

Why you should read this article:

- To better understand why older people are at high risk of infection with, and negative outcomes from, COVID-19
- To discern the role of nutritional interventions in supporting older people to recover from COVID-19
- To locate available guidance on nutrition in older people being treated for or recovering from COVID-19

Nutritional interventions in older people with COVID-19: an overview of the evidence

Stacey Jones, Elizabeth Archer, Dilek Ongan et al

Citation

Jones S, Archer E, Ongan D et al (2021) Nutritional interventions in older people with COVID-19: an overview of the evidence. *Nursing Older People*. doi: 10.7748/nop.2021.e1368

Peer review

This article has been subject to external double-blind peer review and checked for plagiarism using automated software

Correspondence

mmar.rupertolopez@ceu.es

Conflict of interest

None declared

Accepted

14 September 2021

Published online

December 2021

Abstract

Older people are a high-risk group for coronavirus disease 2019 (COVID-19) because of a range of factors, including age-related changes in anatomical pulmonary and muscle function, decreased immunity and increased inflammation. These factors partly explain why older people with COVID-19 experience more severe symptoms and higher mortality than younger adults and are more likely to require nutritional support. Furthermore, there is an association between suboptimal nutritional status and poorer recovery from COVID-19. Therefore, nutritional interventions are an important aspect of care for older people with COVID-19.

All members of the multidisciplinary team, including dietitians and nurses, need to assess, treat and prevent nutritional deficiencies in older people with COVID-19. This literature review provides an overview of the evidence regarding the role of nutritional interventions in the treatment of, and recovery from, COVID-19 in older people.

Author details

Stacey Jones, course director/senior lecturer, dietetics, Coventry University, Coventry, England; Elizabeth Archer, professional lead and dietetic manager, mental health services for older people, Nottinghamshire Healthcare NHS Foundation Trust, Nottingham, England; Dilek Ongan, associated professor, department of nutrition and dietetics, Izmir Kâtip Celebi University, Izmir, Turkey; Cecilia Morais, international office coordinator, faculty of nutrition and food sciences, University of Porto, Porto, Portugal; Robert Speer, clinical dietitian, department of geriatrics, Paracelsus Medical University, Nuremberg, Germany; Amalia Tsagari, clinical dietitian, department of clinical nutrition, KAT Hospital, Athens, Greece; Harriët Jager-Wittenaar, professor of malnutrition and healthy ageing, research group healthy ageing, Hanze University of Applied Sciences, Groningen, the Netherlands; Mar Ruperto, professor of clinical nutrition, faculty of pharmacy and health sciences, CEU San Pablo University, Madrid, Spain. On behalf of the European Specialist Dietetic Network for Older Adults of the European Federation of the Associations of Dietitians

Keywords

clinical, coronavirus disease 2019, COVID-19, diet, health promotion, malnutrition, nutrition, nutritional status, nutritional supplements, nutritional support, obesity, older people, recovery

Permission

To reuse this article or for information about reprints and permissions, please contact permissions@rcni.com

IN EARLY 2020, coronavirus disease 2019 (COVID-19) was declared a pandemic (World Health Organization 2020). Severe acute respiratory syndrome (SARS)-CoV-2 – the virus that causes COVID-19 – is mainly transmitted via respiratory droplets during close contact with an infected person, whether that person is symptomatic, pre-symptomatic or asymptomatic (Gupta et al 2020). Commonly reported symptoms include fever, dry cough,

fatigue, loss of taste and smell, respiratory distress, gastrointestinal symptoms, dyspnoea and hypoxaemia. More severe symptoms include acute respiratory distress syndrome (ARDS), septic shock, refractory metabolic acidosis and cardiac issues (Chen et al 2020a, Gupta et al 2020, Li et al 2020).

According to the Centers for Disease Control and Prevention (2021), almost 72% of deaths with confirmed or presumed

COVID-19 in the US between 1 January 2021 and 10 October 2021 occurred in people aged 65 years or over. Older people are a high-risk group for COVID-19 partly because of age-related changes in anatomical pulmonary and muscle function, which lead to reduced lung reserves, weakened airway clearance and diminished defensive barrier function (Chen et al 2020b). Furthermore, immunity decreases with age because of depleted levels of macrophages, natural killer cells, neutrophils, T-cell receptors and antibody-producing B-cells. In addition, in older people, there is an ongoing inflammatory process induced by increased levels of interleukin-6 (IL-6), interleukin-1 beta (IL-1 β) and tumour necrosis factor-alpha (TNF- α) (Chen et al 2020b). These various factors partly explain why older people with COVID-19 experience more severe symptoms than younger people and are more likely to require nutritional support (Chen et al 2020b).

Before the COVID-19 pandemic, research had shown that in Europe, the prevalence of malnutrition in older people was as high as 28% in hospitals, 17.5% in residential care and 8.5% in community settings (Leij-Halfwerk et al 2019, Dominguez et al 2021). In response to the pandemic, governments across the world implemented measures such as shielding, lockdowns and social distancing. While these restrictions have had some positive effects in reducing transmission rates, in older people they may also have inadvertently led to, or compounded, malnutrition and sarcopenia (loss of muscle mass and strength) due to reduced physical activity and suboptimal nutritional intake because of limited access to shops, social isolation and loneliness (Welch et al 2020).

According to the European Society for Clinical Nutrition and Metabolism (ESPEN), people with COVID-19 who are under-nourished or over-nourished are at higher risk of severe disease and mortality than people with COVID-19 who are well nourished (Barazzoni et al 2020). A cross-sectional study in people with COVID-19 aged over 65 years in Wuhan, China, found that approximately 28% were at risk of malnutrition and 53% were malnourished (Li et al 2020). Another study found that the risk of malnutrition in people with COVID-19 aged over 65 years hospitalised in a Wuhan hospital designated for patients with severe COVID-19 could be as high as 85% (Liu et al 2020). A study undertaken in the first 50 patients admitted to an Italian COVID-19 rehabilitation unit in the spring of 2020 found that 26% were

at moderate risk of malnutrition and 45% at high risk of malnutrition (Brugliera et al 2020). In these studies, malnutrition was associated with suboptimal patient outcomes, so optimising the nutritional status of older people with COVID-19 may improve survival and recovery.

The COVID-19 pandemic has placed additional demands on healthcare teams and dietetic services, with an increased use of nutritional assessments in inpatient and outpatient settings as well as the use of telephone and/or web-based interventions to monitor the nutritional requirements of older people recovering from COVID-19, with the use of apps such as the Remote Malnutrition Application for Primary Practice (www.rmappnutrition.com/en) (Krzynarić et al 2020).

Aim

This literature review aimed to provide an overview of the evidence regarding the role of nutritional interventions in the treatment of, and recovery from, COVID-19 in older people.

Methods

The databases Scopus, ScienceDirect and PubMed were searched between August 2020 and October 2020 for relevant studies published since 2003. Studies were included if they focused on:

- » Older people receiving nutritional interventions via the oral, enteral or parenteral route.
- » Nutritional interventions in older people in inpatient and outpatient and community settings.
- » Nutritional interventions in older people with COVID-19.

Studies were excluded if they did not involve nutritional interventions and/or if their focus was solely on the prevention of malnutrition or on food insecurity, socioeconomic factors or behaviour change. Published COVID-19 guidance and the websites of professional bodies such as the European Federation of the Associations of Dietitians and the British Dietetic Association were searched to source further relevant studies. Overall, 114 articles were identified and screened based on their title and abstract. A total of 42 articles were included in the final review, of which 27 related to older people with COVID-19. The included studies were analysed using a data extraction template to identify the nutrient of interest, population and/or setting, intervention and outcome.

Key points

- Older people are a high-risk group for coronavirus disease 2019 (COVID-19) because of age-related changes in anatomical pulmonary and muscle function, decreased immune function and chronic inflammation
- COVID-19 is associated with an increased risk of malnutrition in older people
- Early interventions aimed at optimising the nutritional status of older people with COVID-19 are essential
- Older people with COVID-19 should receive regular nutritional screening using a validated screening tool
- Older people with COVID-19 who are malnourished or at risk of malnutrition should be referred to a dietitian

Findings

Five themes were identified from the analysis of the selected literature:

- » Identifying the risk of malnutrition in older people.
- » Obesity and COVID-19 in older people.
- » Protein and energy intake.
- » Vitamins and minerals intake.
- » Omega-3 fatty acids intake.

Identifying the risk of malnutrition in older people

Older people are at increased risk of malnutrition due to age-related factors such as involuntary loss of weight, decreases in taste and smell, deteriorating dental health and inadequate dietary intake; to co-morbidities such as diabetes mellitus, emphysema and chronic obstructive pulmonary disease (COPD); and to gastrointestinal symptoms such as diarrhoea, nausea, vomiting, ileus and bowel ischaemia. Malnutrition and risk of malnutrition are often underdiagnosed in older people, both in hospital and in the community (Wolters et al 2019). One quarter of older patients at risk of malnutrition do not receive nutritional support or advice despite being routinely in contact with healthcare professionals (Orrevall et al 2009, Fávoro-Moreira et al 2016, Dominguez et al 2021). Malnutrition and risk of malnutrition in older people with COVID-19 have been associated with longer hospital stays, suboptimal appetite and greater weight loss compared with older people with COVID-19 who are well nourished (Liu et al 2020).

Malnutrition is identified in clinical practice using validated screening tools (Liu et al 2020) such as the Nutritional Risk Screening 2002 (NRS-2002) (Kondrup et al 2003), Malnutrition Universal Screening Tool (MUST) (Stratton et al 2006) or Mini Nutritional Assessment short form (MNA-SF) (Kaiser et al 2009). Guidance from the ESPEN on nutrition

in patients with COVID-19 recommends regular nutritional screening of all patients with COVID-19 and that all members of the multidisciplinary team should be involved in the prevention, diagnosis and treatment of malnutrition (Barazzoni et al 2020).

The US Academy of Nutrition and Dietetics recommends that nutritional care during the COVID-19 pandemic should include early referral to a dietitian so that patients at risk of or with malnutrition receive tailored nutritional care for preventing or treating nutritional status-related disorders such as malnutrition, sarcopenia, frailty and micronutrient deficiencies (Handu et al 2021).

Box 1 shows a practical approach to nutritional screening in older people with COVID-19.

Obesity and COVID-19 in older people

Obesity, which refers to an excessive accumulation of visceral, omental, intra-abdominal and ectopic fat, is a known risk factor for cardiovascular disease and diabetes. Obesity is also a prognostic factor of compromised immunity, illness severity and mortality in older people with COVID-19 (Nikolich-Zugich et al 2020, Onder et al 2020, Watanabe et al 2020).

Ageing is associated with physiological changes that can lead to an accumulation of excess adipose tissue often accompanied by sarcopenia – this is termed sarcopenic obesity. Sarcopenia, in turn, can lead to diminished functional capacity, frailty and other co-morbidities (Azzolino et al 2020). The Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls (SARC-F) questionnaire (Malmstrom and Morley 2013) is recommended for identifying the risk of sarcopenia in older people, independent of body weight.

Ageing is also associated with a gradual weakening of immune function – known as

Box 1. Practical approach to nutritional screening in older people with COVID 19

- » Undertake regular nutritional screening, in the treatment phase and in the recovery phase, as part of routine clinical care during hospital inpatient and outpatient episodes, in patients' homes and in the community
- » Use a validated screening tool such as the Nutritional Risk Screening 2002 (NRS-2002) (Kondrup et al 2003), Malnutrition Universal Screening Tool (MUST) (Stratton et al 2006) or Mini Nutritional Assessment short form (MNA-SF) (Kaiser et al 2009)
- » Diagnose malnutrition using a two-step-approach:
 - Step 1: initial screening to identify at-risk patients using one of the validated screening tools listed above
 - Step 2: nutritional assessment to diagnose and grade the severity of malnutrition using the Global Leaders in Malnutrition (GLIM) criteria (Cederholm et al 2019)
- » Refer patients at risk of or with malnutrition to a dietitian early for tailored nutritional care

COVID-19 = coronavirus disease 2019
(Adapted from Barazzoni et al 2020, Liu et al 2020, Handu et al 2021)

immunosenescence – that negatively affects the body's innate and adaptive immune responses and contributes to inflammation and immunodeficiency (Fulop et al 2018, Nikolich-Zugich et al 2020). Nutritional deficiencies negatively affect the maturation, differentiation and function of lymphocytes and the activity of natural killer cells – two types of cells that play an important role in the immune system. Older people's susceptibility to viral infections, for example COVID-19, is compounded by a process of chronic low-grade inflammation that develops with age – known as inflammaging – which is partially driven by an increased production of cytokines by adipose tissue (Fulop et al 2018, Lighter et al 2020). Sarcopenic obesity and age-related immune dysfunction and chronic inflammation may partly explain why older people are more likely than younger people to develop severe symptoms of COVID-19 (Mueller et al 2020).

Sarcopenic obesity is characterised by excess adipose tissue and loss of muscle mass and strength. Sarcopenia in older people is related to the increased production of proinflammatory cytokines (Cesari et al 2005), the amount of muscle mass being inversely proportional to the plasma concentrations of IL-6 and TNF- α . Excessive adiposity stimulates the secretion of pro-inflammatory cytokines in skeletal muscle and promotes low-grade systemic inflammation, resulting in a cycle that promotes the development of sarcopenic obesity. Azzolino et al (2020) found that this inflammatory state, along with compromised respiratory function, was a factor in the severity of COVID-19 in patients of any age with obesity. Furthermore, older people with obesity have lower cardiorespiratory and metabolic reserves available to combat COVID-19 (Sattar et al 2020).

Ryan and Caplice (2020) found that patients with obesity exhibit low-grade systemic inflammation and increased susceptibility to infection and high viral load. Obesity can also contribute to a potentially fatal immune reaction known as hypercytokinaemia (or 'cytokine storm'), which is characterised by hyper-inflammation. Hypercytokinaemia is associated with an excessive immune response, oxidative stress, endothelial dysfunction, altered microbiome and increased interferon gamma (IFN- γ) production (Voss and Dhurandhar 2017, Goossens et al 2020). In patients with COVID-19, hypercytokinaemia adds to the strain on the body's metabolism (Ye et al 2020).

Kassir (2020) identified that, since obesity increases the vulnerability to infections, it is likely to be a risk factor for COVID-19-related mortality. Two meta-analyses showed that obesity-related complications and abdominal obesity were risk factors significantly associated with the severity of COVID-19 (Földi et al 2021, Yang et al 2021). In a study of 268 patients with COVID-19 in a third-level hospital in Italy, two thirds were older people, half of whom were overweight or obese (Pironi et al 2021). Diabetes, respiratory conditions and cardiovascular disease each affected at least 20% of patients. A higher body mass index (BMI) was associated with higher levels of C-reactive protein (a marker of inflammation), more frequent admission to the intensive care unit (ICU) and a more invasive modality of oxygen therapy than a lower BMI (Pironi et al 2021). Invasive mechanical ventilation in patients with COVID-19 treated in the ICU was reported to be seven times more likely in patients with a BMI greater than 35kg/m² compared with those with a BMI less than 35kg/m² (Simonnet et al 2020).

Various studies found that the amount of visceral adipose tissue was elevated in patients being treated for COVID-19 in the ICU, as were the patients' age, severity of interstitial pneumonia, levels of inflammatory biomarkers (Battisti et al 2020), abdominal fat and waist circumference (Watanabe et al 2020, Földi et al 2021). Visceral adiposity or a high amount of intramuscular fat can independently predict the risk of critical illness in COVID-19 (Földi et al 2021, Yang et al 2021).

Protein and energy intake

In older people with co-morbidities, nutritional risk and malnutrition need to be identified early (Cederholm et al 2019, Barazzoni et al 2020). A food-first approach with dietary counselling should be used to optimise nutritional status. When that approach is not sufficient to meet patients' nutritional requirements, oral supplements should be considered in line with local policy (Volkert et al 2019).

In patients with COVID-19 treated in the ICU who are not mechanically ventilated, a person-centred approach should be implemented, patients should be referred to a dietitian for a detailed dietary assessment and tailored advice where indicated (Barazzoni et al 2020) and dietitians should work with the other members of the multidisciplinary team to ensure adequate protein and energy intake (Handu et al 2021).

The ESPEN guidance on nutrition in patients with COVID-19 recommends a daily intake of up to 1.5g of protein per kilogram – or between 20% and 25% of the total daily calorie count – for older people with a chronic condition. In older people with polymorbidity whose nutritional requirements cannot be met by oral nutrition, enteral nutrition needs to be considered. In non-intubated patients in whom the enteral route presents challenges, peripheral parenteral nutrition needs to be considered. Enteral nutrition in ventilated patients and in intubated patients should start with nasogastric tube feeding. Considering the high prevalence of swallowing disorders in older people after extubation, special attention must be paid to meet the nutritional requirements of this particular patient group (Barazzoni et al 2020).

Box 2 shows a practical approach to nutritional support in older people with COVID-19.

Vitamins and minerals intake

Micronutrients such as vitamins C, D and E, selenium and zinc have been associated with an improved immune response due to their cytokine-calming and antioxidant properties (Calder et al 2020). However, research on their use in older people with COVID-19 is limited and inconclusive.

Vitamin D is required for the regulation of calcium and phosphorous levels and is synthesised in the skin when the skin is exposed to ultraviolet B radiation from sunlight. A review by the National Institute for Health and Care Excellence (NICE) found no evidence of benefits of using vitamin D in adults with COVID-19, but some studies have shown an association between lower levels of vitamin D and the development of COVID-19 (NICE 2020). The prevalence of vitamin D deficiency is higher in older people than in younger adults and higher in older people

living in institutions than in those living in the community (Marcos-Pérez et al 2020). This is attributable to factors such as longer time spent indoors, lower dermal synthesis of pre-vitamin D, inadequate vitamin D intake and decreased kidney function (Marcos-Pérez et al 2020). During the COVID-19 pandemic, the advice to shield may have compounded the risk of vitamin D deficiency in older people. The Scientific Advisory Committee on Nutrition (2016) recommends a daily reference nutrient intake of 10 micrograms (400IU) of vitamin D for everyone aged 4 years and older. Further investigation of the potential benefits of vitamin D in COVID-19 is required.

Vitamins A, B6, B12, C, D and E and the trace elements selenium, zinc, iron, magnesium and copper have been discussed as positive modulators of the immune system (Moghaddam et al 2020). Selenium for example, which is essential for immune function, has been shown to be present at lower levels in older people who have died with COVID-19 compared with older people who have survived the infection (Moghaddam et al 2020). Consuming selenium-containing foods as part of a balanced diet or taking selenium supplements may contribute to maintaining immune function, but the benefits of selenium have not been substantiated in the context of COVID-19 (Moghaddam et al 2020).

Zinc has antioxidant and anti-inflammatory properties and could boost the immune response against viruses. Zinc deficiency compromises immune function in older people (Mossink 2020). Zinc may have a protective effect in patients with COVID-19 by reducing inflammation, improving mucociliary clearance in the lungs and preventing ventilator-induced lung injury. However, clinical and experimental studies are required before practice recommendations regarding zinc intake can be made (Skalny et al 2020).

Box 2. Practical approach to nutritional support in older people with COVID-19

- » The daily protein and energy intakes for older people (and for people of any age at risk of malnutrition) should be ≥ 1 g of protein per kilogram and 27-30kcal per kilogram, respectively
- » Non-ventilated patients in whom a food-first approach with dietary counselling is not sufficient to meet nutritional requirements should receive oral nutritional supplements. Oral nutritional supplements should provide at least 400kcal and 30g of protein per day and be given for at least one month
- » In ventilated or intubated patients, enteral nutrition should start with nasogastric tube feeding
- » In non-intubated patients in whom the enteral route presents challenges, peripheral parenteral nutrition needs to be considered
- » In patients with high gastric intolerance and/or high risk of aspiration, prokinetics may be considered in addition to nasogastric feeding or post-pyloric feeding

COVID-19 = coronavirus disease 2019
(Adapted from Volkert et al 2019, Barazzoni et al 2020)

Omega-3 fatty acids intake

Excessive acute inflammation has been linked to lung diseases including ARDS, COPD and COVID-19 (Sandhaus and Swick 2020). The omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are found in seafood (especially oily fish), are known to have anti-inflammatory, antithrombotic and immunoregulatory properties (Ruperto et al 2021). DHA, EPA and the omega-6 fatty acid arachidonic acid are available at sites of acute inflammation, where they are converted into bioactive pro-resolving mediators, which have a role in limiting acute responses and removing pathogens, dead cells and debris from areas of inflammation (Rogerio et al 2020). Omega-3 fatty acids could have a role in mitigating hypercytokinaemia and resolving inflammation in patients with active COVID-19 infection and in patients with documented omega-3 deficiency recovering from COVID-19. However, further research is needed before practice recommendations regarding omega-3 fatty acids intake can be made (Rogerio et al 2020).

Discussion

The literature on nutritional interventions and COVID-19 is rapidly expanding and it is expected that researchers will learn more about the effects of nutritional interventions on treatment of and recovery from COVID-19.

COVID-19 is associated with an increased risk of malnutrition, possibly due to the effects of the loss of taste and smell on appetite, the gastrointestinal symptoms of the disease and patients' increased nutritional requirements due to inflammation and an upregulated immune response (Mueller et al 2020, Ye et al 2020, Pironi et al 2021). In older people who may already be malnourished, the likelihood of negative outcomes may be increased. Maintaining an optimal nutritional status, including preventing overweight and obesity, will likely support older people to recover from COVID-19.

Early referral to a dietitian enables older people at risk of or with malnutrition to access specialist nutritional assessment and interventions. The early detection of nutritional risk and malnutrition leads to timely nutritional interventions that may aid recovery from COVID-19. Nutritional screening provides a platform for triaging patients and for providing prompt nutritional interventions to those who need them. While nutritional risk screening is mandatory in the hospital setting, it is only recommended in community

settings (NICE 2017). In the context of the COVID-19 pandemic and beyond, everyone aged 65 years or over in community settings should be regularly screened for nutritional risk and malnutrition.

Guidance states the importance of an adequate protein and energy intake to support positive outcomes in older people with COVID-19 (Barazzoni et al 2020, Handu et al 2021). Older people are at higher risk of malnutrition than younger people, so the need to improve their nutritional status is even more important. A suboptimal nutritional status is closely associated with poorer recovery from COVID-19 as well as from other conditions.

Micronutrients including vitamins C, D and E, selenium and zinc have been hypothesised to aid recovery from COVID-19 and reduce the severity of symptoms due to their role in supporting immune function, but evidence regarding the effectiveness of their use in older people with COVID-19 is yet to be demonstrated. Evidence is also needed to make recommendations regarding the use of omega-3 fatty acids in older people with COVID-19. However, these nutrients should already be part of a healthy balanced diet in older people (Volkert et al 2019).

Limitations

COVID-19 is a new and developing disease. The findings of this literature review are limited by the paucity of research published at the time of the review. Many studies did not focus on older people or did not indicate the age of participants and the quality of the studies was suboptimal, with few randomised controlled trials.

Conclusion

Older people with COVID-19 are likely to be at high risk of malnutrition and should be routinely screened for nutritional risk and malnutrition using a validated screening tool. Older people are at higher risk of experiencing severe symptoms of COVID-19 and higher mortality than other patient groups and a suboptimal nutritional status is associated with poorer recovery from COVID-19. Early interventions aimed at optimising the nutritional status of older people with COVID-19 are therefore essential. All members of the multidisciplinary team – including not only dietitians but also nurses, allied health professionals and doctors – should be involved in assessing, treating and preventing nutritional deficiencies in older people with COVID-19.

References

- Azzolino D, Saporiti E, Proietti M et al (2020) Nutritional considerations in frail older patients with COVID-19. *Journal of Nutrition, Health and Aging*. 24, 7, 696-698. doi: 10.1007/s12603-020-1400-x
- Barazzoni R, Bischoff SC, Breda J et al (2020) ESPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection. *Clinical Nutrition*. 39, 6, 1631-1638. doi: 10.1016/j.clnu.2020.03.022
- Battisti S, Pedone C, Napoli N et al (2020) Computed tomography highlights increased visceral adiposity associated with critical illness in COVID-19. *Diabetes Care*. 43, 10, e129-e130. doi: 10.2337/dc20-1333
- Brugliera L, Spina A, Castellazzi P et al (2020) Nutritional management of COVID-19 patients in a rehabilitation unit. *European Journal of Clinical Nutrition*. 74, 6, 860-863. doi: 10.1038/s41430-020-0664-x
- Calder PC, Carr AC, Gombart AF et al (2020) Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*. 12, 4, 1181. doi: 10.3390/nu12041181
- Cederholm T, Jensen GL, Correia MI et al (2019) GLIM criteria for the diagnosis of malnutrition – a consensus report from the global clinical nutrition community. *Clinical Nutrition*. 38, 1, 1-9. doi: 10.1016/j.clnu.2018.08.002
- Centers for Disease Control and Prevention (2021) Weekly Updates by Select Demographic and Geographic Characteristics. www.cdc.gov/nchs/nvss/vsrr/COVID_weekly/index.htm#AgeAndSex (Last accessed: 15 November 2021.)
- Cesari M, Kritchevsky SB, Baumgartner RN et al (2005) Sarcopenia, obesity, and inflammation – results from the trial of angiotensin converting enzyme inhibition and novel cardiovascular risk factors study. *American Journal of Clinical Nutrition*. 82, 2, 428-434. doi: 10.1093/ajcn.82.2.428
- Chen N, Zhou M, Dong X et al (2020a) Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet*. 395, 10223, 507-513. doi: 10.1016/S0140-6736(20)30211-7
- Chen Q, Wang L, Yu W et al (2020b) Recommendations for the prevention and treatment of the novel coronavirus pneumonia in the elderly in China. *Aging Medicine*. 3, 2, 66-73. doi: 10.1002/agm2.12113
- Dominguez Castro P, Reynolds C, Bizzaro MG et al (2021) Characteristics and determinants of high volume dispensing in long-term oral nutritional supplement users in primary care: a secondary analysis. *BJGP Open*. 5, 2, BJGPO.2020.0131. doi: 10.3399/BJGPO.2020.0131
- Fávaro-Moreira NC, Krausch-Hofmann S, Matthys C et al (2016) Risk factors for malnutrition in older adults: a systematic review of the literature based on longitudinal data. *Advances in Nutrition*. 7, 3, 507-522. doi: 10.3945/an.115.01254
- Földi M, Farkas N, Kiss S et al (2021) Visceral adiposity elevates the risk of critical condition in COVID-19: a systematic review and meta-analysis. *Obesity*. 29, 3, 521-528. doi: 10.1002/oby.23096
- Fulop T, Larbi A, Dupuis G et al (2018) Immunosenescence and inflamm-aging as two sides of the same coin: friends or foes? *Frontiers in Immunology*. 8, 1960. doi: 10.3389/fimmu.2017.01960
- Goossens GH, Dicker D, Farpour-Lambert NJ et al (2020) Obesity and COVID-19: a perspective from the European Association for the Study of Obesity on immunological perturbations, therapeutic challenges, and opportunities in obesity. *Obesity Facts*. 13, 4, 439-452. doi: 10.1159/000510719
- Gupta L, Jalang'o GA, Gupta P (2020) Nutritional management and support in COVID-19: emerging nutriviigilance. *Journal of the Pakistani Medical Association*. 70, Suppl 3, 5, S124-S130. doi: 10.5455/JPMA.31
- Handu D, Moloney L, Rozga M et al (2021) Malnutrition care during the COVID-19 pandemic: considerations for registered dietitian nutritionists. *Journal of the Academy of Nutrition and Dietetics*. 121, 5, 979-987. doi: 10.1016/j.jand.2020.05.012
- Kaiser MJ, Bauer JM, Ramsch C et al (2019) Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. *Journal of Nutrition Health and Aging*. 13, 782. doi: 10.1007/s12603-009-0214-7
- Kassir R (2020) Risk of COVID-19 for patients with obesity. *Obesity Reviews*. 21, 6, e13034. doi: 10.1111/obr.13034
- Kondrup J, Rasmussen HH, Hamberg O et al (2003) Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clinical Nutrition*. 22, 3, 321-336. doi: 10.1016/s0261-5614(02)00214-5
- Krznarić Ž, Bender DV, Laviano A et al (2020) A simple remote nutritional screening tool and practical guidance for nutritional care in primary practice during the COVID-19 pandemic. *Clinical Nutrition*. 39, 7, 1983-1987. doi: 10.1016/j.clnu.2020.05.006
- Leij-Halfwerk S, Verwijs MH, van Houdt S et al (2019) Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults ≥65 years: a systematic review and meta-analysis. *Maturitas*. 126, 80-89. doi: 10.1016/j.maturitas.2019.05.006
- Li T, Zhang Y, Gong C et al (2020) Prevalence of malnutrition and analysis of related factors in elderly patients with COVID-19 in Wuhan, China. *European Journal of Clinical Nutrition*. 74, 6, 871-875. doi: 10.1038/s41430-020-0642-3
- Lighter J, Phillips M, Hochman S et al (2020) Obesity in patients younger than 60 years is a risk factor for COVID-19 hospital admission. *Clinical Infectious Diseases*. 71, 15, 896-897. doi: 10.1093/cid/ciaa415
- Liu G, Zhang S, Mao Z et al (2020) Clinical significance of nutritional risk screening for older adult patients with COVID-19. *European Journal of Clinical Nutrition*. 74, 6, 876-883. doi: 10.1038/s41430-020-0659-7
- Malmstrom TK, Morley JE (2013) SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. *Journal of the American Medical Directors Association*. 14, 8, 531-532. doi: 10.1016/j.jamda.2013.05.018
- Marcos-Pérez D, Sánchez-Flores M, Proietti S et al (2020) Low vitamin D levels and frailty status in older adults: a systematic review and meta-analysis. *Nutrients*. 12, 8, 2286. doi: 10.3390/nu12082286
- Moghaddam A, Heller RA, Sun Q et al (2020) Selenium deficiency is associated with mortality risk from COVID-19. *Nutrients*. 12, 7, 2098. doi: 10.3390/nu12072098
- Mossink JP (2020) Zinc as nutritional intervention and prevention measure for COVID-19 disease. *BMJ Nutrition Prevention and Health*. 3, 1, 111-117. doi: 10.1136/bmjnp-2020-000095
- Mueller AL, McNamara MS, Sinclair DA (2020) Why does COVID-19 disproportionately affect older people? *Aging*. 12, 10, 9959-9981. doi: 10.18632/aging.103344
- National Institute for Health and Care Excellence (2017) Nutrition Support for Adults: Oral Nutrition Support, Enteral Tube Feeding and Parenteral Nutrition. Clinical guideline No. 32. NICE, London.
- National Institute for Health and Care Excellence (2020) COVID-19 Rapid Guideline on Vitamin D. NICE guideline No. 187. NICE, London.
- Nikolich-Zugich J, Knox KS, Rios CT et al (2020) SARS-CoV-2 and COVID-19 in older adults: what we may expect regarding pathogenesis, immune responses, and outcomes. *GeroScience*. 42, 2, 505-514. doi: 10.1007/s11357-020-00186-0
- Onder G, Rezza G, Brusaferro S (2020) Case-fatality rate and characteristics of patients dying in relation to COVID-19 in Italy. *JAMA*. 323, 18, 1775-1776. doi: 10.1001/jama.2020.4683
- Orrevall Y, Tishelman C, Permet J et al (2009) Nutritional support and risk status among cancer patients in palliative home care services. *Supportive Care in Cancer*. 17, 2, 153-161. doi: 10.1007/s00520-008-0467-4
- Pironi L, Sassdelli AS, Ravaoli F et al (2021) Malnutrition and nutritional therapy in patients with SARS-CoV-2 disease. *Clinical Nutrition*. 40, 3, 1330-1337. doi: 10.1016/j.clnu.2020.08.021
- Rogero MM, Leão MC, Santana TM et al (2020) Potential benefits and risks of omega-3 fatty acids supplementation to patients with COVID-19. *Free Radical Biology and Medicine*. 156, 190-199. doi: 10.1016/j.freeradbiomed.2020.07.005
- Ruperto M, Rodríguez-Mendiola N, Díaz-Domínguez M et al (2021) Effect of oral administration of docohexanoic acid on anemia and inflammation in hemodialysis patients: a randomized controlled clinical trial. *Clinical Nutrition ESPEN*. 41, 129-135. doi: 10.1016/j.clnesp.2020.12.004
- Ryan PM, Caplice NM (2020) Is adipose tissue a reservoir for viral spread, immune activation, and cytokine amplification in coronavirus disease 2019? *Obesity*. 28, 7, 1191-1194. doi: 10.1002/oby.22843
- 10.1002/oby.22843
- Sandhaus S, Swick AG (2020) Specialized proresolving mediators in infection and lung injury. *BioFactors*. 47, 1, 6-18. doi: 10.1002/biof.1691
- Sattar N, McInnes IB, McMurray JJ (2020) Obesity is a risk factor for severe COVID-19 infection: multiple potential mechanisms. *Circulation*. 142, 1, 4-6. doi: 10.1161/CIRCULATIONAHA.120.047659
- Scientific Advisory Committee on Nutrition (2016) Vitamin D and Health. assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/537616/SACN_Vitamin_D_and_Health_report.pdf (Last accessed: 15 November 2021.)
- Simonnet A, Chetboun M, Poissy J et al (2020) High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. *Obesity*. 28, 7, 1195-1199. doi: 10.1002/oby.22831
- Skalny AV, Rink L, Ajsuvakova OP et al (2020) Zinc and respiratory tract infections: perspectives for COVID 19 (Review). *International Journal of Molecular Medicine*. 46, 1, 17-26. doi: 10.3892/ijmm.2020.4575
- Stratton RJ, King CL, Stroud MA et al (2006) 'Malnutrition Universal Screening Tool' predicts mortality and length of hospital stay in acutely ill elderly. *British Journal of Nutrition*. 95, 2, 325-330. doi: 10.1079/bjn20051622
- Volkert D, Beck AM, Cederholm T et al (2019) ESPEN guideline on clinical nutrition and hydration in geriatrics. *Clinical Nutrition*. 38, 1, 10-47. doi: 10.1016/j.clnu.2018.05.024
- Voss JD, Dhurandhar NV (2017) Viral Infections and obesity. *Current Obesity Reports*. 6, 28-37. doi: 10.1007/s13679-017-0251-1
- Watanabe M, Caruso D, Tuccinardi D et al (2020) Visceral fat shows the strongest association with the need of intensive care in patients with COVID-19. *Metabolism*. 111, 154319. doi: 10.1016/j.metabol.2020.154319
- Welch C, Greig C, Masud T et al (2020) COVID-19 and acute sarcopenia. *Aging and Disease*. 11, 6, 1345-1351. doi: 10.14336/AD.2020.1014
- Wolters M, Volkert D, Streicher M et al (2019) Prevalence of malnutrition using harmonized definitions in older adults from different settings – a MaNuEL study. *Clinical Nutrition*. 38, 5, 2389-2398. doi: 10.1016/j.clnu.2018.10.020
- World Health Organization (2020) WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 – 11 March 2020. www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (Last accessed: 15 November 2021.)
- Yang J, Hu J, Zhu C (2021) Obesity aggravates COVID-19: a systematic review and meta-analysis. *Journal of Medical Virology*. 93, 1, 257-261. doi: 10.1002/jmv.26237
- Ye Q, Wang B, Mao J (2020) The pathogenesis and treatment of the 'cytokine storm' in COVID-19. *Journal of Infection*. 80, 6, 607-613. doi: 10.1016/j.jinf.2020.03.037