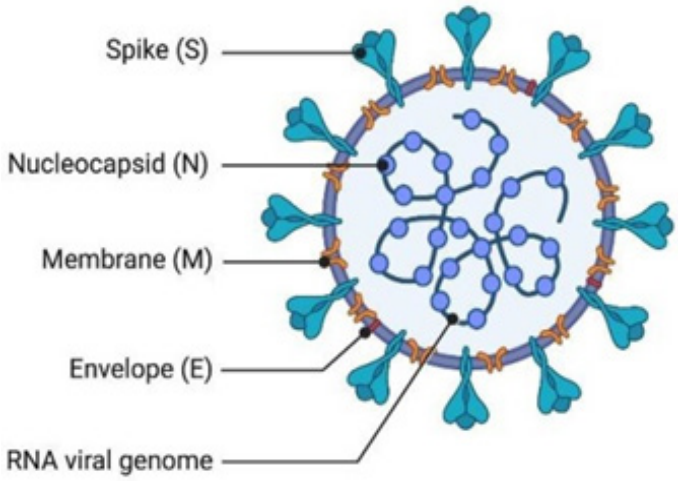

Figure 1: *Structure of coronavirus (https://www.biophysics.org).*

Viral entry into the cells

COVID-19 affects the epithelial cells and they become infected. It can replicate inside the cell and there it uses the biochemical machinery of the host cell itself to its advantage. It also causes the programmed cell death of the host cells (Kowalik *et al.*, 2020). The molecules that are released as a result of such cell death are known as the damage-associated molecular patterns. Innate and adaptive immunity response to virus, innate immunity followed by T-cells are also known as the killer cells. They have the ability of directly killing the virus when they encounter it. They force the B cells to produce antibodies for defense against virus. They produce a cytokine known as interferon that is dominant and helps in keeping the viral infection in check (Swadling and Maini, 2020). In patients affected by severe illness, T-cells do not function properly and cannot defend the body anymore. A distinct ability of COVID-19 is that it can affect T-cells and by doing this it directly affects their functioning. It is also known as lypmhopenia (Moon, 2020). It results in abnormally less number of T-cells. However, upon recovery, patients develop a strong T-cell response towards the virus as generally seen for any sort of viral infection. Adaptive immunity response tends to the production of antibodies. These are actually forked proteins that can bind to the virally infected cells and are secreted by B cells (Quinti *et al.*, 2020). T cells in the blood force B cells to produce antibodies specifically to the viral antigen. It has been observed that the cells that are affected by the virus show a type of response that is based on cellular level (Vardhana *et al.*, 2022; Chen and John, 2020).

Symptoms COVID-19

Long-term COVID symptoms vary from person to person and can impact several organ systems, such as the gastrointestinal tract, joints, bone marrow, endocrine system, central and peripheral neurological systems, and respiratory tracts (Subramanian *et al.*, 2022). Headache, sadness, and exhaustion are the most common symptoms Another syndrome that has symptoms with long-term COVID, including fatigue and post-exertional malaise, is myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) (Han *et al.*, 2022). It has been observed that many infected people do not develop any severe kind of symptoms. COVID-19 virus after the infection multiplies rapidly in respiratory tract and also infect cells present in their surroundings. The virus also damages the membranes and alveoli that can affect the oxygen supply to the body which causes difficulty in breathing (Alimohamadi *et al.*, 2020). The virus can also infect digestive tract that can cause the symptoms like indigestion, vomiting and diarrhea to appear.

Monitoring the COVID-19 patients

Studies showed that the risk factor for majority of patients who were having a severe condition due to virus was age. Most people were of old age and thus they were at high risk. They were found to be having conditions such as heart diseases, hypertension, tumors etc. (Calcaterra *et al.*, 2021). It was also revealed that people of age over 60 having conditions

like hypertension were at a great risk ofdeath due to COVID-19.

Treatment approaches

Polymerase inhibitors, such as Remdesivir, a nucleotide prodrug whose active metabolite can inhibit the activity of RNA polymerases, an essential enzyme for the reproduction of numerous viruses, including coronaviridae, are the principal antiviral medicines against COVID-19 that have been described. Remdesivir was authorised by the FDA to treat COVID-19 after demonstrating antiviral activity against SARS-CoV-2 (Wang *et al*., 2020; Williamson *et al*., 2020). Remdesivir's clinical antiviral efficacy against SARS-CoV-2 is still debatable, nevertheless. A clinical trial of COVID-19 patients who were not hospitalised was described in one article. After three days of remdesivir treatment, the safety of the recruited patients was acceptable, and the risk of hospitalisation or death was 87% lower than with a placebo (Gottlieb *et al*., 2022). Favipiravir is an antiviral medication that has antiviral effects on a range of RNA viruses by specifically inhibiting the viral RNA polymerase (Delang *et al*., 2018). According to a clinical research, patients with mild-to-moderate COVID-19 recovered much faster with conventional supportive care with early oral favipiravir monotherapy than with standard supportive care alone (Udwadia *et al*., 2021).

COVID-19 vaccines

After analyzing 47 people who had recently been given two doses of Pfizer and Moderna, researchers recorded the reaction of T-cells towards the vaccines. They investigated why the two doses of vaccination were necessary. They found that after the first dose, T-cells had responded greatly. Apparently, there was no need of another dose as described by the researchers. But it was eventually understood that for patients who never got COVID-19, first dose did not increase the antibodies significantly thus another dose was needed. But for people who have had COVID-19 in past, only one dose was required and another dose did not produce any significant effects (Agrati *et al*., 2021). This happened because the infection itself served as the first dose and antibodies had already been produced.

Natural strength of the body for protection against COVID-19

Through thick and thin, the human immune system has been trying to keep the body safe. It is the natural capability of the body to be protected from pathogens such as the viruses, bacteria and fungi etc. Immune response is a biological network that consists of different types of cells and proteins which provide resistance to infections. Immune system responds to a wide variety of pathogens including viruses, cancer cells, and foreign objects like wood sphincter. Even in case of COVID-19, immune system tries its best. A person with normal and healthy immune system may not notice any infection like the COVID-19. In general there are three types of the immunity provided by the immune system (Varfolomeev *et al*., 2004). First type is innate immunity which refers to the rapid response that is quick. Second type is the adaptive immunity which indicates a slower immune response. Third type of immunity is the passive one in which there are further two types. One such type is artificial immunity and the other type is termed as natural immunity. Natural immunity is the one coming from parents and artificial immunity is the result of medicine. Once the body is affected, inflammatory responses can be observed. But not every time the body can defenditself properly. Sometimes it cannot and it results in illness as seen in COVID-19. Immune system only needs to respond when there is invasion on the body by any foreign substance. If the immune response occurs without any stimulus, it can lead to autoimmune diseases in humans. So, normal working is necessary (Chowdhury *et al*., 2020).

Improving the human immune system against COVID-19

Lately it has been the aim of researchers to increase the defensive capability of human body. By making the immune system better, we can make it easier to deal with diseases before they even catch people. It is more convenient than having to provide people with medicines after they have been caught by the disease because treatment after the illness becomes difficult. For COVID-19 there have been reports indicating that the genome of COVID-19 is responsible for encoding of 10 proteins (Kousathanas *et al*., 2022). They have been studied and observed for weaknesses and hence located. There is a protein named as S protein. It is a glycoprotein that has been found to exist in the region that is infected with virus (Naserghandi *et al*., 2020). This S protein is of much significance. It can be targeted and therapists after knowing its location can use antibodies to aim for it. Using that knowledge to our advantage we have been able to synthesize neutralizing antibodies that are

oriented towards that Sprotein (Chang *et al*., 2021). Such vaccines have proved to be very effective in prevention of infection from the virus of same nature. Later if human cells happen to be infected with the virus, the epitopes of the proteins of that virus can be identified and bound to by the MHC-1 receptors that are present on the surfaces of the host, thereby initiating some immune responses that are antibody mediated and cell mediated by simply stimulating the CD4 type and CD8 type of T cells (Kousathanas *et al*., 2022).

Boosting the immune system

In the pandemic of COVID-19 when no effective treatment or vaccine was available for the disease, an effective immune system against this infection was necessary for defense. The immune system can be improved by the help of different types of nutrients that include the use of vitamins or minerals that are effective for the proper functioning of immune system (Butler and Barrientos, 2020). Nutrients inside the dietary supplementation benefit the immune response against viral infections. A recent analysis on Pediatric patients depicts that humoral immunity is enhanced by supplements of vitamin A, D and influenza vaccination (Carroll, 2008). Treatments against viral infections are positively affected by the application of several micronutrients, probiotics and herbal therapeutics because they improve the interferon response to the RNA viruses specially COVID-19**.** High morbidity and mortality rates due to pandemic are also connected to the economic condition of countries because malnutrition is due to the lower income of human beings. Malnutrition increases the infection rate and time of recovery, consequently enhancing the death rate (Fore *et al*., 2020). A balanced nutrition is crucial for protection against viral infections. Coronavirus pandemic (COVID-19) has highest rates of morbidity and mortality. It is documented that; the coronavirus disease is closely related to nutritionally ill patients whether they are children or adults. A study performed in the university hospital confirms the prevalence of malnutrition associated with the COVID-19. Malnutrition not only leads to COVID-19 but also prolongs the hospitalization period**.** Another study was performed which came across an eye-opening finding that 49% of COVID-19 patients admitted in the hospital were facing malnutrition and the mortality rate was possibly 10 times as compared to well-nourished people (Rouget *et al*., 2020).

Dietary recommendations are the solution against malnutrition and COVID-19 and can decrease the disease load and severity (Savant *et al*., 2021)**.** During the period of covid pandemic, beneficial impact of nutraceuticals was under spot light, because they play a preventive as well as therapeutic role in the human body and maintain the normal body functions by aiding the immune system to work against pathogens especially, influenza-like. Intake of low saturated fatty acids, plant-based diet assists the body to defend itself against the harmful agents. White blood cells produced by the body protect against pathogens. A high intake of vitamins and a low intake of fats leads to the growth of simpler white blood cells in vegetarians (Hargreaves *et al*., 2021). Antiviral properties of trace elements, vitamins and other nutraceuticals have been tested within as well as outside the body on animals.

The natural bioactive compounds can also reduce the inflammatory response induced by the SARS COVID-19 (Sriram and Insel, 2020). Currently, the COVID-19 is prevented and treated based on vaccines. Due to the limited availability of data about COVID-19, there is no specific diet to treat coronavirus disease, therefore the international community changes to endorsing a well dietary design planned to control thrombosis and inflammation that lead to the syndrome related complications. Polyphenols, curcumin, resveratrol, luteolin, lignans and flavonoids are specific phytochemicals that protect against COVID-19. Polyphenols with antioxidant properties play a crucial role in the modulation of LDL oxidation and also have antiplatelet, anti-inflammatory and antiviral characteristics (Paraiso *et al*., 2021). Polyphenols including Epigallocatechin Gallate (EGCG) (Menegazzi *et al*., 2020) and Theaflavin-3,3′-gallate (TF3) (Mhatre *et al*., 2021) present in black tea and green tea interact with receptors present on the binding site to prevent the entry into the cell. Another study performed laid stress on the use of phytochemicals present in Garlic including Flavonoid, e.g., Quercetin can be used in medications as it interferes with the structure of protease (3CLPro) and blocks its functioning and mitigates the SARS COVID-2 enzyme, that plays a role in duplication and infection. Clinical trials confirm the broad antiviral potential of Quercetin (Diniz *et al*., 2020).

Micronutrients diet as immune response

Micronutrients like vitamins (vitamin A**,** D, C, E)

are included in the micronutrients diet. Vitamin A performs several functions in oxidative stress (reducing free radicals), immunoregulatory activities and is also responsible for pro-inflammatory compounds, like Tumor Necrosis Factor (TNF) and interleukin-2(IL-2) (Gerster, 1997). It is also involved in the down-regulation of IFN Retinol's high and low amount in the human body causes many respiratory tract infections and diseases. Vitamin A1 is involved in the modulation of expressing genes of platelet-activating factors. In the presence of PAF, the retinoic acid acts synergistically and play role in the activation of the inducible prostaglandin synthase gene that protects gastric mucosal (Detopoulou *et al*., 2021). Moreover, the serum of retinol is inversely involved in the activity of Lipoprotein-associated phospholipase A2 that is noted in the epidemiology (Hajibabaei, 2016).

Vitamin C with antioxidant characteristics improves the immune system. Functionally, it plays role in the T-cell maturation. Currently used medicinal dosage of ascorbic acid (24 grams per day within the vein through a syringe for a week) in hospitalized patients of COVID-19. It is shown that the level of LP-PLA_2 which is a catabolic enzyme increased in COVID-19 outcomes and the level of vitamin C, E, d-tocopherol decrease. Thus, vitamin C can affect micro-thrombotic, inflammatory and PAF morbidity of COVID-19 (Abobaker *et al*., 2020).

Vitamin D stimulates the maturation of immune cells. The level of Vitamin D in the body is lower in winter as compared to summer. People having lesser exposure to sunlight due to their life routine can face the deficiency of vitamin D. First case of SARS COVID-19 was recorded in Wuhan during the winter season, when Vitamin D level is comparatively lower in the northern hemisphere (Ebadi and Montano-Loza, 2020). It is reported that deficiency of vitamin D causes bovine coronavirus infection. Vitamin D supplement is a safer way to improve its total content in the body. Mechanisms of how vitamin D boost immunity against COVID 19 involves inhibition of Platelet-activating factor and interference in the structure of an enzyme involved in the replication of SARS CoV-2 to stop its proliferation (Detopoulou *et al*., 2021). Vitamin D has anti-oxidant and antimicrobial effects and protects the immune system from respiratory diseases (Ebadi and Montano-Loza, 2020). According to meta-analysis, supplementation of vitamin D is involved in the reduction of chronic respiratory diseases, and inversely connected to a viral load of hepatitis and improves the antimicrobial immunity of HIV-1 patients. The level of vitamin D is lesser in COVID-19 positive patients. In vitro, it is proposed that 1, 25-dihydroxy vitamin D_3 decreases the release of (PAF-AH) enzymes from heterozygous immune cells known as placenta macrophages (Strathmann *et al*., 2011). Vitamin D stops the cytokine production by switching pro-inflammatory Th1 and Th17 to the anti-inflammatory Th2 and Treg response as shown in the Figure 2 (Daneshkhah *et al*., 2020). It reduces the chances of pneumonia and also helps in preventing many other symptoms of infection as well.

Vitamin D lessens the possibility of viral infection and mortality through a variety of mechanisms. It works through three pathways to reduce the risk of catching a cold: the physical barrier, natural cellular immunity, and adaptive immunity (Ebadi and Montano-Loza, 2020). The adaptive immunity regulate immunity through inhibiting type 1 responses and stimulating induction. Vitamin D supplementation was also found to enhance CD4+ T cell count, one of the major manifestations of severe SARS-CoV-2 infection (Ohaegbulam *et al*., 2020). The COVID-19 has a significant impact on people who are suffering from this type of illness (Karim *et al*., 2021). Countries south of latitude 35° north have low death rates, indicating a task of vitamin D in determining outcomes from COVID-19. Supplementation is used when the deficiency of vitamin D is confirmed.

Vitamin E antioxidant activity plays a significant part in the improvement of immunity. It provides a defense to the cell membrane and immune cells against lipid peroxidation. It is shown that the level of vitamin E is decreased in the infection and supplementation doses of vitamin E are useful in reducing harshness and period of illness (Tavakol and Seifalian, 2021). The low level of vitamin E follows the production of PAF in the polynuclear cell of rat. Additionally, vitamin E is involved in the inhibition of platelet aggregation induced by PAF and its synthesis (Detopoulou *et al*., 2021). Moreover, lycopene separates or by combining with a-tocopherols decreases PAF synthesis as the result of stimulation of endothelial cells that are further involved in inflammatory cataract and increase the level of LP-PLA_2, the bits of help in the reduction of asthma infection. It can also affect levels of PAF, metabolism, their activities on platelets for example the pro-thrombotic status (Chowdhury *et al*., 2020).

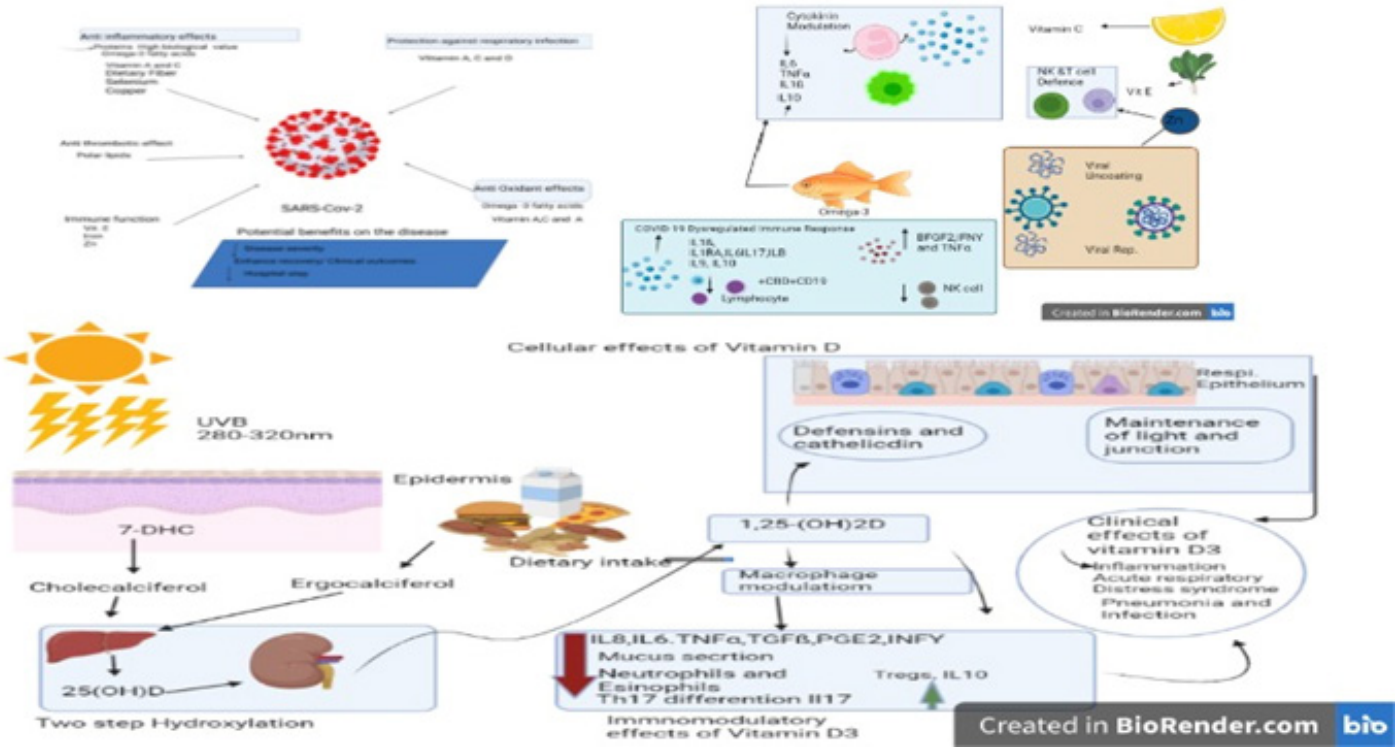

Figure 2: *Vitamin D activity: Vitamin D[25(OH)D] can be obtained through diets or when sunlight hits the skin. When vitamin D is produced it has major cellular and immunomodulatory effects. At cellular level it leads to production of Defensing and Cathelicidins which are defense peptides. It also maintains light junction. It bumps up immune system via different processes such as mucous secretion and white blood cells formation. Clinical effects include inflammation and infections.*

Dietary recommendations

Diets high in vitamin A, B, C, D, E, B-complex vitamins, and minerals are pertinent immune system modulators. Vitamins and minerals are abundant in fruits and vegetables Furthermore, fruit and vegetables are high in water, antioxidants, and fiber, all of which aid in the management of hypertension, diabetes, and obesity, three of the most significant risk factors for COVID-19 complications. The risk of viral infection is decreased by Vitamin D because it stops the entry of the virus into the cell by acting as an anti-inflammatory and an immunomodulatory agent. Vitamins can be obtained from dietary sources as discussed previously.

Studies have encouraged the use of whole-grain foods, fruits, and vegetables during the COVID-19 pandemic. Vitamins and minerals such as zinc and vitamin C, A, and D maintain the well-functioning immune system. Supplementation is especially beneficial for those facing nutrient deficiency (Lordan *et al.*, 2021).

Conclusion

COVID-19 continues to challenge global health systems through the emergence of new variants and variable vaccine responsiveness. Future efforts should prioritize vaccine adaptation to ensure broad and durable protection against evolving SARS-CoV-2 strains, including the development of next-generation vaccines targeting conserved viral regions and mucosal immunity. Additionally, integrating nutrition-based preventive strategies offers a promising complementary approach to enhance immune resilience. Diets enriched with essential micronutrients, phytochemicals, and antioxidants can strengthen host defenses, mitigate inflammatory responses, and improve vaccine efficacy. A multidisciplinary focus combining immunogenomic surveillance, adaptive vaccine design, and nutritional immunology will be crucial in establishing long-term preparedness and minimizing future pandemic risks.

Acknowledgement

This study was not funded by any funding agency.

Novelty Statement

The review is the first to combine existing evidence on corona virus pathogenesis with a comprehensive assessment of nutrition-based means to improve immunity, with the view of how micronutrients, phytochemicals, and nutraceuticals can be used in combination with the current treatment and vaccination methods. Compared to previous reviews, where the virology or clinical management is primarily considered, this article is a cross-disciplinary viewpoint of the association between the characteristics of viral genomes and immune dysregulation and dietary interventions and presents new information on the prevention of COVID-19 and long-term resilience on a holistic basis.

Author's Contribution

All Authors contributed equally to the manuscript.

Competing interest statement

The authors have no relevant financial or non-financial interests to disclose.

Ethical approval

Not applicable: No human or animal studies were performed.

Informed consent

Not applicable.

Consent for publication

Not applicable.

Data availability statement

No datasets were generated or analyzed during the current study. The authors declare that the data supporting the findings of this study are available within the paper.

Generative AI and AI-assisted technology statement

The authors declare that they have not used generative AI and AI-assisted technologies in the writing process before submission.

Conflict of interest

The authors have declared no conflict of interest.

References

Abobaker, A., Alzwi, A. and Alraied, A.H.A., 2020. Overview of the possible role of vitamin C in management of COVID-19. Pharmacol. Rep., 72(6): 1517-1528. https://doi.org/10.1007/s43440-020-00176-1

Agrati, C., Castilletti, C., Goletti, D., Meschi, S., Sacchi, A., Matusali, G. and Notari, S., 2021. Coordinate induction of humoral and spike specific T-cell response in a cohort of Italian health care workers receiving BNT162b2 mRNA vaccine. Microorganisms, 9(6): 1315. https://doi.org/10.3390/microorganisms9061315

Alagawany, M., Attia, Y.A., Farag, M.R., Elnesr, S.S., Nagadi, S.A., Shafi, M.E. and El-Hack, A., 2021. The strategy of boosting the immune system under the COVID-19 pandemic. Front. Vet. Sci., 712. https://doi.org/10.3389/fvets.2020.570748

Alimohamadi, Y., Sepandi, M., Taghdir, M. and Hosamirudsari, H., 2020. Determine the most common clinical symptoms in COVID-19 patients: A systematic review and meta-analysis. J. Prevent. Med. Hyg., 61(3): E304.

Brown, L.B., Spinelli, M.A. and Gandhi, M., 2021. The interplay between HIV and COVID-19: Summary of the data and responses to date. Curr. Opin. HIV Aids, 16(1): 63-73. https://doi.org/10.1097/COH.0000000000000659

Butler, M.J. and Barrientos, R.M., 2020. The impact of nutrition on COVID-19 susceptibility and long-term consequences. Brain, Behav. Immun., 87: 53-54. https://doi.org/10.1016/j.bbi.2020.04.040

Byléhn, F., Menéndez, C.A., Perez-Lemus, G.R., Alvarado, W. and De Pablo, J.J., 2021. Modeling the binding mechanism of remdesivir, favilavir, and ribavirin to SARS-CoV-2 RNA-dependent RNA polymerase. ACS Central Sci., 7(1): 164-174. https://doi.org/10.1021/acscentsci.0c01242

Calcaterra, G., Bassareo, P.P., Barillà, F., Sergi, D., Chiocchi, M., Romeo, F. and Mehta, J.L., 2021. The deadly quartet (Covid-19, old age, lung disease, and heart Failure) explains why coronavirus-related mortality in northern Italy was so high. Curr. Cardiol. Rev., 17(1): 74-77. https://doi.org/10.2174/1573403X16666200731162614

Carroll, M.C., 2008. Complement and humoral

immunity. Vaccine, 26: I28-I33. https://doi.org/10.1016/j.vaccine.2008.11.022

Chang, C.K., Lin, S.M., Satange, R., Lin, S.C., Sun, S.C., Wu, H.Y. and Hou, M.H., 2021. Targeting protein-protein interaction interfaces in COVID-19 drug discovery. Comput. Struct. Biotechnol. J., 19: 2246-2255. https://doi.org/10.1016/j.csbj.2021.04.003

Chen, Z. and John, W.E., 2020. T cell responses in patients with COVID-19. Nat. Rev. Immunol., 20(9): 529-536. https://doi.org/10.1038/s41577-020-0402-6

Chowdhury, M.A., Hossain, N., Kashem, M.A., Shahid, M.A. and Alam, A., 2020. Immune response in COVID-19: A review. J. Infect. Publ. Health. https://doi.org/10.1016/j.jiph.2020.07.001

Daneshkhah, A., Agrawal, V., Eshein, A., Subramanian, H., Roy, H.K. and Backman, V., 2020. The possible role of vitamin D in suppressing cytokine storm and associated mortality in COVID-19 patients. MedRxiv., https://doi.org/10.1101/2020.04.08.20058578

Delang, L., Abdelnabi, R. and Neyts, J., 2018. Favipiravir as a potential countermeasure against neglected and emerging RNA viruses. Antiviral Res., 153: 85–94. https://doi.org/10.1016/j.antiviral.2018.03.003

Detopoulou, P., Demopoulos, C.A. and Antonopoulou, S., 2021. Micronutrients, phytochemicals and mediterranean diet: A potential protective role against COVID-19 through modulation of PAF actions and metabolism. Nutrients, 13(2): 462. https://doi.org/10.3390/nu13020462

Detopoulou, P., Fragopoulou, E., Nomikos, T., Yannakoulia, M., Stamatakis, G., Panagiotakos, D. and Antonopoulou, S., 2015. The relation of diet with PAF and its metabolic enzymes in healthy volunteers. Eur. J. Nutr., 54(1): 25-34. https://doi.org/10.1007/s00394-014-0682-3

Diniz, M. C., Martins, M. G., Xavier, K. V. M., Silva, M. D., and Santos, E. D. A. 2020. Crise global coronavírus: monitoramento e impactos. Cadernos de prospecção, 13(2), 359-377.

Ebadi, M. and Montano-Loza, A.J., 2020. Perspective: Improving vitamin D status in the management of COVID-19. Eur. J. Clin. Nutr., 74(6): 856-859. https://doi.org/10.1038/s41430-020-0661-0

Fore, H.H., Dongyu, Q., Beasley, D.M. and Ghebreyesus, T.A., 2020. Child malnutrition and COVID-19: The time to act is now. Lancet, 396(10250): 517-518. https://doi.org/10.1016/S0140-6736(20)31648-2

Gao, Y., Yan, L., Huang, Y., Liu, F., Zhao, Y., Cao, L. and Zhang, L., 2020. Structure of the RNA-dependent RNA polymerase from COVID-19 virus. Science, 368(6492): 779-782. https://doi.org/10.1126/science.abb7498

Gerster, H., 1997. Vitamin A-functions, dietary requirements and safety in humans. Int. J. Vitamin Nutr. Res., 67(2): 71-90.

Gottlieb, R.L., Vaca, C.E., Paredes, R., Mera, J., Webb, B.J., Perez, G., Oguchi, G., Ryan, P., Nielsen, B.U., Brown, M. and Hidalgo, A. 2022. Early remdesivir to prevent progression to severe covid-19 in outpatients. N. Engl. J. Med., 386(4): 305– 15. https://doi.org/10.1056/NEJMoa2116846

Hajibabaei, K., 2016. Antioxidant properties of vitamin E. Ann. Res. Antiox., 1(2).

Han, Q., Zheng, B., Daines, L. and Sheikh, A., 2022. Long-term sequelae of COVID-19: A systematic review and meta-analysis of one-year follow-up studies on post-COVID symptoms. Pathogens, 11: 269. https://doi.org/10.3390/pathogens11020269.

Hargreaves, S.M., Nakano, E.Y., Han, H., Raposo, A., Ariza-Montes, A., Vega-Muñoz, A. and Zandonadi, R.P., 2021. Quality of life of vegetarians during the COVID-19 pandemic in Brazil. Nutrients, 13(8): 2651. https://doi.org/10.3390/nu13082651

Hossain, M.K., Hassanzadeganroudsari, M. and Apostolopoulos, V., 2021. The emergence of new strains of SARS-CoV-2. What does it mean for COVID-19 vaccines? Exp. Rev. Vaccines, 20(6): 635-638. https://doi.org/10.1080/14760584.2021.1915140

Karim, M.M., Sultana, S., Sultana, R. and Rahman, M.T., 2021. Possible benefits of zinc supplement in CVD and COVID-19 comorbidity. J. Infect. Publ. Health, 14(11): 1686-1692. https://doi.org/10.1016/j.jiph.2021.09.022

Kousathanas, A., Pairo-Castineira, E., Rawlik, K., Stuckey, A., Odhams, C.A., Walker, S. and Millar, J., 2022. Whole genome sequencing reveals host factors underlying critical Covid-19. Nature, pp. 1-10.

Kowalik, M.M., Trzonkowski, P., Łasińska-Kowara, M., Mital, A., Smiatacz, T. and Jaguszewski,

M., 2020. COVID-19 toward a comprehensive understanding of the disease. Cardiol. J., 27(2): 99-114. https://doi.org/10.5603/CJ.a2020.0065

Lordan, R., Rando, H.M. and Greene, C.S., 2021. Dietary supplements and nutraceuticals under investigation for COVID-19 prevention and treatment. Msystems, 6(3): e00122-21. https://doi.org/10.1128/mSystems.00122-21

Menegazzi, M., Campagnari, R., Bertoldi, M., Crupi, R., Di Paola, R. and Cuzzocrea, S., 2020. Protective effect of epigallocatechin-3-gallate (EGCG) in diseases with uncontrolled immune activation: Could such a scenario be helpful to counteract COVID-19? Int. J. Mol. Sci., 21(14): 5171. https://doi.org/10.3390/ijms21145171

Mertens, G., Duijndam, S., Smeets, T. and Lodder, P., 2021. The latent and item structure of COVID-19 fear: A comparison of four COVID-19 fear questionnaires using SEM and network analyses. J. Anxiety Disord., 81: 102415. https://doi.org/10.1016/j.janxdis.2021.102415

Mhatre, S., Srivastava, T., Naik, S. and Patravale, V., 2021. Antiviral activity of green tea and black tea polyphenols in prophylaxis and treatment of COVID-19: A review. Phytomedicine, 85: 153286. https://doi.org/10.1016/j.phymed.2020.153286

Mishra, J., Mishra, P. and Arora, N.K., 2021. Linkages between environmental issues and zoonotic diseases: with reference to COVID-19 pandemic. Environ. Sustain., 4(3): 455-467. https://doi.org/10.1007/s42398-021-00165-x

Moon, C., 2020. Fighting COVID-19 exhausts T cells. Nat. Rev. Immunol., 20(5): 277-277. https://doi.org/10.1038/s41577-020-0304-7

Naserghandi, A., Allameh, S.F. and Saffarpour, R., 2020. All about COVID-19 in brief. New microbes and new infections, pp. 35. https://doi.org/10.1016/j.nmni.2020.100678

Ohaegbulam, K.C., Swalih, M., Patel, P., Smith, M.A. and Perrin, R., 2020. Vitamin D supplementation in COVID-19 patients: A clinical case series. Am. J. Therapeut., pp. e485. https://doi.org/10.1097/MJT.0000000000001222

Ota, M., 2020. Will we see protection or reinfection in COVID-19? Nat. Rev. Immunol., 20(6): 351-351. https://doi.org/10.1038/s41577-020-0316-3

Panigrahy, D., Gilligan, M.M., Huang, S., Gartung, A., Cortés-Puch, I., Sime, P.J. and Hammock, B.D., 2020. Inflammation resolution: A dual-pronged approach to averting cytokine storms in COVID-19? Cancer Metastasis Rev., 39(2): 337-340. https://doi.org/10.1007/s10555-020-09889-4

Paraiso, I.L., Revel, J.S. and Stevens, J.F., 2020. Potential use of polyphenols in the battle against COVID-19. Curr. Opin. Food Sci., 32: 149-155. https://doi.org/10.1016/j.cofs.2020.08.004

Pawlowski, C., Silvert, E., O'Horo, J.C., Lenehan, P.J., Challener, D.W., Gnass, E. and Geyer, H., 2022. SARS-CoV-2 and influenza co-infection throughout the COVID-19 pandemic: An assessment of co-infection rates and cohort characterization. medRxiv. https://doi.org/10.1101/2022.02.02.22270324

Pilkington, V., Pepperrell, T. and Hill, A., 2020. A review of the safety of favipiravir–a potential treatment in the COVID-19 pandemic? J. Virus Eradic., 6(2): 45-51. https://doi.org/10.1016/S2055-6640(20)30016-9

Quinti, I., Lougaris, V., Milito, C., Cinetto, F., Pecoraro, A., Mezzaroma, I. and Filippini, M., 2020. A possible role for B cells in COVID-19? Lesson from patients with agammaglobulinemia. J. Allergy Clin. Immunol., 146(1): 211-213. e214. https://doi.org/10.1016/j.jaci.2020.04.013

Rouget, A., Vardon-Bounes, F., Lorber, P., Vavasseur, A., Marion, O., Marcheix, B. and Conil, J.M., 2020. Prevalence of malnutrition in COVID-19 inpatients: The Nutricov study. https://doi.org/10.21203/rs.3.rs-41500/v1

Savant, S., Srinivasan, S. and Kruthiventi, A.K., 2021. Potential nutraceuticals for COVID-19. Nutr. Dietary Suppl., 13: 25. https://doi.org/10.2147/NDS.S294231

Shiehzadegan, S., Alaghemand, N., Fox, M. and Venketaraman, V., 2021. Analysis of the delta variant B. 1.617. 2 COVID-19. Clin. Pract., 11(4): 778-784. https://doi.org/10.3390/clinpract11040093

Sriram, K. and Insel, P.A., 2020. Risks of ACE inhibitor and ARB usage in COVID-19: Evaluating the evidence. Clin. Pharmacol. Therapeut., 108(2): 236-241. https://doi.org/10.1002/cpt.1863

Strathmann, F.G., Laha, T.J. and Hoofnagle, A.N., 2011. Quantification of 1α, 25-dihydroxy

vitamin D by immunoextraction and liquid chromatography–tandem mass spectrometry. Clin. Chem., 57(9): 1279-1285. https://doi.org/10.1373/clinchem.2010.161174

Subramanian, A., Nirantharakumar, K., Hughes, S., Myles, P., Williams, T., Gokhale, K.M., Taverner, T., Chandan, J.S., Brown, K., Simms-Williams, N., and Shah, A.D., 2022. Symptoms and risk factors for long COVID in non-hospitalized adults. Nat. Med., 28: 1706–1714. https://doi.org/10.1038/s41591-022-01909-w

Swadling, L. and Maini, M.K., 2020. T cells in COVID-19 united in diversity. Nat. Immunol., 21(11): 1307-1308. https://doi.org/10.1038/s41590-020-0798-y

Tavakol, S. and Seifalian, A.M., 2021. Vitamin E at a high dose as an anti-ferroptosis drug and not just a supplement for COVID-19 treatment. Biotechnol. Appl. Biochem., https://doi.org/10.1002/bab.2176

Udwadia, Z.F., Singh, P., Barkate, H., Patil, S., Rangwala, S., Pendse, A., Kadam, J., Wu, W., Caracta, C.F. and Tandon, M. 2021. Efficacy and safety of favipiravir, an oral RNA-dependent RNA polymerase inhibitor, in mild-tomoderate COVID-19: A randomized, comparative, open-label, multicenter, phase 3 clinical trial. Int. J. Infect. Dis., 103: 62–71. https://doi.org/10.1016/j.ijid.2020.11.142

Vardhana, S., Baldo, L., Morice, W.G. and Wherry, E.J., 2022. Understanding T cell responses to COVID-19 is essential for informing public health strategies. Sci. Immunol., 7(71): eabo1303. https://doi.org/10.1126/sciimmunol.abo1303

Varfolomeev, E., Kischkel, F., Martin, F., Seshasayee, D., Wang, H., Lawrence, D. and French, D., 2004. APRIL-deficient mice have normal immune system development. Mol. Cell. Biol., 24(3): 997-1006. https://doi.org/10.1128/MCB.24.3.997-1006.2004

Wang, M., Cao, R., Zhang, L., Yang, X., Liu, J., Xu, M., Shi, Z., Hu, Z., Zhong, W. and Xiao, G., 2020. Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) *in vitro*. Cell Res., 30(3): 269–271. https://doi.org/10.1038/s41422-020-0282-0

Williamson, B.N., Feldmann, F., Schwarz, B., Meade-White, K., Porter, D.P., Schulz, J., Van Doremalen, N., Leighton, I., Yinda, C.K., Pérez-Pérez, L. and Okumura, A. 2020. Clinical benefit of remdesivir in rhesus macaques infected with SARS-CoV-2. Nature, 585(7824): 273–276. https://doi.org/10.1038/s41586-020-2423-5

Yan, R., Zhang, Y., Li, Y., Xia, L., Guo, Y. and Zhou, Q., 2020. Structural basis for the recognition of SARS-CoV-2 by full-length human ACE2. Science, 367(6485): 1444-1448. https://doi.org/10.1126/science.abb2762

Yan-Rong, G., Qing-Dong, C., Zhong-Si, H., Yuan-Yang, T., Shou-Deng, C., Hong-Jun, J. and Yan, Y., 2020. The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak–an update on the status. Milit. Med. Res., 7: 11. https://doi.org/10.1186/s40779-020-00240-0