Diet and Nutritional Factors in the Prevention and Treatment of COVID-19: An Umbrella Review

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ABSTRACT

Background: There is growing interest in the use of natural therapies for the prevention and treatment of COVID-19 and related illnesses. The aim of this review was to identify and examine the systematic and narrative reviews reporting on the relationship between diet or nutritional status and COVID-19.

Methods: This paper is part of an umbrella review of studies related to natural health products and therapies for the prevention or treatment of COVID-19, as a follow-up to a live review that was conducted by the World Naturopathic Federation. PubMed and Google Scholar were searched for systematic and narrative reviews.

Results: Seven narrative reviews and four systematic reviews were included. The reviews included evidence suggesting that dietary patterns and nutritional status are important modifiable risk factors relevant to the prevention and treatment of COVID-19. Three systematic reviews reported an association between poor nutritional status and greater COVID-19 severity or death. Narrative reviews suggested a possible benefit of the Mediterranean diet, fibre-rich diets, and antioxidant-rich fruits and vegetables.

Conclusion: The research suggests that nutrition status is a significant factor in the progression of COVID-19 infection. While more clinical and interventional evidence is needed to precisely understand the impact of diet, dietary constituents, and nutritional status on modifying COVID-19 risk, the findings of this review highlight the importance of following existing dietary guidelines to support healthy immune function.

Key Words COVID-19, SARS-CoV-2, nutrition, diet, naturopathic medicine, anti-inflammatory, immune

INTRODUCTION

Coronavirus-19 disease (COVID-19; see Appendix 1 for a list of terms and acronyms used in this article) is an infectious disease caused by the novel severe acute respiratory syndrome of the coronavirus-2 (SARS-CoV-2) which emerged in late 2019. Prevention strategies such as hygiene measures, mask wearing, and vaccines played a role in mitigating spread and disease severity.[1] Medical treatment strategies for the treatment of COVID-19 were limited in availability and efficacy.[2] The lack of successful treatment strategies led to significant worldwide morbidity and mortality,[3,4] as well as high prevalence of post-viral syndrome, referred to as long COVID.[5] In an effort to find effective solutions to prevent or treat COVID-19, many patients and health providers pursued alternative therapies, including herbal supplements, vitamin supplements, and natural health products.[6]

Nutrition is at the core of optimal health and a key component of naturopathic medicine and many traditional systems of medicine globally. Dietary patterns and diet constituents are known to be important modifiable risk factors in a range of acute and chronic illnesses and in overall mortality.[7] Diet is a source of essential macronutrients and micronutrients that support maintenance of a healthy immune response. The Mediterranean diet,[8] high-fibre diets, and intermittent fasting (IF)/time-restricted eating (TRE)[9] have demonstrated clinical benefit in the mitigation of disease factors such as increased inflammation[10] and high blood glucose.[11,12] Diets which are high in omega-3 and omega-9 fatty acids, fruit, vegetables, herbs and spices and fibre are also linked to reduced systemic inflammation and support lower blood glucose levels.[13] An additional benefit of diets that include (1) fresh fruits and vegetables,[14] (2) sufficient fibre intake,[15] and (3) plant-based or whole foods with healthy fats, is a healthy gut microbiome, which provides a barrier to potential pathogens. Multiple studies verify a relationship between diminished gut health and increased risk for viral infection, especially respiratory diseases similar to COVID-19.[16] The anti-inflammatory, anti-viral, and anti-oxidant effects of these diets and diet constituents suggest these nutritional

interventions may be effective in helping with prevention and symptoms of COVID-19.[10]

Insufficient and improper diet selection can lead to malnutrition,[17] which is associated with an increased risk of mortality as a result of sarcopenia, frailty, insulin resistance, and overall inflammation.[18] Malnutrition has been identified as a highly important factor in immune health and a critical modifiable risk factor for severe infectious disease outcomes. In addition to concerns about the effects of undernutrition on COVID-19 prevention and treatment, overnutrition is also a concern. Obesity disrupts metabolic function in a way that dramatically increases COVID-19 severity, recovery time, intensive care unit admission, and death.[19] Obesity is associated with an increase in inflammatory cytokines which has been identified as a predictor of COVID-19 severity and mortality.[20]

The aim of this review was to identify and evaluate the systematic and narrative reviews reporting on the relationship between dietary patterns or nutritional status and the prevention and treatment of COVID-19 and long COVID. An additional goal was to identify areas of opportunity for further research and clinical application on topics related to diets, dietary constituents, and nutritional status.

METHODS

Design

This review is part of an umbrella review of studies related to natural health products and natural therapies for the prevention or treatment of COVID-19. It is a follow-up to a live review that was recently completed.[21] The live review took place between May 2022 and May 2023 and involved monthly literature searches for relevant publications. This review reported on the narrative reviews and systematic reviews related to diet and nutrition. While narrative reviews are not typically included in an umbrella review, this study team included those that met specific criteria as the narrative reviews provided insights on topics that are not yet broad enough to be covered in systematic reviews.

Search Strategy

Over the course of one year (May 2022 – May 2023), researchers performed monthly literature searches. These searches followed Cochrane Guidelines for a live systematic review. Monthly meetings served to review and collate collected literature and to ensure that it met inclusion criteria. These searches helped to collect all current and emerging data on natural prevention or treatment of COVID-19.

Databases used included PubMed and Google Scholar. Examples of search terms used in the full umbrella review include: "natur*," "herb*," "nutraceutical," "botanical," "medicinal plant," "Ayurvedic," "Chinese medicine," "herbal patent formula," "vitamin," "mineral," combined with "prevention," "prophylaxis," "deficiency," "treatment," "management," and "*COVID*," "Coronavirus," "SARS-CoV-2." Individual herb names, compounds, vitamins, minerals and other health protocols were also searched. These articles were grouped, and the tally for each type of natural

therapy as well as location (i.e., world region) of research were updated monthly. Articles with a primary focus on diet, dietary constituents or nutrition status were included in this review and grouped as a systematic review, narrative review, meta-analysis, or other based on their description in the abstract. While the live review provided a continually updated summary of the evidence that captured the evolving nature of this topic, this review now serves as a synthesis of the included papers.

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they were related to the use of diet, dietary constituents, or nutrition status for the prevention or treatment of COVID-19 and were identified in the live review. Articles primarily focused on other topics within the umbrella review, including vitamins, minerals, natural health products, or herbal supplements were excluded.

Systematic reviews were assessed by two independent reviewers using a measurement tool to assess systematic reviews (AMSTAR). In order to be eligible for inclusion, studies needed to have a response of "Yes" or "Partially Yes" to Questions 9 and "Yes" to Question 13. Reviewers were blind to the AMSTAR score required for eligibility while completing the assessment. Narrative reviews were reviewed by two reviewers and the quality of the review was evaluated using the scale for the assessment of narrative review articles (SANRA).[22] Articles were included if they had a scientific reasoning score of 1 or 2 AND an overall total sum >5. Individuals providing data extraction were blind to the quality assessment criteria for inclusion/exclusion.

Any discrepancies found in the inclusion questions were verified by a separate reviewer. The data in the studies had to be statistically significant to be included. Only outcomes related to natural health products and therapies were extracted. Some reviews covered topics that spanned multiple categories of the umbrella review; researchers used a reference overlap analysis to track these papers.

Data Extraction

Data extraction for the systematic and narrative reviews took place using separate shared, online spreadsheets. Narrative reviews were collated and data in each of the following categories was extracted: study number, study identification, citation in American Medical Association (AMA) style, author(s), date, journal, country/world region, review objective, details of any search conducted, area of focus, single/mixed category, doses, therapeutic considerations, associations with other vitamins/minerals/pathways, therapeutic considerations, and additional clinical notes. For the systematic reviews, the following data was extracted: study number, study identification, citation in AMA style, author(s), date, journal, country/world region, area of focus (prevention, treatment, post-COVID), review objective, review type (narrative, systematic, or meta-analysis), search date, search databases, study designs included, countries included in the studies, publication date range, tools for assessment of risk of bias and methods of synthesis/analysis. The study results data extracted included the intervention or

exposure assessed, the outcomes measured, the number of studies included in the synthesis, the number of participants included in the studies, the age of the participants, the sex of the participants, the results or findings and results of heterogeneity analysis (if applicable).

RESULTS

On the topic of "nutrition," "food," or "diet," 13 narrative reviews were captured in the original search and 7 of these met qualifications for inclusion (see Table 1). The narrative reviews were completed by researchers from Canada ($n = 1$), India ($n = 1$), Brazil ($n = 2$) and the USA ($n = 3$). Some reviews addressed multiple diet and nutrition topics included in this analysis: the role of fibre and

the gut microbiome ($n = 3$), plant-based and Mediterranean diets ($n = 3$), fruit and vegetable intake ($n = 2$), IF/TRE ($n = 1$), and a ketogenic diet ($n = 1$).

Four systematic reviews related to nutrition were identified (see Table 2). The systematic reviews were completed in Taiwan, China, Israel, and the United Kingdom. All of the reviews related to the prevention of COVID-19 and severe COVID-19 outcomes. Of these reviews, three aimed to examine the relationship between malnutrition and COVID-19 hospitalization, severity and/or mortality. The fourth review synthesized research on the effects of a fibre-dense, hypocaloric Mediterranean diet on body mass index (BMI) and inflammatory markers among participants whose BMI was in the overweight or obese ranges and who were at risk of developing severe outcomes following COVID-19 infection.

TABLE 1 Summary of the Included Narrative Reviews

Article	WHO Region	Review Type/ Study Design	Intervention	Properties Referenced	Associations/ Mechanisms Referenced	Findings
Enichen et al., 2023[23]	AMR	Narrative review/ included designs not disclosed	Fiber-rich foods, fruits and vegetables	Anti-inflammatory, anti-viral	Gut microbiome composition impacts expression of ACE2 receptor (COVID-19 cellular entry point).	Fruits, vegetables and fibre-rich foods support butyrate-producing gut microbiome that reduces ACE2 receptor expression and promotes healthy immune system.
Trivedi et al., 2022[24]	AMR	Narrative review/ in vivo, in vitro, and clinical trial studies	Fiber-rich foods, plant compounds	Anti-inflammatory	Fibres (in diet or as prebiotics) help modulate inflammation and support healthy gut immune responses.	In-silico studies confirm efficacy of fibre and plant compounds in modifying the gut microbiome production of SCFA.
Dos Santos et al., 2022[25]	AMR	Narrative review/ literature related to nutrition, immune system, COVID-19	Fiber-rich foods, gut microbiome	Anti-viral, anti-inflammatory, anti-oxidation, immune heath	Fibre-rich diet fosters gut microbiome producing SCFA, tryptophan metabolites and secondary bile acids supporting health gut immune function.	Healthy diet aids in maintaining healthy immune system preventing and lessening symptoms of COVID-19.
Bell et al., 2023[26]	AMR	Narrative review/ included designs not disclosed	Plant-based diet, Mediterranean diet	Anti-inflammatory, anti-oxidation, immune health	Plant-based diet had a 73% lower OR of moderate-to-severe COVID-19 and Mediterranean diet lowers risk of COVID-19 infection	Lessened risk of infection and severity of symptoms with a well-balanced diet.
Chatterjee et al., 2022[27]	SEA	Narrative review/ articles linking viral infections (esp. COVID-19), micronutrients and the immune system	Plant-based diet, fresh fruits and vegetables	Anti-oxidation, immune health	Under-nutrition and lack of antioxidants linked with greater risk of COVID-19 and viral infection.	Whole foods diet, consisting of fresh fruits and vegetables, improves gut health and reduces risk of viral infection.
Manica-Cattani et al., 2022[28]	AMR	Narrative review, qualitative analysis/ experimental, epidemiological and clinical	Amazonian fruits	Anti-viral, anti-inflammatory, anti-oxidation, geno-protective	Acai may limit activity of COVID-19 ACE2 receptor spike protein and INF-γ, antioxidants limit ROS and resulting tissue damage	Amazonian fruits may be beneficial in prevention of COVID-19 and lessening severity of symptoms.
Ezzati et al., 2022[29]	AMR	Narrative Review/ peer-reviewed RCT, observational and clinical data published between Jan. 2017 and March 2022	Intermittent fasting	Anti-inflammatory, anti-oxidation	IF/TRE reduce inflammatory and stress markers in the immune system (IL-1β, IL-6, IL-8, INF-γ, 8-isoprostane)	IF/TRE in combination with micronutrient supplementation may help reduce COVID-19 severity

ACE2=angiotensin-converting enzyme 2; AMR=region of the Americas; IF=intermittent fasting; IL=interleukin; INF-γ=interferon gamma; OR=odds ratio; RCT=randomized controlled trial; ROS=reactive oxygen species; SCFA=short chain fatty acids; SEA=South-East Asian region; WHO=World Health Organization.

TABLE 2 Summary of the Included Systematic Reviews

Article	WHO Region	Review Type/ Include Study Designs	# of Studies, Sample Size Range, Total Sample Size	Intervention/ Exposure	Outcomes Reported	Findings
Boaz et al., 2023[30]	EMR	Meta-analysis/ observational studies: prospective, retrospective, cross-sectional	12, 75–343,188, 354,332	Malnutrition as measured by a range of tools	In-hospital death among COVID-19 patients	Malnutrition or increased risk of malnutrition increased the risk of death (OR 3.43, 95% CI [2.549, 4.60])
Hung et al., 2022[31]	WPR	Meta-analysis/ observational studies: retrospective	13, 111–748, 4204	Malnutrition as measured by PNI	COVID-19 mortality and disease severity	Lower PNI associated with increased severity (mean difference −5,19, $p < .001$) and increased mortality (mean difference −8.65, $p < .001$). An increase in PNI per point was associated with reduced mortality (OR=0.84, 95% CI [0.77, 0.9]) and severity (OR=0.84, 95% CI [0.77, 0.92])
Feng et al., 2022[32]	WPR	Meta-analysis/ observational studies: cohort and cross-sectional	53, 27–760, 3614	Malnutrition as measured by NRS-2002	ICU hospitalization	High malnutrition among COVID-19 patients hospitalized in the ICU (92.2%, 95% CI [85.9, 96.8%] compared with those in the general ward (70.7% 95% CI 56.4–83.2%)
Moore et al., 2022[33]	EUR	Systematic review/ intervention studies: RCTs, controlled intervention, crossover RCT, cohort study involving an intervention	6, 36–225, 582	Intervention: Mediterranean diet	BMI and inflammatory markers	Significant reduction in BMI and inflammatory markers

BMI=body mass index; CI=confidence interval; EMR=Eastern Mediterranean region; EUR=European region; ICU=intensive care unit; NRS=nutrition risk score; OR=odds ratio; PNI=prognostic nutritional index; RCT=randomized controlled trial; WHO=World Health Organization; WPR=Western Pacific region.

Narrative Reviews

High-Fibre Diet

Three narrative reviews synthesized the evidence for the role of a high-fibre diet in maintaining a healthy digestive system and of the gut microbiome as part of a healthy immune response for the prevention and treatment of respiratory diseases, including COVID-19.[23-25] Two of these did not clearly outline the types of studies included,[23,25] while one stated inclusion of in vivo, in vitro, and clinical studies.[24] These reviews discussed the role of fibre in cultivating a gut microbiome that produces short-chain fatty acids (SCFA), such as butyrate, that are anti-inflammatory and anti-viral. One of the reviews discussed the role of butyrate in minimizing angiotensin-converting enzyme 2 (ACE2) receptor expression, limiting the ability of COVID-19 to enter host cells.[23] While the ability of a high-fibre diet to reduce the ACE2 receptor expression has been documented, no clinical trials have measured its impact in modifying the progression or symptom severity of COVID-19.

Mediterranean and Plant-Based Diets

Three narrative reviews investigated the impact of a plant-based diet, including but not limited to Mediterranean diet, on reducing the risk of acquiring and limiting the symptom severity of COVID-19 infection.[23,26,27] All three reviews described the benefit of a plant-based or Mediterranean diet in establishing a healthy immune system to prevent COVID-19.[23,26,27] One paper cited a 73% lower odds ratio (OR) of moderate-to-severe COVID-19 in individuals consuming a plant-based diet in a population case study.[26] The other two studies stated, without specific figures, the greater risk of acquiring COVID-19 associated with low antioxidant consumption.[23,27] Together, these studies suggest a possible benefit from consuming a plant-based or Mediterranean diet in improving immune health. This may aid in prevention and treatment of COVID-19; however, limited clinical data exists to date.

Fresh Fruits and Vegetables

Two narrative reviews discussed the impact of including fresh fruits and vegetables on specific inflammatory factors related to respiratory diseases and COVID-19.[27,28] Both reviews completed systematic literature searches on key terms. One included experimental, epidemiological, and clinical data and the other did not specify data type. One study cited a reduction in plasma levels of interferon-gamma (IFN-γ) with regular consumption of Acai juice in subjects with metabolic syndrome.[28] Both of these reviews suggested the relationship between antioxidant content in Amazonian fruits[28] and fresh fruits and vegetables[27] and improving immune system function. However, neither study provided data directly related to COVID-19 risk or severity of symptoms.

Intermittent Fasting

One narrative review investigated the role of food intake timing with the consideration of TRE or IF.[29] This study completed a systematic literature search on key terms. It included randomized

controlled trials (RCTs), clinical interventions and observational data. The review summarizes the impact of IF and TRE on reducing markers of immune stress including interleukin 1 beta (IL-1β), interleukin 6 (IL-6), interleukin 8 (IL-8), IFN-γ, and 8-isoprostane. This data confirms reduction of inflammation with IF/TRE diet patterns; however, no direct data is available investigating TRE or IF with COVID-19.

Systematic Reviews

Malnutrition

Three systematic reviews highlighted the impact of malnutrition in increasing the risk of COVID-19 hospitalization, disease severity, or mortality.[30-32] All three completed a meta-analysis to combine the data identified. All three reviews included studies that used observational design. The first one included prospective, retrospective, and cross-sectional studies,[30] while a second included retrospective studies,[31] and the third included cohort and cross-sectional studies.[32] Each review assessed the quality of the included studies; the tools used included the Quality in Prognostic Studies (QUIPS) tool,[31] the Newcastle-Ottawa Scale,[32] and the 14-question Quality Assessment Tool for Studies with Diverse Designs (QATSDD).[30] The exposure of interest was malnutrition, as measured by the Prognostic Nutritional Index (PNI)[31] in one meta-analysis and the Nutrition Risk Score (NRS-2002)[32] in a second. The third meta-analysis included studies using a wide range of malnutrition measures.[30] The outcomes of the observational studies included COVID-19 prevalence, disease severity, intensive care unit (ICU) hospitalization, and COVID-19 mortality. The number of studies included in each review was 12,[30] 13,[31] and 53[32] with a total sample size of $n = 354,332$, $n = 4204$, and $n = 3614$, respectively.

All the meta-analyses found an association between poor nutritional status and worse COVID-19 outcomes. In one, a significant association was found between lower PNI and both increased mortality (mean difference [MD]: –8.65, $p < .001$) and increased severity (MD: –5.19, $p < .001$).[31] This association was found when PNI was analyzed as both a continuous (range) and binary (high versus low) parameter. In the second review, it was found that the risk of malnutrition among patients hospitalized in the ICU with COVID-19 (92.2% 95% confidence interval [CI] [85.9, 96.8%]) was significantly higher than among COVID-19 patients hospitalized in the general ward (70.7%, 95% CI [56.4, 83.2%]) ($p = .002$).[32] In a sub-analysis, which categorized the studies based on the country's income level, no difference was identified between high, upper-middle, and lower-middle countries. In the third meta-analysis, it was found that malnutrition, or increased risk of malnutrition, increased the risk of death in hospital among adults diagnosed with COVID-19 by greater than three-fold (OR 3.43, 95% CI [2.549, 4.60], $p < .001$).[30]

Mediterranean Diet

One systematic review aimed to evaluate the effects of a hypocaloric, fibre-dense Mediterranean diet on BMI and inflammatory markers among adults who were overweight or obese, and thus at increased risk of severe COVID-19 outcomes.[33] The review identified and combined six intervention studies that delivered a Mediterranean diet intervention to overweight/obese adults 18 years of age or older. The number of participants in the six studies ranged from 36 to 225, with a total of 582. The individual studies reported on changes in BMI and inflammatory markers.[33] Study quality was assessed using the criteria from the Academy of Nutrition and Dietetics Evidence Analysis Manual. The researchers found that most of the studies reported a reduction in BMI and the inflammatory cytokines tumour necrosis factor (TNF)-a, IL-6 and high-sensitivity C-reactive protein (hs-CRP); the majority of these reductions were considered statistically significant.[33] None of the included studies assessed outcomes related to COVID-19 incidence, severity, or mortality.

DISCUSSION

There is significant evidence suggesting that dietary patterns, dietary constituents, and nutritional status are important modifiable risk factors relevant to the prevention and treatment of COVID-19. Important factors highlighted in this review include the deleterious effects of malnutrition as well as the possible benefits of the Mediterranean diet, fibre-rich diets, IF/TRE, and antioxidant-rich foods. Clinically significant findings were limited from the data reviewed, and many areas of opportunity for future research were detected.

Malnutrition Is a Risk Factor

This review identified evidence suggesting that malnutrition is a significant risk factor for COVID-19 outcomes such as higher disease severity, ICU hospitalization, and death. This finding is in line with other research on the effects of malnutrition on immune function, acute infection,[34] and the risk of death.[35] The papers reviewed in this study suggested potential mechanisms to explain the relationship between malnutrition and diminished immune function including impairment of gut-barrier function, decreased secretion of protective exocrine substances, decreased levels of plasma complement, atrophy of lymphatic tissues such as the thymus, decreased antibody production in response to vaccination, and cytokine patterns favouring a Th2-response.

The changes in immune function may be associated with deficiency of a range of dietary constituents, including protein, energy, vitamins C and E, selenium, iron, copper, folic acid, and zinc.[36] These are all areas of opportunity for further study related to COVID-19. Another area of opportunity for future research is the impact of treatment of malnutrition in improving COVID-19 symptoms and severity. While studies assessing the impact of correcting malnutrition in the prevention or treatment of COVID-19 were not identified, such studies exist for other infectious diseases. A meta-analysis of RCTs providing protein-energy-fortified macronutrient supplementation to patients with HIV found significant improvement in one immune parameter (CD4 count).[37,38] The effects of nutritional supplementation for prevention of COVID-19 and treatment of long COVID is an opportunity for further research.

Mediterranean Diet and Diets Containing Fresh Fruits and Vegetables May Be Beneficial

The evidence for the benefit of the Mediterranean diet or fresh fruits and vegetables related to COVID-19 outcomes is minimal and of moderate quality. Further study is needed to make clear connections between diets containing fresh fruits and vegetables and COVID-19. One emerging strategy in COVID-19 prevention is reduction in inflammation, which is cited as a positive outcome of consuming the Mediterranean diet.[39] Many diseased states are initiated, worsened, or progressed as a result of unchecked inflammation and oxidation.[40] Plant-based diets containing high amounts of fruits and vegetables have demonstrated similar effectiveness in reducing inflammation. Fruits and vegetables have antiviral properties which may be of benefit in the prevention and treatment of COVID-19.[41] Acai and similar fruits discussed in this review have compounds that may reduce the level of inflammatory markers and proteins related to ACE2 receptor expression which are the cellular entry point of COVID-19. Despite the current lack of conclusive evidence related to COVID-19, this is a definite area of opportunity for future research.

Lack of Evidence Related to IF/TRE and COVID-19

This review did not find conclusive evidence linking IF/TRE diets to COVID-19 symptom and severity reduction. However, the ability of IF/TRE diets to improve glycemic control, decrease insulin resistance,[42] reduce inflammation,[43] and limit cytokine secretion[44] may make it a beneficial strategy related to COVID-19. This diet seems to be a successful intervention for conditions such as metabolic syndrome and type 2 diabetes,[45,46] both comorbidities that increase the likelihood of severe COVID-19 outcomes.[47] More interventional data to test the efficacy and treatment strategies related to IF/TRE and COVID-19 is warranted.

A High-Fibre Diet may be Preventive

Data from studies in this review articulated the beneficial effects of the production of SCFA and the reduction of ACE2 resulting from a high-fibre diet. More clinical data is needed to assess the impact of a high-fibre diet and modification of the gut microbiome on the severity and progression of COVID-19. There is sufficient evidence that beneficial changes in the gut microbiome can reduce expression of the ACE2 receptor, limiting potential entry points for the SARS family of viruses.[48,49] There is also a suggested link between gut and lung health; through the gut–lung axis, diet impacts the health of respiratory defenses.[50] A high-fibre diet fosters microbial production of SCFA and serotonin in the intestinal cells, which directly strengthens respiratory immune responses and membranes.[51] Though data on this topic is still very limited, the suggested relationship between a high-fibre diet and reduction of COVID-19 risk is a promising area for more clinical and interventional study.

Limitations

This review includes a relatively high proportion of narrative reviews and a limited body of clinical and interventional data within these reviews. While some of the reviews evaluated included data from clinical or in vitro studies, others did not specify or included mainly observational data. Several of the included reviews presented evidence on the impact of dietary factors on COVID-19 risk or on the risk of developing other infections, or highlighted mechanisms by which dietary constituents may theoretically improve COVID-19 outcomes. Authors made every effort to base conclusions about COVID-19 and dietary patterns or nutritional status primarily on clinical and interventional data. While these studies provide useful information about therapeutic approaches that warrant further investigation, they cannot be used to make definitive clinical recommendations. More interventional data is needed to establish the impact of a healthy diet, metabolic health, and a healthy gut microbiome on COVID-19 prevention and treatment.

CONCLUSION

It is evident that nutrition is a significant factor impacting the incidence and severity of COVID-19 infection. Under- and over-nutrition are risk factors that can be reduced through dietary intervention; however, studies assessing the impact of modulating these risk factors on COVID-19 outcomes are lacking. Diets and dietary components that are anti-viral, anti-inflammatory and antioxidant may lower the risk and severity of symptoms and illness associated with COVID-19. While more clinical and interventional evidence is needed to precisely understand the impact of diet changes on COVID-19 risk, the findings of this review support the importance of following existing dietary guidelines such as consuming a diet that is calorically appropriate, rich in fruits and vegetables, healthy fats, and fibre to support healthy immune function.

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CONFLICTS OF INTEREST DISCLOSURE

We have read and understood the *CAND Journal*'s policy on conflicts of interest and declare that we have none.

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APPENDIX 1: GLOSSARY OF TERMS

ACE2	angiotensin-converting enzyme
AMA	American Medical Association
BMI	body mass index
CI	confidence interval
COVID-19	Coronavirus-19 disease
hs-CRP	high-sensitivity C-reactive protein
ICU	intensive care unit
IF	intermittent fasting
IFN-γ	interferon-gamma
IL	interleukin
MD	mean difference
NRS-2002	Nutrition Risk Score
OR	odd ratio
PNI	Prognostic Nutritional Index
QATSDD	Quality Assessment Tool for Studies with Diverse Designs
QUIPS	Quality in Prognostic Studies
RCT	randomized controlled trial
RCTs	randomized controlled trials
SARS-CoV-2	severe acute respiratory syndrome of the coronavirus-2
SCFA	short-chain fatty acids
TNF	tumour necrosis factor
TRE	time-restricted eating