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Article · January 2023

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## Research Article

### Long COVID in the Older Adult and Vitamin D

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#### Abstract

**Background:** The coronavirus COVID-19 strain that emerged in December 2019 continues to produce a widespread and seemingly intractable negative impact on health and longevity and life quality in all parts of the world, especially, among older adults with chronic health conditions.

**Objectives:** The first aim of this updated review article was to examine, summarize, synthesize, and report on the research base concerning the possible use of vitamin D in the realm of the recently emergent syndrome termed long or post-acute COVID-19 disease. A second was to establish any health associated preventive and intervention recommendations for the older adult with long COVID-19 manifestations, who may yet be susceptible to future COVID-19 variant infections and others.

**Methods:** To examine the association between vitamin D and long COVID-19 illness manifestations, articles responding to several key words entered into leading data bases were examined: These included the terms: Vitamin D, Long/Post-Acute COVID-19 and/or COVID-19. Databases employed were PUBMED, PubMed Central and Google Scholar. All relevant articles were carefully examined and those meeting the review criteria were carefully read, and described in narrative form.

**Results:** Data reveal some possible benefits may accrue in the context of COVID-19 illness prevention and rehabilitation by efforts to ensure optimal vitamin D serum levels among high risk, vitamin D deficient, and chronically challenged post-acute COVID-19 older adults.

**Conclusion:** More rigorous and carefully construed research efforts to examine vitamin D implications and its moderating or mediating role in averting or mitigating long COVID-19 health complications are strongly warranted.

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**Citation:** Ray Marks (2023) Long COVID in the Older Adult and Vitamin D. J Gerontol Geriatr Med 9: 155.

**Received:** December 27, 2022; **Accepted:** January 02, 2023; **Published:** January 09, 2023

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**Keywords:** Coronavirus; COVID -19; Long COVID -19; Older adults; Post-acute COVID-19 syndrome; Vitamin D

#### Abbreviations

COVID-19: Corona Virus (Coronavirus) Disease 19

#### Introduction

In December 2019, a lethal coronavirus later termed COVID-19 and that was initially observed in Wuhan, China, spread rapidly to become a pandemic that was unanticipated [1]. Now, at the close of 2022, almost three years later, while somewhat attenuated, COVID-19 disease remains a serious global health concern despite months of intense investigation into its origins, as well as a search for effective strategies to counter its impact. At the same time, a subgroup of older as well as younger adults who survived one or more acute bouts of COVID-19 disease have now been shown to remain variably impaired physically and mentally by the disease now termed 'long or post COVID-19' syndrome [2,3-5], which can persist for up to one year, and especially among cases in the higher age ranges [6].

This long term or post COVID-19 health condition or syndrome of multiple health complications that may involve a syndrome characterized by persistent symptoms and/or delayed or long-term complications beyond 4 weeks from the onset of symptoms [5], may last for up to a year and possibly more than a year. Although not initially anticipated in 2019 and thereafter, or well understood, it appears the long COVID-19 syndrome is commonly associated with multiple symptoms of debility that include, but are not limited to: fatigue, shortness of breath, persistent coughing, joint and chest pain, muscle aches, headaches, and a cognitive condition situation known as 'brain fog' [1,3,6-8]. At the same time, although the organ specific COVID-19 disease targets are quite well established [7], why there are long-term effects on physical and leisure time function as well as mood, and why this occurs among some cases and not others, is unclear. Moreover, how to anticipate this state and prevent it, as well as how to treat this state once it prevails, including possible symptoms of depression, anxiety and concentration challenges [9] is currently uncertain at best. However, among the various attributes or mechanisms underpinning the condition may be dietary status and the presence of various suboptimal levels of essential nutrients including vitamin D [9]. Indeed, due to its well established anti inflammatory and many life affirming biologically crucial mediating properties [10,11], a role for the presence of adequate vitamin D levels cannot be overlooked in our view, even though results suggest that persistent fatigue and reduced exercise tolerance following COVID-19 are independent of vitamin D [12].

This narrative report focuses on a possible role for vitamin D as an antidote to one or more of post acute COVID-19 health concerns that impede a speedy recovery among survivors, and for possibly fostering a more rapid return to pre COVID-19 health status or the

mitigation of these adverse symptoms. Since vitamin D may prove helpful for ameliorating or preventing COVID-19 infections directly [13,14], and regular exposure to sunlight, one source of vitamin D, may be challenging to harness by many older adults who are now limited functionally, home bound or bedridden, are exposed to artificial lighting, or live in nursing homes, northern countries, or regions where the potency of ultraviolet light is diminished as a result of global warming or skin color, can a case be made for vitamin D supplementation among older adults and others suffering from long COVID-19 disease? Indeed, older adults, especially those who now have both public health restrictions as well as mobility restrictions placed on their movements due to the impact of long COVID-19, as well as those with poor nutritional access and status [15], may not only be highly vulnerable to the consequences of a vitamin D deficiency [16], but may not understand the implications of their situation in this respect, especially if their providers do not broach this topic.

Discussed is the evidence base in favor of efforts to address this issue, as indicated especially among their older clients, and those with chronic health conditions associated with a deficiency of vitamin D, such as diabetes, one of the four main disease correlates found among COVID-19 cases. Vitamin D, an immunomodulatory hormone with proven efficacy against various upper respiratory tract infections is also found to have the potential ability to inhibit excess inflammatory reactions, while accelerating the healing process in affected tissues, especially in lung tissue [1]. Moreover, a vitamin D deficiency has been associated with the severity and mortality of a fair percentage of COVID-19 cases, and is highly prevalent in those cases of COVID-19 who experience acute respiratory failure, as well those who suffer from one or more chronic health conditions [17]. There are thus multiple compelling reasons, as well as reasonable empirical evidence as to the possible benefits of weighing the value of vitamin D supplementation in the realm of averting or mitigating the extent of any long COVID-19 syndrome among vulnerable older adults. As well, the presence of a consistently adequate, rather than an inadequate intake or exposure to vitamin D and its analogues, may yet promote muscle function and reduce pain, while enhancing sleep and cognition-all possible long COVID complications- favorably, rather than unfavorably. Alternately, the nutrition-COVID-19 relationship and related dietary changes that tend to mimic a vicious cycle of the double burden of malnutrition and both obesity and under nutrition with micronutrient deficiencies, including those specifically of vitamin D, may be instrumental in promoting COVID-19 infections, plus its disease progression, and potential impact on premature death [18]. Drawn largely from the PUBMED database, it is hoped the present scoping review can provide the interested reader a general view of past work as well as current trends in this regard that might be worthy of further consideration and study, as well as applications in the geriatric health care field.

A wealth of data now clearly show that COVID-19 infections, which may occur independently or in conjunction with one or more chronic health conditions, remain of great concern at the end of 2022, especially among vulnerable older adults. This is because it has now been shown in many instances that the exposure to an acute COVID-19 infection may well induce a multitude of aversive long-term symptoms, including but not limited to acute or late-onset endocrine diseases or dysfunction wherein adrenal insufficiency and an accompanying cortisone excess may yet be risk factors for a worse than desired clinical progression and outcome [19]. At the same time, COVID-19 infection exposure also potentially sets the stage

for heightening the progression of one or more of the individual's pre-existing clinical conditions [16], including obesity, depression, and anxiety. In turn, unresolved post acute COVID-19 symptoms may likewise heighten the extent of any prevailing adverse life events and functional losses, that can have an immense bearing on life quality and overall physical and social mobility. While the world waits for a possible uniformly efficacious COVID-19 antidote, other remedies to offset excess risk of its long term consequences must clearly be sought and examined [20].

In this regard, mounting evidence points to a possible role for vitamin D in both averting or minimizing infection risk, as well in efforts to alleviate COVID-19 disease severity and its possible long term residual impact, especially through the administration of high vitamin D doses [21]. Indeed, considerable evidence indicates COVID-19 infection and death rates do appear to be notably higher in the older adult than in any other sub group, and this may be mediated in part, by the presence of a prevailing and persistent vitamin D deficiency. On the other hand, since many adults suffer from a vitamin D deficiency, supplementation of this vital nutrient or exposure to adequate sunlight or both, along with nutrients containing vitamin D may help to prevent or reduce complications associated with COVID-19 disease, including its severity [22].

Clearly, if found to be influential in any way that would impact either the physical or mental health status of a high risk older adult either before or after sustaining a COVID-19 infection, in a reasonably practical manner, especially in the case of the chronically ill older adult, examining the serum vitamin D level of the high risk vulnerable individual and acting accordingly, could have far-reaching positive effects. These potential benefits include those that impact on immune, musculoskeletal and cognitive health attributes, as well as being likely to be yield 'good' rather than poor surgical or ventilator candidates if these interventions are required. Building on prior work in this regard, this current scoping review examines the potential for vitamin D to minimize COVID-19 risk, in general, as well as establishing if it has the potential to advance the amelioration of its possible long term impacts, especially among those older adults confined to their homes or nursing homes, or situations that limit sunlight and nutrient based vitamin D exposure. As the COVID-19 pandemic proceeds unabated, and does so despite considerable public health efforts to mitigate its spread, and variants of the initial infectious agent continue to emerge that may not be impacted by available vaccines, compounds with antiviral properties, such as vitamin D, may be helpful to consider not only in the interim, but in the future [23,24], even if negated by some [12].

## Aim

This scoping review aimed to specifically examine what is known about the possible value of vitamin D therapy for minimizing the risk of acquiring COVID-19 infections in the older adult population, and especially for purposes of health optimization and antiviral protection after sustaining an acute bout of COVID-19, but without a high degree of resolution of its multiple complex adverse multi system health impacts. A second aim was to identify gaps in our understanding and to offer recommendations for consideration by clinicians and researchers in the field based on these findings.

## Materials and Methods

To obtain the data for this review, the electronic data sources PUBMED, PubMed Central and Google Scholar were carefully

searched. The time period searched ranged from January 1 2020- December 20, 2022 and the key words included, COVID -19 [syndrome, symptoms, review], long COVID and its management, vitamin D, coronavirus, older adults and post-acute COVID-19 syndrome. All forms of study or analysis were deemed acceptable. However, because this is an emerging topic, no in depth or consistent intervention or clear deterministic approach or set of understandings concerning long term COVID disease and a role for vitamin D supplementation could be readily identified. As a result, a scoping narrative summary of all available data including case studies, and uncontrolled observational studies was implemented. Selected material had to focus on vitamin D related facts relevant to infection risk and recovery, as well as symptoms of infection in the older adult. Excluded were articles that did not focus specifically on this set of issues and non English based articles. Preprints were used to highlight the possible scope and updated findings concerning this present topic, rather than for prescribing clinical guidelines.

## Results

### General findings

Of the more than 316,175 publications on COVID-19, published as of December 13, 2022, a total of 21, 788 using the term long COVID-19, and a listing of 20, 881 articles potentially relevant to the current topic of long COVID was observed. In addition, 5303 articles were listed when using the terms long COVID syndrome, and 7,480 referred specifically to long COVID-19 symptoms. A total of 1,284 referred to aspects of COVID-19 rehabilitation, and 78 appeared to link vitamin D and long COVID-19 syndrome when entered into the PUBMED data base, the world's largest research repository. Very few additional articles were found on the additional web sites. In terms of the topic of interest of this report, only the key 78 articles and related vitamin D and COVID-19 reviews were downloaded and examined as most other publications did not meet criteria for covering the vitamin D aspect of this review. To provide an overview of this quite considerable, but potentially highly relevant material in this regard, this review chose to discuss the science base and basis as regards vitamin D as a form of possible form of prevention and/or therapy relative to acute respiratory infections, such as COVID-19 among older adults, the most vulnerable group as far as this virus infection manifests. Findings regarding its specific immune related benefits and others relevant to the safety and health attributes of the older adult are described. The term vitamin D is applied throughout, even though several formulae and categories of this compound exist. The term long COVID-19 or long COVID was used throughout to represent the post acute COVID-19 state. Excluded were articles on populations other than older adults, and those that discussed future protocols designed to examine vitamin D usage in the context of COVID-19 or long COVID-19 health complications.

### Early pandemic observations

Past research on the value of vitamin D in the context of health status, shows this compound in its various forms has the potential to strongly influence overall health status and outcomes across the lifespan, including those of the older adult, along with the outcomes of infectious respiratory virus exposures, including COVID-19. However, while most recent data point to research that indicates a high rate of vitamin D deficits among cases deemed COVID-19 positive, and a highly probable risk of them having a more severe infection response than not in the vulnerable adult [25,26], this is not an accepted

fact to any degree [27,28]. It is also confusing because Laird et al., [29] who specifically examined the role of vitamin D in the context of inflammation implied a favorable role for vitamin D in mitigating COVID-19 risk as proposed by Melzer et al., [30]. Mendy et al., [31] who attempted to identify factors associated with hospitalization and COVID-19 disease severity in a racially and ethnically diverse cohort of COVID-19 positive patients similarly found a vitamin D deficiency was one factor that appeared to be consistently associated with COVID-19 hospitalizations and/or their more severe disease presentation.

In another study, Radujkovic et al., [32] who studied 185 patients diagnosed with COVID-19 as regards vitamin D status found 50% of these patients required hospitalization and of these 22% were deemed vitamin D deficient. When adjusted for age, gender, and comorbidities, the presence of a vitamin D deficiency was found significantly associated with a higher risk of severe COVID-19 illness and excess death. Similarly, Carpagnano et al., [33] found 81% of their COVID-19 cases to be vitamin D deficient, and patients with a severe vitamin D deficiency reportedly had a 50% chance of dying, while those with vitamin D levels  $\geq 10$  ng/mL had a 5% chance of dying at 10 days.

### Key post pandemic observations [2020-22]

As per a multitude current reports detailing the emergence of a long or post-acute COVID-19 syndrome, it appears that a sizeable proportion of acute COVID-19 survivors may experience a complicated array of diverse symptoms that are currently found to emerge within three months of the initial infection, and can persist for up to one year beyond the acute COVID-19 phase of recovery. Among these symptoms are feelings of persistent fatigue-the most common complaint- and/or cognitive impairments of a debilitating nature, such as depression [34-37]. A number of emerging studies that have tried to understand who is at most risk clearly show that long COVID can affect diverse groups of COVID-19 survivors, from those with very mild acute disease to those with the most severe forms of this health condition [35]. As in the case of acute COVID-19, long COVID-19 can also involve multiple organs and affect many body systems including, but not limited to, the respiratory, cardiovascular, neurological, gastrointestinal, and musculoskeletal systems. Unsurprisingly, Huang et al., [38] found that at six months after acute infection, COVID-19 survivors when examined appeared to be most troubled by multiple persistent feelings of fatigue, muscle weakness, sleep difficulties, and bouts of anxiety or depression. Patients who were more severely ill during their COVID-19 hospital stay had more severely impaired pulmonary diffusion capacities and abnormal chest imaging manifestations that could explain complaints of breathlessness that have been reported. It has also been shown that COVID-19 survivors can experience residual significant clinical and biochemical alterations that affect multiple body systems and that necessitate comprehensive medical care and close follow-up for longer periods than was anticipated at the outset of the 2019 COVID pandemic, including deficits in vitamin D levels [39]. Fillipo et al., [40] who updated the main evidences regarding the distinct components of acute and long COVID-19, found the latter characterized by a widespread acute calcium and vitamin D deficiency along with an impaired parathyroid hormone response, and a high prevalence of skeletal complications, such as vertebral fractures. Low possible vitamin D exposure has also been linked to higher COVID-19 mortality rates [41].



Ohaegbulam et al., [10] report that the activation of the vitamin D receptor expressed on immune cells has been shown to directly reduce the secretion of inflammatory cytokine mediators, such as interleukin-6, and to indirectly affect C-reactive protein. However, patients that received a high dose of vitamin D supplementation readily achieved normalization of their vitamin D levels and showed an improved clinical recovery as evidenced by shorter lengths of stay, lower oxygen requirements, and a reduction in inflammatory marker status. Merzon et al., [42] who evaluated the degree of association between plasma vitamin D levels and the presence of COVID-19 disease and hospitalizations among 14,000 members of a Health Services unit found 10.1% to be COVID-19-positive, and that among this group the mean plasma vitamin D level was significantly lower than that of the negative COVID-19 group. While the low vitamin D level may have been caused by the COVID-19 presence, their univariate analysis demonstrated an association between low plasma vitamin D levels and the increased likelihood of acquiring a COVID-19 infection, followed by hospitalization due to this virus. In a multivariate analyses, it appeared that a low vitamin D status was a possible risk factor for acquiring or exacerbating COVID-19 infection risk and severity, even though it may not account for long COVID-19 fatigue and mobility dysfunction emergent post COVID-19 signs of impairment [12]. Smaha et al., [43] show available data from epidemiological studies do suggest that low serum vitamin D levels are associated with an increased susceptibility to the new coronavirus infection, as well as with a more severe course of the disease.

Kerget et al., [44] concluded that due to COVID-19, pandemic, long-running quarantines caused insufficient use of sunlight and worsening of vitamin D deficiency, which could be responsible for the highly variable negative clinical course of COVID-19, in contrast to observations that vitamin D supplementation does appear to reduce the risk of an acute respiratory tract infection and can safely protect against acute respiratory tract infection overall, especially in cases who are vitamin D deficient [45]. As per Patchen et al., [46], even if vitamin D is not a causal factor in the realm of COVID-19, this does not exclude the possibility of low-magnitude causal effects or causal effects of acute responses to therapeutic doses of vitamin D. Ali et al., [24] further propose that since vitamin D is known to mitigate the scope of acquired immunity and to help regenerate endothelial lining damage, its thoughtful usage may be especially beneficial in minimizing the damage that often accompanies acute respiratory diseases such as COVID-19. Furthermore, there is a possible 70% chance of an effective protective outcome when a vitamin D deficiency is corrected by supplementation according to this group.

### Additional observations

As noted above, the reports documented in this review, which are largely current, stem predominantly from observational data with widely varying protocols, research questions, samples, long COVID and vitamin D definitions, hence should be viewed with caution. However as per Grant et al., [47] several observational studies and clinical trials, although not without limitations, do imply that vitamin D supplementation may yet have the potential to reduce the risk of acquiring viral infections that affect the respiratory system, such as COVID-19, and should thus be examined further [48]. As well, even though support for this idea may not be universal, a role for vitamin D in the realm of long COVID-19 cannot be ruled out, and is being proposed as a salient topic for further study as outlined in several 2022 PUBMED citations.

As proposed by Caccialanza et al., [49] efforts towards ensuring safe efficacious vitamin D serum levels and methods of delivery that ensure optimal vitamin D serum levels [50] and that are forthcoming among vulnerable groups and individuals, may yet have a strong bearing on COVID-19 risk as well the predisposition of many older adult to the development of severe forms of this illness, with its possible highly disabling neurological and neuropsychiatric long term outcomes. Vitamin D may also serve as anti-inflammatory or immune-system modulating role that may have the capacity to attenuate or mitigate the harmful consequences of COVID-19 [51], which are emerging, even if deemed possibly non significant by some [50], but not all. For example, findings by D'Avolio et al., [52] obtained from a cohort of patients in Switzerland did tend to suggest vitamin D may be one potentially important adjunct to bear in mind in the context of efforts to mitigate the onset and severity of COVID-19 infections and its variants. Vitamin D deficits are also found to predispose vulnerable adults and others to lung infections [26], and older adults who are affected most by COVID-19 are more likely than not to be vitamin D deficient. As well, those who are vitamin D deficient may experience higher mortality rates than those deemed vitamin D sufficient [53], plus a generally worse COVID-19 infection outcome even if this is only associated with obesity, ethnicity, and social deprivation factors [50].

On the other hand, Ohaegbulam [10] found COVID-19 patients who received a high dose of vitamin D supplementation achieved more observable normalized levels of vitamin D, as well as improved clinical recovery rates. Other data reveal that those older adults with low physical activity levels who may be at high risk for viral infections, may be vitamin D deficient [54], hence along with other vitamins, Catalano et al., [55] propose vitamins D as a possible alternative preventive and therapeutic means of support for fostering the health of COVID-19 disease in both adults as well as children, especially in those with mobility challenges. In accord with Bae et al., [56], helping individual adults to maintain a serum vitamin D concentration of at least 30 ng/mL can not only help reduce the risk of incurring a COVID-19 infection and its severe outcomes, but excess mortality in the event the individual acquires the disease. Consequently, although further well designed studies are warranted, it may yet appear prudent to recommend vitamin D supplements to those older adults suffering from a persistent vitamin D deficiency/insufficiency, at least, during the ongoing COVID-19 pandemic, or until some contrary evidence emerges. Indeed, available evidence suggests that efforts to maintain an optimal serum vitamin D status in the case of the COVID-19 patient may significantly reduce the risk of them acquiring both an acute respiratory distress syndrome, as well as a severe syndrome, with possible beneficial effects on obviating the need for mechanical ventilation, and/or intensive care unit admission, as well as reducing deaths in the course of the disease [57].

As concluded by Thacher [58], vitamin D may prove especially beneficial in those cases found to have mild or asymptomatic COVID-19. In addition, those with higher rather than lower vitamin D serum levels may have a lower risk of acquiring this dangerous infection. Because those at greatest risk of COVID-19 are also at greatest risk for a vitamin D deficiency, Pal et al., [59] recommend that consideration be given to the administration of vitamin D supplements among the general population during the ongoing COVID-19 pandemic, and especially those who live in areas with high air pollution or where outdoor activity or sun exposure is limited [60].

## Discussion

Although modern medicine has previously been quite successful in managing global infection rates, it has not been optimally successful in arresting rates of COVID-19 and its emergent variants. Even more worrying is the increasingly evident set of findings that recovery from acute COVID-19 disease is often attenuated and associated with multiple symptoms of ill health that may preside for up to one year after the initial infection. However, it is possible some degree of amelioration against long COVID-19 symptoms and health complications may be possible as shown in some recent subgroup analyses where vitamin D supplementation was associated with improved clinical outcomes only in those COVID-19 patients who received this vitamin supplement. This may reflect the biological effects of vitamin D on diverse symptoms of multiple body systems implicated in long COVID-19 cases, including those of fatigue, muscle weakness, and diverse features of psychological distress [61] that may or may not be associated with factors such as age and prior vitamin D deficiencies [62]. In this regard, and while the world awaits an effective vaccine or antidote against COVID-19 in general, and post COVID symptoms of distress, in particular, and in the face of very few current guidelines for mitigating the complications and significant disability and negative daily life impact of any lingering COVID-19 manifestations [63], it appears plausible to make a case for the possible usage of vitamin D supplements, if the affected/at risk older adult is clearly vitamin D deficient.

Moreover, cumulative evidence points not only to the impact of vitamin D on many genes with a well-established salience to airway infections, as well as immune processes believed to be implicated in long COVID [63], but to a possible mechanistic link between age, the presence of one or more co-morbid health conditions and an increased susceptibility to its multiple complications, such as muscle and joint pain, 'brain fog' and fatigue [64]. Indeed, although not discussed at any length currently, and several proposed clinical trial protocols that appear promising have not been implemented or completed to date, it appears that if provided under the insightful care of physicians and on an individual basis, as needed, sufficient evidence points to the likelihood of a probable reduction in infection risk and even if infected, possibly to a reduction in the degree of any adverse COVID-19 outcome that may otherwise ensue among many vulnerable older adults, even if they practice social distancing, are adequately vaccinated and use masks consistently. Those who are obese, those who are deemed 'food insecure', live in air-polluted neighborhoods, and those persons of Black or Asian origin may need to be preferentially targeted in this regard.

Ali and colleagues [24] who examined the role of vitamin D in preventing of COVID-19 infection, progression and severity concluded that despite the weak evidence base, people at higher risk of vitamin D deficiency during this global pandemic should consider taking safe levels of vitamin D supplements or food based sources to maintain the desired levels of circulating vitamin D. The observation of a quadratic relationship between the prevalence of vitamin D deficiency in most commonly affected countries by COVID-19 and the latitudes [65], plus possible additional health benefits of vitamin D supplementation alone in deficient older cases appears to be an added reason for considering this idea. Vitamin D can also protect against COVID-19 by modulating innate and adaptive immunity [66]. As well, such improvements, as well as less severe COVID-19 disease are likely to significantly outweigh the risks of failing to do this [67].

Finally, is it ethical to withhold a reasonably well established supplement from high risk older populations with high COVID-19 susceptibility, high mortality rates, along with predictable vitamin D deficits, when the need is so acute? Even if older adults have adequate vitamin D levels when admitted to hospital, they may surely suffer vitamin D deficits attributable to inflammatory respiratory disease factors [63] that may delay their recovery if not addressed. In short, it appears low vitamin D levels may adversely impact innate and adaptive immunity that can lead to COVID-19 infections and can mediate their severity [65], and its long term COVID-19 impacts that have not been well studied should be studied further. Until then, as per Tsourdi et al., [68], even if a vitamin D deficiency is associated with a more severe COVID-19 clinical course, data supporting improvements in outcomes with vitamin D supplementation will remain unresolved or ambiguous if no consensus is duly reached. As such, and even if vitamin D has no COVID-19 implications, the wealth of evidence supporting its benefits in multiple chronic illness realms might yet yield a desirable outcome in selected cases and should not be overlooked in our view. On the other hand, one can predict possibly more-rather than less- harm will befall older adults as a vulnerable group, in general, as regards COVID-19 infection risk, and in particular, those older adults with low levels of vitamin D that potentially contributes to a poorer than desired COVID-19 prognosis [67-75] and may hence be a critical COVID outcome factor among many at any age [76].

## Conclusion

This brief scoping review, while not all encompassing and not without limitations has shown:

- COVID-19 infections clearly remain immensely problematic to control and treat, especially among older adults, but could be impacted favourably at all stages of the disease and its recovery by concerted efforts to ensure vitamin D serum levels are optimised, as indicated
- Vitamin D supplementation provided or made available on a needs basis, may help to diminish multiple disabling post-COVID-19 syndrome manifestations among many older adults, as well as reducing the risk of new infections, and immense current disease and human costs, even if a vaccine is forthcoming
- To affirm whether low vitamin D levels are salient independent COVID-19 disease correlates or biomarkers, as strongly implied by multiple studies, it is concluded that more comprehensive case studies and the degree to which vitamin D correlates with both acute COVID-19 and its emergent diverse long COVID-19 symptoms among older adults of various ages, ethnicities, and socioeconomic levels that have not been well studied appear strongly desirable

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