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COVID-19 and Nutrition

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Merrimack College Honors Senior Capstone

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Abstract

Many individuals who contract COVID-19 and experience poor outcomes are also found to be deficient in certain vitamins and minerals. As a result, many nutrients have been related to improved outcomes for patients suffering from COVID-19. While it is not proven that increased intake of any one vitamin or mineral can prevent COVID-19, the supplementation of specific vitamins or minerals such as vitamin C, vitamin D, zinc, and magnesium could impact the risk of getting COVID-19 and the severity of cases of COVID-19. Positive benefits are expected from this relationship because certain vitamins and minerals have been known to support the immune system and impact the effects of respiratory diseases. Since COVID-19 impacts populations differently, nutritional measures of prevention and treatment may be more beneficial for those who are more at risk of developing COVID-19 and experiencing poorer outcomes.

When discussing the relationship between COVID-19 and nutrition, there are many significant topics to consider. Topics that will be discussed throughout this paper include immune response, vitamin C, vitamin D, zinc, magnesium, food insecurity, and comorbidities. In order for one to increase their sense of self efficacy in assessing their risk of contracting COVID-19 and reacting appropriately, it is important to have a general understanding of the immune response that COVID-19 evokes. Awareness of adequate intake and function of vitamins and minerals is also of notable importance. Recognizing how this virus impacts various populations such as communities that experience food insecurity will also help one assess their risk of contracting COVID-19 and understand how to react appropriately. Awareness of other factors such as pre-existing chronic diseases, being clinically overweight or obese, and experiencing a deficiency in vitamins and minerals also contribute to risk of contracting and severity of COVID-19 will also be discussed.

Many have grown all too familiar with the novel coronavirus since headlines started reporting its widespread transmission beginning at the end of 2019. The current pandemic sweeping the world is caused by the SARS-CoV-2 virus also known as the coronavirus or COVID-19. This is an enveloped zoonotic virus of the coronaviridae family that causes disruption to the respiratory system (Virus Explorer). This virus differs from the previous two coronavirus outbreaks known as SARS-CoV-1 and MERS-CoV. COVID-19 is spread very easily among humans through respiratory droplets. The symptoms of COVID-19 can range in severity and can even lead to death in vulnerable individuals especially those who are immunocompromised. Individuals who already experience chronic disease, the elderly, those who are from racial and ethnic minority groups, and individuals who are classified as clinically

overweight or obese are more at risk of contracting this virus as well as experiencing a poorer outcome (Coronavirus (COVID-19) Frequently Asked Questions). There is currently no vaccine to prevent this virus and no treatment, instead health care professionals focus on managing symptoms as best as possible, as well as focus on reducing transmission.

Immune Response

COVID-19 is a respiratory virus that seriously attacks the immune system. The presence of the virus produces a systemic inflammatory response which causes cytokines to be released in an attempt to contain and get rid of the virus (Coperchini, Francesca, et al.). As a result, patients who are afflicted by COVID-19 experience high levels of pro-inflammatory cytokines and chemokines (Shakoor, Hira, et al.). This state is known as a cytokine storm and occurs when cytokine production is uncontrolled and does not slow down. In managing COVID-19, it is necessary to address this inflammatory response. Many micronutrients are known to play a positive role in supporting an anti-inflammatory response. For example, vitamins C, D, E, zinc, selenium and the omega 3 fatty acids have been proven to positively support the immune response and thus provide benefits in fighting infectious disease (Shakoor, Hira, et al.).

Considering this, adequate intake of these specific micronutrients could play a crucial role in supporting the body's immune response when considering COVID-19 severity and prevalence. This is especially true when considering the older population who are more susceptible to being affected by COVID-19 because aging naturally puts the body and the immune system in an inflamed state (Shakoor, Hira, et al.). Supplementation of these micronutrients offers minimal

risk and could potentially aid in supporting the body's immune response in all individuals, but especially in the older population.

There is much debate surrounding which micronutrients might be helpful in managing COVID-19 cases and symptoms. Vitamins such as C, D, and E are said to be some of the most necessary. One study found that adequate levels of vitamins C, D and E are crucial during COVID-19 because they have the potential to reduce symptom burden as well as lessen the duration of respiratory infection. Minerals such as zinc should also be considered because zinc has antiviral effects that may improve immune responses and suppress viral replication (Shakoor, Hira, et al.). Supplementation of these vitamins should be considered if an adequate intake is not provided through diet. The entity at stake is the integrity of our immune system; therefore, adequate consumption of these vitamins and minerals through the diet or through supplementation is necessary to guarantee the proper functioning of the immune system (Shakoor, Hira, et al.). This suggestion is not to be taken lightly when considering the potential dangers of contracting the COVID-19 virus.

As there is currently no treatment or vaccination to prevent the spread of the COVID-19 virus, many are turning to other approaches to protect themselves. One approach that has continued to grow in popularity since the beginning of the spread of the virus is the supplementation of various vitamins and minerals. So far, this method is seen to have significantly positive outcomes. Vitamins that support the immune response are of the greatest importance at a time like this. Vitamins such as C and D as well as zinc and magnesium are just some of the main micronutrients that are necessary to promote normal capacity to develop an adequate immune response. Deficiencies of any of these micronutrients are common and may

predispose an individual to certain infections as well as increase susceptibility of experiencing a poorer outcome (de Almeida Brasiel). Ensuring that intake of these vitamins meets at least the recommended dietary allowance could impact one's outcome when considering the severity of contracting or being able to evade the COVID-19 virus and thus is of the utmost importance.

Vitamin C

Vitamin C plays a large role in supporting the body's immune system. It plays an essential role in immune cell function as well as supporting various mechanisms of both the innate and adaptive immune systems (Waqas Khan, Hafiz Muhammad, et al). Specifically, it supports the epithelial barrier function, which helps protect the body from environmental oxidative stress and participates in microbial killing, against pathogens (Carr and Maggini). It helps remove infected cells which helps decrease overall cell death caused by a pathogen (Carr and Maggini). The recommended dietary allowance of vitamin C for an adult is around 75 to 90 milligrams per day (Office of Dietary Supplements - Vitamin C). The best food sources of vitamin C include red peppers, oranges, and broccoli (Office of Dietary Supplements - Vitamin C). Vitamin C intake can also be supplemented through pills and intravenous infusions. These methods of supplementation can offer many health benefits because of the specific properties of vitamin C in supporting the immune system such as its antioxidant and anti-inflammatory properties (Waqas Khan, Hafiz Muhammad, et al). For someone whose immune system is under attack, it can be most beneficial if delivered as a continuous high-dose intravenous infusion of around 2000 mg (Simonson). Vitamin C can be most beneficial when the body is suffering

extreme stress. As a result of this relationship, it is likely that vitamin C has the ability to positively impact the outcomes of patients suffering from COVID-19.

The potential benefits of administering an intravenous infusion of vitamin C can be very positive. According to a study conducted by Waqas Khan, Hafiz Muhammad, et al., there are benefits in giving high-dose intravenous vitamin C to critically ill COVID-19 patients. These benefits include reduction of systemic inflammation, shortened length of mechanical ventilation and ICU stay, and quicker recovery. Supplementation of vitamin C is considered to be an appropriate option for individuals who are micronutrient deficient and are at risk of contracting the COVID-19 infection because it can assist with the prevention and support of immune responses (Shakoor, Hira, et al.). Another study by Hiedra, Raul, et al. noted that there was a significant decrease in certain inflammatory markers and in the fraction of inspired oxygen requirements after vitamin C was administered. This study concludes that the use of intravenous administration of vitamin C in patients with moderate to severe COVID-19 disease may be an extremely beneficial option (Hiedra, Raul, et al.). Based on these findings, it is clear that the supplementation of vitamin C among patients suffering from COVID-19 has the potential to strengthen the immune system and offers a positive response.

Based on these findings it is recommended that intake of vitamin C meet at least the recommended daily allowance. A medical doctor from Oregon State University even recommended that optimum daily intake for those who are not suffering from COVID-19 may be about 2000 milligrams, but he noted that the first 250 milligrams is most important for achieving adequate serum levels (Simonson). Attaining adequate intake of vitamin C through the diet is preferred before supplementation is considered. Achieving at least 250 milligrams of vitamin C

through the diet is not challenging as long as high quality, vitamin C rich food sources are available. This level can be exceeded through consuming one orange, one cup of raw red pepper, one kiwi, and eight medium size strawberries. Intake beyond the recommended adequate intake can be supplemented orally or through an intravenous infusion. Oral supplementation if it is necessary is widely accessible and affordable. Increasing intake of vitamin C for precautionary measures seems like an effective idea at a time as uncertain as this one, especially when the risk is minimal since vitamin C toxicity is rare. The relationship between vitamin C and COVID-19 is clearly one that is positive in favor of the patient. Since it could improve the overall outcomes, it should be strongly considered. If one is on medication or is skeptical about introducing a new supplement into their daily regiment they should consult their doctor.

Vitamin D

The relationship between Vitamin D and COVID-19 is essential to consider when focusing on mitigating the prevalence and severity of the virus. Vitamin D is primarily synthesised from the sun by the skin through exposure to the ultraviolet light of the sun (Forrest, Kimberly Y.Z., and Wendy L. Stuhldreher). The recommended dietary allowance of vitamin D ranges from 10-20 mcg (Office of Dietary Supplements - Vitamin D). The best sources of vitamin D are the flesh of fatty fish such as trout, salmon, tuna, and mackerel as well as fish liver oils (Office of Dietary Supplements - Vitamin D). Fish are such excellent sources of vitamin D because their bodies do not synthesize it and they are able to store large amounts in their fatty tissue (Lock, E. J., et al.). In the body, vitamin D plays a vital role. It helps your body absorb calcium and plays a role in supporting the nervous, muscle, and immune systems (Vitamin D

Deficiency). It has roles in a wide variety of body systems, including in both innate and adaptive immune responses and enhances innate cellular immunity (Shakoor, Hira, et al.).

Supplementation of this vitamin should be considered because of the prevalence of vitamin D deficiency. Vitamin D deficiency is common in children and adults especially in the winter months when sun exposure is decreased (Mundell). Vitamin D deficiency is so common that a study from 2011 estimated 41.6% of U.S. adults are considered deficient (Forrest, Stuhldreher). In the United States, the prevalence of vitamin D deficiency is clearly widespread. Vitamin D intake should be regularly monitored because deficiency could contribute to development and progression of hypertension and cardiovascular disease. Vitamin D deficiency has also been linked to the development of other chronic diseases such as type 1 diabetes, multiple sclerosis, rheumatoid arthritis and other autoimmune conditions (Forrest, Kimberly Y.Z., and Wendy L. Stuhldreher). Clearly, vitamin D deficiency is serious as it can increase one's risk of developing other chronic diseases. Those at risk of vitamin D deficiency should be especially cautious because the prevalence of vitamin D deficiency varies among different populations. Race is one factor that can impact vitamin D deficiency. Prevalence of vitamin D deficiency varies widely depending on race with 82.1% of Black Americans and 69.2% of Hispanic Americans being deficient (Forrest, Stuhldreher). Individuals who are classified as overweight or obese are also at an increased risk of experiencing vitamin D deficiency. One study found that as skin thickness and subcutaneous fat increase, vitamin D levels decrease (Ata, Ayşe Merve, et al.). These individuals especially should air on the side of caution and seriously consider vitamin D supplementation because they are already predisposed to experience deficiency.

Vitamin D supplementation should definitely be considered when treating patients with COVID-19. Low vitamin D is common in cases of respiratory infection (Weir, E. K., et al.). Due to its benefits in addressing other respiratory infections, the relationship between increased intake of vitamin D and COVID-19 is assumed to be positive in favor of the patient. One study conducted by a Dr. Michael Holick of Boston University found that “Among patients older than 40, those who were vitamin D-sufficient were also 51.5% less likely to die from COVID-19 compared to those who were vitamin D-deficient or insufficient” (Mundell). This study exemplifies the suspected positive relationship between vitamin D sufficiency and COVID-19. Another reason that vitamin D should be considered for patients experiencing COVID-19 is because it also promotes anti-inflammatory cytokines (Shakoor, Hira, et al.). This could be beneficial in attempting to subdue the proinflammatory cytokine storm that COVID-19 causes. Since COVID-19 produces a systemic inflammatory response, this effect of vitamin D could be very beneficial for patients. This will not only boost immunity against COVID-19 but also reduce human mortality which is incredibly valuable in a time that lacks COVID-19 treatment (Shakoor, Hira, et al.). These benefits should encourage vitamin D to be strongly considered for the prevention and positive outcomes of cases of COVID-19.

Based on these findings it is recommended that intake of vitamin D should meet at least the recommended daily allowance. This amount might need to be modified when considering individuals who are at risk. Some recommend that those who are more at risk of contracting COVID-19 should consider “taking 10,000 IU/d of vitamin D3 for a few weeks to rapidly raise 25(OH)D concentrations, followed by 5000 IU/d to reduce the risk of infection” (Grant, William B., et al.). This recommendation is seen as extreme by some since it is many times larger than the

average recommended dietary allowance, but those more at risk should at least exceed the recommended daily allowance. Populations such as the elderly, those who are considered immunocompromised, those who are most at risk of contracting an infection because they have a chronic disease, those who have a low 25(OH)D status, and those who are in frequent contact with these individuals should be taking vitamin D (Grant, William B., et al.). Through the winter months or when sun exposure is minimal, adequate intake of this vitamin is more important than ever because countries that experience a higher prevalence of vitamin D deficiency also tend to have a higher burden of COVID-19 morbidity and mortality which is not a coincidence (Shakoor, Hira, et al.). Increasing vitamin D intake is a safe prevention and mitigation strategy with minimal risk. Vitamin D toxicity is possible, but if approached appropriately, the risk of supplementing a micronutrient such as vitamin D should be minimal. Like vitamin C, vitamin D is also widely accessible as well as affordable. If one is on medication or is skeptical about introducing a new supplement into their daily regiment they should consult their doctor.

Zinc

Zinc is not a vitamin but a trace mineral. It is commonly known that zinc has an enhancing effect on the immune system. This micronutrient aids in processes such as growth, development, and the maintenance of immune function (de Almeida Brasiel). As a result of this relationship, many increase their intake of zinc by taking supplements when they begin to show signs of sickness. The recommended dietary allowance of zinc for adults ranges from eight through thirteen milligrams (Office of Dietary Supplements - Zinc). Food sources of zinc include oysters, beef chuck roast, crab, beef patties, and lobster (Office of Dietary Supplements - Zinc).

Considering many of the food sources of zinc are from animals, those who follow vegetarian and vegan diets in particular might be at risk of being deficient in zinc. Proper zinc intake is necessary to ensure a proper immune response.

The relationship between COVID-19 outcome and the role of zinc has been widely discussed in recent months. Many relate positive outcomes of COVID-19 cases with the increased presence of micronutrients like zinc in the blood. Researchers from Spain have conducted small studies that found that patients who are hospitalized with COVID-19 who also have low blood levels of zinc tended to fare worse and experience poorer outcomes compared to those with healthier levels (Mundell). This finding supports the proposed relationship; that an increased presence of zinc in the blood can positively influence a COVID-19 outcome. When considering its relationship with the inflammatory response, zinc deficiency significantly increases pro-inflammatory cytokines which unnecessarily triggers an immune response (Shakoor, Hira, et al.). This suggests that maintaining an adequate intake of zinc will promote a normal or anti-inflammatory immune response. Since COVID-19 also forces the body to enter an inflamed state, adequate presence of zinc is necessary to ensure that this state is able to be managed and controlled because deficiency further contributes to this inflamed state. One particular study found that when four patients who had COVID-19 were treated with high-dose zinc they all showed both clinical symptomatic improvements. This finding supports that zinc supplementation is able to decrease COVID-19 related symptoms such as lower respiratory tract infection and general respiratory distress by evoking an appropriate immune response (Shakoor, Hira, et al.). Clearly, supplementation of the mineral zinc can offer positive benefits to

individuals afflicted by the COVID-19 virus and should be considered in mitigation and treatment strategies.

Based on these findings, it is recommended that zinc intake meet at least the recommended dietary allowance for individuals who are not experiencing COVID-19. Those who already experience suboptimal levels of zinc intake may want to consider supplementation to achieve adequate intake. Zinc deficiency is very common; it affects one third of the worldwide population (Inga Wessels, et al.). Clearly, much of the population struggles to meet the recommended dietary allowance of zinc through diet alone, so alternative methods of supplementation should be considered. Individuals especially who follow vegetarian, vegan, or other diets that restrict intake of animal products should strongly consider zinc supplementation. These individuals may struggle the most to achieve adequate zinc intake through diet alone and are among the most vulnerable of experiencing zinc deficiency. A patient who is experiencing COVID-19 may want to consider a larger dose of zinc ranging from five to two hundred milligrams because of the beneficial relationship that has been seen when zinc is included in treating other respiratory tract infections such as pneumonia and cystic fibrosis (Inga Wessels, et al.). Zinc toxicity is rare, so there is little risk in increasing the overall intake of zinc. There are few challenges in acquiring zinc supplements. Zinc supplements are also widely available as well as relatively affordable. If one is on medication or is skeptical about introducing a new supplement into their daily regimen they should consult their doctor.

Magnesium

The mineral magnesium is also reported to have a beneficial relationship with instance and severity of COVID-19 cases. Magnesium plays an important role in supporting many functions of the body and as a result, adequate intake of this mineral is essential to maintaining proper health. Magnesium plays a key role in regulating muscle and nerve function, blood sugar levels, blood pressure and making protein, bone, and DNA (Office of Dietary Supplements - Magnesium). These processes may not seem like they relate directly to those that COVID-19 impacts, but that is not the case. The positive relationship seen between adequate magnesium intake and COVID-19 outcome and prevalence encourages adequate magnesium intake to be considered as a method of prevention and treatment. The recommended dietary allowance of magnesium for adults ranges from 310 to 400 milligrams (Office of Dietary Supplements - Magnesium). Common sources of magnesium include pumpkin seeds, chia seeds, almonds, and spinach (Office of Dietary Supplements - Magnesium). Experiencing chronic magnesium deficiency can have adverse health effects such as predisposition to developing a chronic disease like high blood pressure, heart disease, type two diabetes, osteoporosis, and migraines (Office of Dietary Supplements - Magnesium). For these reasons as well as its ability to positively impact the prevalence of COVID-19 and the outcome of cases, adequate magnesium intake should be encouraged.

The mineral magnesium has a variety of functions in the body, but most notably, magnesium has anti-inflammatory properties. Evidence exists supporting magnesium supplementation through magnesium sulfate and magnesium oxide to prevent or treat numerous types of diseases related to the respiratory system. It has offered benefits for those suffering from

asthma by decreasing the inflammatory response and oxidative stress, as well as improving lung inflammation (Tang, Chuan-Feng, et al.). As a result of this relationship, magnesium is presumed to similarly benefit those suffering from COVID-19 since both are conditions that cause respiratory distress. Magnesium sulfate specifically is likely beneficial for controlling pulmonary symptoms such as shortness of breath, fatigue, and chest pain which are symptoms commonly experienced by COVID-19 patients (Tang, Chuan-Feng, et al.). As a result of its offered benefits, magnesium supplementation is expected to play a large role in clinical practice when considering the prevention and treatment of COVID-19 (Tang, Chuan-Feng, et al.). This being said, adequate intake of magnesium is more important than ever. Being deficient in the mineral magnesium can have adverse effects on the body. Such effects include decreased immune cell activity and increased inflammation which promotes the cytokine storm associated with COVID-19. (Shakoor, Hira, et al.). This could be incredibly dangerous for someone who is experiencing COVID-19 because their body will already be experiencing an inflamed state. Deficiency in vitamins and minerals such as magnesium may contribute to the decline of a COVID-19 patient's condition (Tang, Chuan-Feng, et al.). As a result, magnesium levels should be monitored in those who are afflicted with COVID-19.

Based on these findings it is recommended that magnesium intake meet at least the recommended dietary allowance for individuals who are not experiencing COVID-19. Clearly adequate intake of magnesium is essential to the integrity of the immune system. Experiencing suboptimal intake of magnesium can have serious consequences. For individuals experiencing COVID-19, adequate intake of magnesium is required to ensure that their prognosis is as good as it can possibly be. One study recommended a “daily oral magnesium supplementation 310–320

mg or 400–420 mg for COVID-19 adult women or men patients with mild symptoms, respectively, especially in patients with mild magnesium deficiency (serum magnesium concentration range from 0.5 to 0.75 mmol/L)” (Tang, Chuan-Feng, et al.). This recommendation ensures that the recommended dietary allowance of magnesium. Additional magnesium intake through the diet can continue because it will ensure adequate intake. Those experiencing COVID-19 might be advised to ensure that magnesium intake when delivered through a serum does not exceed 3.5 and 5 mmol/L as at this range, the first signs of toxicity will occur (Tang, Chuan-Feng, et al.).

Although adequate intake of magnesium is important, it is possible to supplement with too much magnesium. Mega doses of this mineral are controversial because excessive intake of magnesium may cause nausea, vomiting, diarrhea, hypotension, confusion, slowed heart and respiratory rates, coma, cardiac arrhythmia, deficiency of other minerals, as well as death from cardiac arrest (Tang, Chuan-Feng, et al.). As these are not desirable outcomes, magnesium intake must be monitored. If one is on medication or is skeptical about introducing a new supplement into their daily regimen they should consult their doctor.

Food Insecurity

As a result of the COVID-19 pandemic, many individuals and families are struggling with financial stress from unemployment or underemployment. This is only adding to economic stress and increasing the prevalence of poverty on a global scale. An indirect consequence of COVID-19 is that it is making access to food as well as availability of food more challenging for many families and individuals worldwide (Perez-Escamilla, Rafael, et al.). COVID-19 is

impacting peoples' status when considering food security. Those who previously did not experience challenges financing or obtaining their food may be for the first time. One study predicted that "COVID-19 is projected to hit particularly hard the food, nutrition, and health security of vulnerable groups" (Perez-Escamilla, Rafael, et al.). Vulnerable groups include those whose access to food has been altered as a result of the pandemic. Factors such as transportation, economic status, and location are examples of social determinants of health meaning they have the ability to positively or negatively impact an individual's health status. All of these factors may have been impacted by the pandemic and thus may make someone more vulnerable to experiencing food insecurity especially if they have experienced it in the past.

Areas that experience food insecurity have also experienced poorer outcomes when considering COVID-19. Those who experience nutritional deficiencies such as deficiencies of vitamins and minerals have an increased risk of poor outcomes from COVID-19 which makes adequate nutrition even more important than ever (Shakoor, Hira, et al.). Being undernourished or malnourished, much like being immunocompromised, increases one's risk of contracting COVID-19 and negatively impacts one's prognosis once the virus has been established in the body. India is an example of a country that experiences widespread food insecurity. This is generally concerning but is even more of a concern with the presence of COVID-19. The undernourished children in this area have a higher risk of death from common illnesses such as diarrhea, pneumonia, and malaria. This gives the COVID-19 virus even greater potential to devastate this area. There is concern around the death toll when considering individuals who experience COVID-19 in India because this population is already so vulnerable to experiencing hunger (Mishra, Khushbu, and Jeevant Rampal). As of April 13th, 2020 in India, 195 people died

because of the lockdown. Of these deaths, 53 were caused by lack of food or livelihood (Mishra, Khushbu, and Jeevant Rampal). Clearly, the prevalence of food insecurity in this country is impacting the outcome of those who live there as well as the death toll.

Some criticize specific countries' approaches of addressing COVID-19 especially in areas which previously experienced food insecurity; “the multi-dimensional implications of food insecurity points that the steps to preventing COVID-19 related deaths should have been accompanied with steps to preventing deaths related to food insecurity and hunger” (Mishra, Khushbu, and Jeevant Rampal). Food insecurity is obviously not something that can be solved overnight, but considering its detrimental effects, some argue that addressing it should have been considered in response to the COVID-19 pandemic. The COVID-19 pandemic has illustrated that the world is incredibly unprepared to protect populations against hunger, food, nutrition, and health insecurity during global emergency situations which has proved to be incredibly problematic (Perez-Escamilla, Rafael, et al.). The fallout of this could be detrimental to all populations but most specifically to populations who are already vulnerable in some way. This experience is an opportunity to rethink our response to ensure that if a similar situation were to arise in the future, we would be prepared to respond immediately in a more efficient manner.

Comorbidities

Experiencing a pre-existing chronic illness such as heart disease, diabetes, cancer, arthritis, and bowel diseases like Crohn's disease and ulcerative colitis could increase one's risk of contracting COVID-19 as well as experiencing a worse outcome (Understanding Acute and Chronic Inflammation). These chronic illnesses force the body into a state of chronic

inflammation. Although inflammation can be a good thing in moderation because it is a natural immune response that helps the body heal and repair itself, maintaining a chronically inflamed state can negatively impact one's health because it forces the immune system into overdrive.

Individuals who experience hypertension and diabetes mellitus are among those who are most at risk of contracting COVID-19 because these are some of the most common diseases seen in COVID-19 patients (Tang, Chuan-Feng, et al.). The understanding of this relationship is a crucial step in protecting these vulnerable populations.

Being overweight or obese also increases one's risk of obtaining COVID-19 and experiencing a poorer outcome. This can be explained because people who are overweight or obese are not only at risk of developing a chronic disease, but also at high risk for experiencing severe complications of COVID-19 such as cardiac issues (Ryan, Donna H.). In this respect, the United States is extremely at risk because between 2015 and 2016, 71.6% of adults ages 20 and over were either considered overweight or obese (FastStats - Overweight Prevalence.). This is incredibly concerning because of the implications that it could potentially have on the US population.

Experiencing a chronic disease may also increase one's risk of being deficient in vitamins and minerals which further increases their risk of contracting COVID-19. In individuals who experience conditions such as end-stage renal disease and chronic hemodialysis, lower vitamin C concentrations are typically observed (Office of Dietary Supplements - Vitamin C). Vitamin D deficiency is commonly observed in individuals who experience chronic kidney disease (Study Findings from Indus Hospital Provide New Insights into Vitamin D Deficiency). In patients who experience chronic obstructive pulmonary disease (COPD), bronchial asthma, cardiovascular

diseases, autoimmune diseases, kidney diseases, dialysis, obesity, diabetes, cancer, atherosclerosis, liver cirrhosis, immunosuppression, and known liver damage, low serum zinc levels are regularly seen. These groups of individuals are highly at risk of contracting COVID-19 (Inga Wessels, et al.). For those who suffer from any of these diseases, zinc supplementation would be beneficial and could even be a preventative measure decreasing their risk of contracting the COVID-19 virus. Those who experience Crohn's disease, celiac disease, regional enteritis, and type two diabetes are likely to also experience suboptimal levels of magnesium and thus experience deficiency (Office of Dietary Supplements - Magnesium). For these individuals, supplementation might be necessary to ensure adequate intake as long as the supplements are safe to consume with any medication they might be on. Those who experience chronic disease especially should consult their doctor to ensure that introduction of a new supplement will not cause any unintentional harm or side effects.

Conclusion

Clearly, nutritional status is incredibly important to consider when addressing the COVID-19 virus. Especially in a time when a vaccine for this virus is not FDA approved, the need of alternative approaches that can contribute to reducing the severity of the virus is urgent. Adequate intake of the vitamins and minerals discussed is an example of a method that can contribute to improving the health status of individuals, and could decrease the severity of the virus. Proper nutrition or supplementation is essential because adequate levels of certain vitamins such as C and D are imperative to reduce symptom burden and lessen the duration of a respiratory infection such as COVID-19. Adequate intake of minerals such as zinc are also

crucial because of their antiviral effects which may improve immune responses and suppress viral replication (Shakoor, Hira, et al.). In order to ensure that the immune system functions properly, adequate intake is necessary. The integrity of the human immune system is being threatened by COVID-19, and adequate intake of these vitamins and minerals offers individuals a method of mitigating or evading its effects. This is especially important for individuals who experience chronic diseases as they are more susceptible to contracting the virus and experiencing poor outcomes and thus are most at risk.

As a public health initiative, communities should encourage individuals to be proactive in improving their health status. As an individual, it is possible to impact one's risk of both contracting COVID-19 and experiencing a poorer outcome due to pre-existing conditions or inadequate intake of vitamins and minerals. With an understanding of information regarding vitamin and mineral intake and health status, one should feel an increased sense of self efficacy in assessing their risk of contracting COVID-19 and reacting appropriately. Monitoring one's vitamin and mineral intake and making dietary improvements is a recommended precaution to take in an attempt to decrease their risk of contracting COVID-19 and experiencing a poorer outcome. It is important that all communities have adequate access to proper nutrition, vitamin and mineral supplementation, or both. Vulnerable populations such as those living in elderly care facilities and those who live in food deserts especially should have access to these resources as they are most in need of the potential benefits.

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