Vitamin E and Immune System: A Protective Nutrient Against Influenza and COVID-19 in Elderly Humans  
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ABSTRACT  
Older adults have relatively weak immune and antioxidant systems and thus, are more vulnerable to viral infections especially respiratory tract infections as compared to younger adults. Recent reports of high mortality rate due to the Coronavirus disease 2019 (COVID-19) in the elderly population are suggestive that perhaps a compromised antioxidant status might be contributing to increased virulence in elderly people. Since vitamin E insufficiency is common in old age, it is conceivable that low vitamin E status could be among the factors causing high mortality in elderly people suffering from influenza and COVID-19 infections. Recent studies have shown an immune-boosting role of supplemental vitamin E along with other antioxidants against respiratory tract viral infections. Therefore, the objective of this review is to examine and discuss the data pertaining to the effects of vitamin E on boosting the immune response against respiratory tract viral infections such as influenza and COVID-19 in elderly individuals.  
Keywords: Vitamin E supplementation, elderly population, antioxidant status, immune system, respiratory tract infections, influenza, COVID-19.

INTRODUCTION  
Vitamin E was originally discovered by Herbert McLean Evans and Katharine Scott Bishop as an essential dietary nutrient required for normal animal fertility and reproduction [1]. The main dietary sources of vitamin E include nuts, vegetable seeds and their oils and grains [2].

Table 1 shows the major dietary sources and the average amount of vitamin E per 100 grams of food [3]. Potential health benefits of dietary vitamin E intake in humans are mostly related to the prevention of certain types of cancer, heart disease and other chronic degenerative disorders [4].

Vitamin E is one of the most potent fat-soluble antioxidants located predominantly in the human Table 1: Major dietary sources and average amount of vitamin E per 100 grams of food [3].

| Dietary Source       | Amount of Vitamin E (mg) per 100 gm of Dietary Sources |
|----------------------|--------------------------------------------------------|
| Wheat germ oil       | 172                                                    |
| Sunflower oil        | 46                                                     |
| Cotton seed oil      | 44                                                     |
| Safflower seed oil   | 42                                                     |
| Almonds              | 26                                                     |
| Corn oil             | 22                                                     |
| Palm oil             | 20                                                     |
| Hazelnuts            | 15                                                     |
| Olive oil            | 14                                                     |
| Peanut               | 05                                                     |

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METHODS  
Research Design and Methods: A systematic literature review was conducted to examine the data pertaining to the effects of vitamin E on boosting the immune response against respiratory tract viral infections such as influenza and COVID-19 in apparently healthy elderly humans.

Search Strategy and Selection Criteria: In this review, the authors explored in detail the scientific works from March 1989 till August 2021 related to the effects of vitamin E on boosting the immune response against respiratory tract viral infections in elderly individuals. The search strategy adopted was an article title/
Keywords/abstract-based search using key terms such as 'vitamin E', 'tocopherol', 'elderly people', 'antioxidant status', 'immune system', 'respiratory tract infections, and 'COVID-19'. The literature searches for locating, selecting, extracting, and analyzing the published data were performed using PubMed, Web of Science and Google Scholar. The selected articles and some of their linked references were also reviewed to obtain relevant information. However, the focus was on the effect of vitamin E on the immune system in elderly people and the mechanism of action in case of any protection against respiratory tracts viral infections such as influenza and COVID-19. The pertinent information including authors, institute, study setting, duration, sample size, target population, age group, objectives and dosage used were extracted from a total of 345 retrieved articles.

Vitamin E and Immune System in Elderly People

Effect of Vitamin E on Immune System Normal aging process in otherwise healthy elderly individuals is associated with a progressive decline in both cell-mediated and humoral immunity. This deterioration in the immune status with increasing age is due to decreased synthesis and release of CD4 +ve and CD8 +ve T lymphocytes, natural antibodies and natural killer (NK) cells, increased destruction of circulating neutrophils by apoptosis, increased production of pro-inflammatory cytokines (e.g. Interleukin-1β, Interleukin-6, Interleukin-8 and Tumor necrosis factor-alpha) with simultaneous decreased production of anti-inflammatory cytokines (e.g. Interleukin-2 and Interferon-gamma), enhanced production of autoantibodies, reduced immune responses to vaccination and impairment inability to generate immune responses against new/novel antigens [9-11].

Moreover, some of the earlier studies have suggested that healthy elderly individuals have a relatively compromised antioxidant status [12, 13]. Thus, apparently healthy elderly humans are more predisposed than younger adults to infections, chronic inflammatory diseases, and cancers [14]. Antioxidant vitamins are suggested to modulate and boost up the human immune system [15, 16]. Multiple double-blinded, case-control and placebo-control clinical trials have suggested that supplementation with both natural and synthetic vitamin E given for 1-6 months to apparently healthy elderly human subjects significantly improved their natural and acquired immunity [17-19]. The suggested major immunomodulatory effects of dietary vitamin E in immune cells are depicted in Fig. (1) [17-19].

Vitamin E Protection Against Respiratory Tract Infections. Acute respiratory tract infections are a major cause of morbidity and mortality worldwide. The enhanced respiratory oxidative stress due to viral infections such as influenza has been shown to increase the severity of lung inflammation and altered immune responses, especially in old people and immunosuppressed patients [20].

Some of the antioxidants including vitamin E and its various forms had been previously proposed to play a significant role in protecting lung cells against viral and bacterial infections which often lead to increased intrapulmonary oxidative burden [21, 22].

Some of the earlier clinical trials in the elderly have demonstrated beneficial effects of vitamin E in protecting against acute respiratory infections [23, 24].

An earlier experimental animal study conducted on white male albino mice indicated that treatment with alpha-tocopherol significantly reduced the mortality rate and enhanced the mean survival time of these albino mice inoculated with influenza virus [25]. The results of a previous randomized control trial showed that supplementation with 200 I U of vitamin E per day had a protective effect on upper respiratory tract infections, especially the common cold in elderly people [26]. The protective effect of vitamin E against viral infections is further supported by in vitro experiments in a mouse model in an earlier study by Beck et al. showing that the host nutritional status in terms of antioxidants such as vitamin E and selenium is critical not only for virulence
but might also be influencing the genetic make-up of the virus [27].

**Vitamin E and COVID-19**

Novel COVID-19 is an acute respiratory viral infection that was initially reported to emerge in December 2019 from Wuhan, China and then within a few months became a worldwide pandemic [28]. Coronavirus infection has been proposed to dysregulate the human immune system by causing pro-inflammatory cytokines (Interleukin-2, Tumor necrosis factor-α and Granulocyte-colony stimulating factor) hyper release syndrome, reduction in T and B lymphocytes, decreased activity of NK cells and hyperactivation of cytotoxic T cells [29, 30].

Some of the recent studies have illustrated that the severity of COVID-19 is far more in elderly individuals as compared to children and young adults. Poor nutritional status of elderly people (in terms of low levels of essential nutrients and vitamins) in COVID-19 could be contributing to increased virulence and pathology/mortality in these patients. There is a “cytokine storm” in elderly COVID-19 patients and perhaps due to low levels of some of the vitamins (such as vitamins D, A, C, E), these elderly patients are unable to suppress these pro-inflammatory cytokines [31]. Moreover, some human studies have pointed out the potential role of some of the vitamins in the management of COVID-19 patients [32].

It has been suggested that oxidative stress due to excessive production of reactive oxygen species (ROS) might lead to severe local or systemic tissue damage in COVID-19 patients [33]. Some most recent studies have suggested the possible use of dietary and supplemental antioxidant vitamins in the treatment of COVID-19 [34]. Moreover, treatment with some of the antioxidants could play a significant role in the management of excessive inflammation and “cytokine storm” in the elderly COVID-19 patients [35].

**Vitamin E Deficiency and Viral Infections**

Vitamin E deficiency had been suggested to increase the virulence and the extent of tissue injury by respiratory viruses in experimental animal studies [36]. Earlier animal studies had suggested the potential use of vitamin E in the treatment of influenza virus infections. It was demonstrated that mice experimentally infected with the influenza virus had developed significantly reduced levels of endogenous vitamin E, and supplementation with vitamin E attenuated the free radicals induced by the virus [37]. An association between decreased vitamin E and D status and infection of bovine coronavirus has been suggested [37].

All these reports support the therapeutic potential of vitamin E against viral infections. However, no clinical trials have been carried out to evaluate the therapeutic potential of vitamin E alone in COVID-19. Some of the recent studies suggest that oxidative stress should be reduced in frail people suffering from COVID-19 infection by increasing their antioxidant defense system [38].

A recent randomized controlled trial is underway to examine the impact of vitamins A, B, C, D and E supplementation on the improvement and mortality rate of COVID-19 patients [39]. The results are likely to provide reasonable evidence regarding the outcomes of this intervention. Moreover, a recent study suggested an immune-boosting role of some of the dietary antioxidants including selenium, vitamin C and vitamin E as well as their specific effect in COVID-19 patients [40].

Older adults (> 65 years) have relatively compromised immune responses as well as antioxidant defense mechanisms, which increases the risk of both infections and chronic inflammatory diseases in them as compared with younger adults [38]. Recent reports of high mortality rates among elderly COVID-19 patients are suggestive that perhaps a compromised antioxidant status might be contributing to severe pathology and increased virulence in elderly people [41]. Since vitamin E insufficiency is most likely to occur in old age, it is conceivable that low vitamin E status and a relatively weak immune system could be among the factors causing high mortality in elderly people suffering from influenza and COVID-19 infections [42]. Some of the recent clinical trials have indicated that supplemental antioxidant vitamins including vitamin E could be beneficial in reducing the morbidity and mortality of patients infected with respiratory viral infections such as influenza and COVID-19 [43]. However, large clinical trials with larger numbers of subjects are required to unravel this phenomenon.

**Immune-boosting in Elderly by Vitamin E**

In a recent chapter in a book on vitamin E in Health and Disease, the role of vitamin E in enhancing immunity in elderly people has been highlighted [44]. Vitamin E was found to increase resistance against viral infections and stimulate the immune response against distinctive antigens. In an interventional study, supplementation with 200 mg of vitamin E per day boosted the immune response in elderly subjects including enhanced T cell proliferation. However, dietary intake of vitamin E is the best approach to enhance immunity in the elderly, especially in immuno-compromised persons [45]. Supplementation with vitamin E was found to reverse the age-associated decline in immune responses [45].

**Vitamin E Rich Foods**

Although Table 1 lists various vitamin E-rich seed oils and nuts, yet in a balanced diet, different food items need to be consumed to meet the essential nutrient requirements. Some of the other dietary sources of vitamin E include broccoli, spinach, kiwi fruit, fish and egg yolk [2, 46]. It is suggested that in elderly persons vitamin E-rich diet should preferably be used to meet their Recommended Dietary Allowance (RDA) of 15 mg/day for this vitamin.
Recommendations/Way Forward

1. Primary care has a special focus on the elderly population. An adequate anti-oxidant status of elderly people is essential for the prevention of disease in them. Vitamin E along with other anti-oxidants has great potential. However, the health benefits of vitamin E supplementation in respiratory viral infections and COVID-19 could be more evident through well-planned, large-scale intervention studies in humans especially those having vitamin E deficiency/insufficiency.

2. The relationship of vitamin E insufficiency with severity in the pathology of COVID-19 in elderly people needs further investigation.

CONCLUSION

Vitamin E supplementation is likely to be more beneficial in the elderly population especially those with less than normal levels or compromised antioxidants status. Further research studies are needed to investigate any protective and/or curative role of vitamin E against COVID-19.

ABBREVIATIONS

Natural killer (NK) cells, Interleukin-2 (IL2), Interleukin-4 (IL4), Interferon-gamma (IFN-γ), Prostaglandin E2 (PGE2), Cyclooxygenase 2 (COX 2) activity.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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