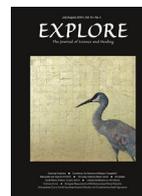




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Review Article

Integrative considerations during the COVID-19 pandemic

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There is a high level of interest in integrative strategies to augment public health measures to prevent COVID-19 infection and associated pneumonia. Unfortunately, **no integrative measures have been validated in human trials as effective specifically for COVID-19**. Notwithstanding, this is an opportune time to be proactive. Using available in-vitro evidence, an understanding of the virulence of COVID-19, as well as data from similar, but different, viruses, we offer the following strategies to consider. Again, we stress that these are supplemental considerations to the current recommendations that emphasize regular hand washing, physical distancing, stopping non-essential travel, and obtaining testing in the presence of symptoms.

While the pathogenicity of COVID-19 is complex, it is important to understand the role of inflammation in this disease. The virulence and pathogenicity (including acute respiratory distress syndrome) associated with SARS corona viruses develops as the result of viral activation of cytoplasmic NLRP3 inflammasome. This inflammasome within activated (upregulated NFκB) macrophages and Th1 immune cells releases proinflammatory cytokines, namely IL-1B and IL-18, which dictate the pathogenic inflammation responsible for the virulence and symptoms of COVID-19.¹ Understanding this component of COVID-19 infection provides a mechanistic underpinning to several of the following.

Risk reduction

- **Adequate sleep:** Shorter sleep duration increases the risk of infectious illness. One study found that less than 5 h of sleep (monitored over 7 consecutive days) increased the risk of developing rhinovirus associated cold by 350% (odds ratio [OR] = 4.50, 95% confidence interval [CI], 1.08–18.69) when compared to individuals who slept at least 7 h per night.² Important specifically to COVID-19 infection, sleep deprivation increases CXCL9 levels. CXCL9 is a monokine, induced by interferon, which increases lymphocytic infiltration,³ and which is implicated in NLRP3 inflammasome activation.⁴ Adequate sleep also ensures the secretion of melatonin, a molecule which may

play a role in reducing coronavirus virulence (see **Melatonin** below).

- **Stress management:** Psychological stress disrupts immune regulation and is specifically associated with increased pro-inflammatory cytokines such as IL-6.⁵ Acute stress in mice increases IL-1B via NLRP3 inflammasome activation.⁶ Various mindfulness techniques such as meditation, breathing exercises, guided imagery, etc. reduce stress, reduce activated NFκB, may reduce CRP and do not appear to increase inflammatory cytokines.⁷
- **Zinc:** Coronavirus appear to be susceptible to the viral inhibitory actions of zinc. Zinc may prevent coronavirus entry into cells⁸ and appears to reduce coronavirus virulence.⁹ Typical daily dosing of zinc is 15 mg–30 mg daily with lozenges potentially providing direct protective effects in the upper respiratory tract.
- **Vegetables and fruits +/- isolated Flavonoids:** Many flavonoids have been found, in vitro, to reduce NLRP3 inflammasome signaling, and consequently NFκB, TNF-α, IL-6, IL-1B and IL-18 expression.¹⁰ Some of the specific flavonoids which have been shown to have this effect, and which can be found in the diet and/or dietary supplements include:
 - **baicalin**¹¹ and **wogonoside**¹² from **Scutellaria baicalensis** (Chinese skullcap);
 - **liquiritigenin**¹³ from **Glycyrrhiza glabra** (licorice)
 - **dihydroquercetin**¹⁴ and **quercetin**¹⁵ found in **onions** and **apples**. Of note, **quercetin** also functions as a **zinc ionophore**, **chelating zinc** and transporting it into the **cell cytoplasm**.¹⁶ This could, theoretically, enhance the anti-viral actions of **zinc**.
 - **myricetin**¹⁷ found in **tomatoes, oranges, nuts, and berries**
 - **apigenin**¹⁸ (found in **Matricaria recutita (Chamomile), parsley and celery**).
 - **curcumin**^{19,20} (found in **turmeric** root)
 - **epigallocatechin gallate (EGCG)** from green tea. EGCG has been found to have antiviral activity against a wide range of DNA and RNA viruses, especially in the early stages of infection by preventing viral attachment, entry and membrane fusion²¹ EGCG, link **quercetin**, is a **zinc ionophore**,¹⁶ thereby potentially enhancing the antiviral actions of zinc.

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At least 5–7 servings of vegetables and 2–3 servings of fruit daily provide a repository of flavonoids and are considered a cornerstone of an anti-inflammatory diet.

- **Vitamin C:** Like flavonoids, ascorbic acid inhibits NLRP3 inflammasome activation.²² Clinical trials have found that vitamin C shortens the frequency, duration and severity of the common cold and the incidence of pneumonia.²³ Typical daily dosing of vitamin C ranges from 500 mg to 3000 mg daily with even higher doses utilized during times of acute infection.
- **Melatonin:** Melatonin has been shown to inhibit NFκB activation and NLRP3 inflammasome activation.²⁴ In fact, the age-related decline in melatonin production is one proposed mechanism to explain why children do not appear to have severe symptoms as frequently as do older adults. Melatonin also reduces oxidative lung injury and inflammatory cell recruitment during viral infections.²⁵ Typical dosing of melatonin varies widely from 0.3 mg to 20 mg (the latter used in the oncological setting).
- **Sambucus nigra (Elderberry):** There is preclinical evidence that elderberry inhibits replication and viral attachment of Human coronavirus NL63 (HCoV-NL63),²⁶ which although different than COVID-19, is still a member of the same coronavirus family. Sambucus appears most effective in the prevention or early stage of corona virus infections.²⁷ Of note, Sambucus significantly increases inflammatory cytokines, including IL-B1²⁸ so should be discontinued with symptoms of infection (or positive test). An evidence-based systematic review of elderberry conducted by the Natural Standard Research Collaboration concluded that there is level B evidence to support the use of elderberry for influenza²⁹ which may or may not be relevant to COVID-19 prevention. Typical dosing of 2:1 elderberry extract is 10 mL–60 mL daily for adults and 5mL–30 mL daily for children.
- **Vitamin D:** In certain conditions, vitamin D has been found to decrease NLRP3 inflammasome activation³⁰ and vitamin D receptor activation reduces IL-1b secretion.³¹ However, 1,25(OH)vitamin D has also been found to increase IL-1b levels,^{32,33} and should, therefore, be used with caution and perhaps discontinued with symptoms of infection.

During symptoms of infection or positive test for COVID-19

To avoid: Given the integral role of inflammatory cytokines (namely IL-1B and IL-18) in the pathogenicity of COVID-19, as well as the impossibility of predicting which individuals are susceptible to the “cytokine storm”, technically called secondary hemophagocytic lymphohistiocytosis, or sHLH, it appears to be prudent to avoid high and regular use of immunostimulatory agents which increase these cytokines. Again, in the absence of human clinical data, **caution is warranted with the following immune activating agents** due to preclinical evidence of increased IL-1B and/or IL-18 production in infected immune cells:

- ! Sambucus nigra (Elderberry)³⁴ (i.e. Elderberry may be used for prevention but should be stopped if any symptoms of infection appear.)
- ! Isolated polysaccharide extracts from medicinal mushrooms or mycelium^{35,36}
- ! Echinacea angustifolia and E. purpurea^{37,38}
- ! Larch arabinogalactan³⁹
- ! Vitamin D^{40,41}

Likely safe: Other commonly used natural immunostimulatory and antiviral agents including the following do not appear to increase IL-1B or IL-18 as a part of their immunomodulatory actions. Several of these, in fact, reduce these cytokines and may restore immune

homeostasis. These are, therefore, likely safe to use both prior to, and during, COVID-19 infection. Whether these agents mitigate the symptoms or virulence of COVID-19 is unknown and therefore the benefit of these agents during COVID-19 infection is unknown.

- Allium sativum (garlic)⁴²
- Quercetin⁴³
- Astragalus membranaceus^{44,45}
- Mycelium mushroom extracts^{46,47} as well as fruiting body extract of Agaricus blazeii⁴⁸
- Mentha piperita (peppermint)⁴⁹
- Andrographis paniculata⁵⁰
- Green tea and green tea extracts^{51,52}
- Zinc⁵³
- Vitamin A⁵⁴ [note: This study found that 25,000iu daily for 4 months in 84 women resulted in lower serum IL-1b and IL-1b/IL-4 ratios in obese women. Oral vitamin A can cause hypervitaminosis A especially at doses greater than 25,000 IU daily for more than 6 years or 100,000iu daily for more than 6 months.⁵⁵ Monitoring liver function tests for hepatotoxicity during vitamin A dosing of any duration, even at lower doses, is advised given variable individual sensitivity.]
- Vitamin C⁵⁶

The information and understanding of COVID-19 continues to change rapidly. We encourage you to make integrative recommendations carefully and with consideration of the underlying mechanisms of both the COVID-19 infection and the intended intervention. **It is also important to reiterate that to date there are no clinically evidence-based integrative prevention or treatment strategies for COVID-19 infection.**

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