COVID-19: Lessons on malnutrition, nutritional care and public health from the ESPEN-WHO Europe call for papers

Barazzoni, Rocco; Breda, Joao; Cuerda, Cristina; Schneider, Stephane; Deutz, Nicolaas E.; Wickramasinghe, Kremlin

Collaborators: Genton Graf, Laurence

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Editorial

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SUMMARY

With prolonged pandemic conditions, and emerging evidence but persisting low awareness of the importance of nutritional derangements, ESPEN has promoted in close collaboration with World Health Organization-Europe a call for papers on all aspects relating COVID-19 and nutrition as well as nutritional care, in the Society Journals Clinical Nutrition and Clinical Nutrition ESPEN. Although more COVID-related papers are being submitted and continue to be evaluated, ESPEN and WHO present the current editorial to summarize the many published findings supporting major interactions between nutritional status and COVID-19. These include 1) high risk of developing the disease and high risk of severe disease in the presence of pre-existing undernutrition (malnutrition) including micronutrient deficiencies; 2) high risk of developing malnutrition during the course of COVID-19, with substantial impact on long-term sequelae and risk of long COVID; 3) persons with obesity are also prone to develop or worsen malnutrition and its negative consequences during the course of COVID-19; 4) malnutrition screening and implementation of nutritional care may improve disease outcomes; 5) social and public health determinants contribute to the interaction between nutritional status and COVID-19, including negative impact of lockdown and social limitations on nutrition quality and nutritional status. We believe the evidence supports the need to consider COVID-19 as (also) a case of malnutrition-enhanced disease and disease-related malnutrition, with added risk for persons both with and without obesity. Similarities with many other disease conditions further support recommendations to implement standard nutritional screening and care in COVID-19 patients, and they underscore the relevance of appropriate nutritional and lifestyle prevention policies to limit infection risk and mitigate the negative health impact of acute pandemic bouts.

1. Introduction

The COVID-19 pandemic continues to impose substantial global threats for individual health and public health systems. A strong association between nutritional derangements and COVID-19 has been hypothesized very early in the pandemic course, with potential substantial impact of malnutrition on infection risk, disease severity and outcome. ESPEN has therefore rapidly issued guidance documents for nutritional management of COVID-19 patients, at the onset of the pandemic and later in 2021 to focus on the emerging nutritional risk in COVID-19 patients with obesity [1,2]. With prolonged pandemic conditions and emerging evidence, but persisting low awareness of the importance of nutritional derangements, ESPEN has promoted in close collaboration with World Health Organization (WHO)-Europe a call for papers on all aspects relating COVID-19 and nutrition as well as nutritional care, in the Society Journals Clinical Nutrition and Clinical Nutrition ESPEN. ESPEN and WHO-Europe present the current paper to summarize the many findings published as a result of this call in ESPEN journals. In particular, the paper was prepared by collecting and summarizing all original articles accepted and published in the ESPEN journals Clinical Nutrition and Clinical Nutrition ESPEN on the topic of COVID-19 until April 2022. Due to the nature of this work, that is not a formal systematic review, there were no explicitly defined inclusion and exclusion criteria related to study type, exposure, outcome and population group. A comprehensive review of papers published in other journals was also outside the scope of the current work, which is focused on the ESPEN-WHO Europe call for papers. The authors then identified five main topics under which published papers were sub-divided, based on authors judgment, into general fields of interaction between disease and nutritional status: 1) negative impact of pre-existing undernutrition (hereafter indicated as malnutrition according to clinical terminology in the clinical nutrition community) and micronutrient deficiencies on COVID-19 risk and severity; 2) COVID-19-related malnutrition as a case of disease-related malnutrition (DRM), and its potential involvement in the more recently-defined long COVID; 3) association between obesity and malnutrition in COVID-19 and their clinical impact; 4) initial evidence supporting implementation of nutritional treatment to improve COVID-19 outcomes; 5) lifestyle and public health nutritional implications.

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2. Negative impact of pre-existing malnutrition and micronutrient deficiencies on COVID-19 risk and severity

COVID-19 is a respiratory disease caused by SARS-CoV-2 infection that can lead to respiratory insufficiency with potentially fatal complications [3–7]. Patient groups with pre-existing comorbidities as well as older age have been soon recognized to have higher risk for severe disease and mortality [3–7]. Also importantly, both older age and polymorbidity are per se associated with high risk and prevalence of malnutrition [8,9] due to combined catabolic derangements, low food intake and low physical activity, resulting in loss of body and skeletal muscle mass and function [8–10]. Malnutrition is conversely an independent cause of morbidity and mortality in most disease conditions, through mechanisms including negative impact on immune function and high risk of infections or superinfection [11,12] as well as respiratory and cardiac muscle dysfunction [13,14]. Micronutrient deficiencies are also common in high-risk and older individuals, and they are well-recognized risk factors for immune dysfunction and consequent infection risk [2]. Malnutrition characterized by loss of skeletal muscle mass may also notably worsen quality of life, disability and morbidities in disease survivors long after infection resolution and hospital discharge [8–10,15–17].

2.1. Malnutrition: prevalence

Consistent with these concepts, evidence has emerged that risk of malnutrition, and malnutrition per se, are highly prevalent in COVID-19 patients in various clinical settings [18–24], fully consistent with high risk of COVID-19 infection in malnourished individuals. The ESPEN-WHO Europe call has contributed to further establish and expand available information. Malnutrition was confirmed to be common in both non-ICU and ICU hospitalized cohorts and in various age groups, with combined prevalence of malnutrition and malnutrition risk consistently above 40% [24–30], with a systematic review of 27 studies identifying average prevalence at 49% [31]. The recent GLIM approach for malnutrition diagnosis was also employed, and detected malnutrition with comparable prevalence [29,32], while reports from several Countries and world regions confirmed the global negative role of malnutrition in the COVID-19 pandemic [29,32].

2.2. Malnutrition: negative clinical impact

Similar to virtually any other disease condition [10], malnutrition risk and malnutrition per se were associated with higher disease severity and worse outcomes in early reports on COVID-19 [18–21,23,24,27]. Several studies published in the ESPEN-WHO Europe call have further confirmed and dissected this association. In non-ICU patients with COVID-19, poor nutritional state was associated with higher mortality in a systematic review [31] and with higher risk of transfer to ICU from hospital wards [30] as well as longer length of hospital stay [30,33], active complications at discharge [34], and ultimately negative outcomes and mortality in several studies and databases [29,30,34,35]. Specifically in geriatric settings, malnutrition risk at admission predicted hospital length of stay [27] while MNA-assessed malnutrition also predicted in-hospital mortality in a large population cohort [36]. Despite ongoing discussions on its suitability for assessment of nutritional status in ICU, the NUTRIC score also predicted mortality in critically ill patients [24,37]. Independently of other nutritional parameters, self-reported reduction of food intake before admission, and physician judgment of expected low food intake after admission were also reported to predict admission to ICU and mortality in non-ICU patients [38]. This finding is notably consistent with observations that recent pre-admission weight-loss is an independent risk factor for mortality in all-cause hospitalized patients from the nDay database [39].

2.3. Malnutrition: role of muscle mass

Besides changes in body mass, altered body composition with selective reduction in skeletal muscle mass has clearly emerged as a major determinant of malnutrition-induced acute and chronic complications, particularly in disease-related malnutrition [10]. New evidence from the ESPEN-WHO Europe call has unveiled that altered body composition per se, with low measured or estimated muscle and lean body mass, are also predictors of poor clinical outcomes in COVID-19. In non-ICU patients [40] phase-angle measured with bioelectrical impedance, a surrogate of lean body mass, was associated with 90-day mortality as well as longer hospital stay and inflammation markers, such as low albumin and elevated C-reactive protein. Phase angle also predicted COVID-19 severity with a composite score of morbidity, ICU admission and mortality in a mixed non-ICU and ICU population [41,42]. In several studies, low muscle mass measured by thoracic CT scans in hospitalized COVID-19 patients was associated with clinical parameters ranging from risk of ICU admission to successful ventilator weaning, length of stay and in-hospital mortality [43]. Consistent with these findings, a meta-analysis of nine studies confirmed associations between low skeletal muscle mass and COVID-19 severity and mortality [44]. Low muscle quality, particularly myosteatosis with high muscle lipid content, is an additional component of sarcopenia closely associated with malnutrition and potentially low muscle mass [10]. CT-assessed thoracic myosteatosis was accordingly also independently associated with negative ICU outcomes [43] or with transition to severe disease [45] in ICU patient cohorts.

2.4. Micronutrient deficiencies: prevalence and impact

Several vitamins (vitamin A, B_6, B_{12}, folate, C, D, E) and trace elements (Zinc, Selenium, Copper) are known to play important roles in regulating both innate and adaptive immune responses, with putative negative roles of micronutrient deficiencies to enhance susceptibility to infectious diseases including, but not limited to, viral respiratory tract infections [46]. Vitamin D is the most commonly measured micronutrient, and vitamin D deficiencies are common in many high-risk conditions including older age and obesity [2], being associated with viral infections including influenza. An early association between lower plasma vitamin D and risk of Sars-CoV2 infection was reported early in the course of the pandemic [47], and studies from the ESPEN-WHO Europe call have addressed and expanded this concept. Most reports confirmed the association between vitamin D deficiency and COVID-19 infection in the general population both in Europe and Asia [48], as well as in hospitalized patients with COVID-19 [49,50], with highest prevalence in older patient groups with obesity [51,52]. Low 25OH vitamin D was reported in ICU patients with COVID-19 and associated with higher systemic inflammation markers in one study [53,54]. Another study further suggested that lower 25OH vitamin D may predict risk of death, particularly in older COVID-19 ICU patients [55]. The association between low 25OH vitamin D and poor clinical outcomes was however not confirmed in a larger study that actually suggested a paradoxical association between high 25OH vitamin D and mortality [56]. Inconsistent findings could at least in part be explained by heterogeneous measurements, since another ICU study reported no clinical impact of low 25OH vitamin D but higher disease severity and need for mechanical ventilation in patients with low 1,25OH dihydroxylated form [57]. In additional studies, deficient zinc and iron status were also reported to be common in patients with COVID-19 [26,49,58]. Hypozincemia was reported in early disease stages and associated with risk of hospitalization [58], whereas low iron status was associated with severe disease in hospitalized patients [59].

Altogether the above-summarized reports provide strong support for a causal link between malnutrition, micronutrient deficiencies and risk of COVID-19 infection and severity (Fig. 1).

3. COVID-19: a case of disease-related malnutrition (DRM) - impact on long covid

The ESPEN guidelines on definitions and terminology in clinical nutrition define DRM as a "specific type of malnutrition caused by a concomitant disease". Inflammation is common in most acute and chronic disease conditions, representing a key determinant of DRM [10,11,16]. While factors triggering inflammation may vary in different diseases, metabolic and nutritional consequences of the inflammatory response are common and include skeletal muscle catabolism with muscle loss as well as anorexia and reduced food intake. Reduced physical activity or bedrest may also contribute to muscle catabolism. The same ESPEN guideline also generally defined two levels of inflammation intensity, with milder inflammatory response being more common in chronic disease and stronger inflammation in acute disease- or injury-related malnutrition [10].

COVID-19 is an acute infectious disease with potentially strong inflammatory response also at systemic level [60]. In addition, gastrointestinal symptoms, ageusia and anosmia are common and may contribute to reduce food intake. Pre-existing comorbidities may also occur, particularly in older patients, thereby synergistically enhancing catabolic responses. The combined catabolic impact of inflammation, bedrest and lack of spontaneous food intake may be strongest in intensive care COVID-19 patients [16]. Again the ESPEN terminology guideline [10] indicates that high pro-inflammatory cytokines, increased stress hormones as well as treatment, resistance to insulin, bed rest and no or reduced food intake "pave the way for a fast decline of body energy and nutrient stores".

Evidence of malnutrition ensuing or being exacerbated during the course of COVID-19 has accumulated in the past two years and the ESPEN-WHO Europe call to action has contributed to clarify nutritional defects and their clinical consequences. Importantly, acute impairment of nutritional state may have prolonged consequences on patient health, by favoring the onset of complications and comorbidities and by impairing functional status, thereby directly causing and sustaining the long-term clinical picture that is currently defined as "long COVID". COVID-induced malnutrition, with potential muscle loss and sarcopenia, may indeed directly contribute to major symptoms of long COVID such as fatigue and weakness, which may delay recovery and cause prolonged disability in a large fraction of COVID patients following acute infection.

3.1. COVID-19 causes malnutrition

Several studies reported high prevalence of moderate to severe weight loss (>5 or 10% of body weight) during the course of COVID-19 in non-ICU [61–66] and ICU hospitalized patients [63,67,68], with malnutrition prevalence at discharge reaching >80% in ICU survivors [67]. One study also reported 21% prevalence of weight loss above 5% also in non-hospitalized patients [69]. Also important, one study investigated changes in body composition measured by body impedance analysis in a small non-ICU patient cohort [70], reporting stable body fat and water but significant reduction in phase angle during two-week hospital stays. Causes of negative energy balance appeared to include lower food intake also before admission [65,71], gastrointestinal symptoms with reduced appetite, feeling of gastric and abdominal fullness, altered taste and smell [66,71]. Higher inflammation as assessed by C-reactive protein was also reported in weight-losing compared to weight-stable individuals [69]. In post-intubation ICU patients, but also in the non-ICU setting, a high prevalence of dysphagia was reported [64,72]. Also relevant for ICU patients, marked and prolonged hyper-metabolism was consistently described by different authors through indirect calorimetry [73–76]; from a methodological standpoint, poor predictive value of common equations to estimate energy expenditure was reported by one group [75]. A pilot study also addressed the issue of use of protective masks while implementing indirect calorimetry [77] suggesting superimposable results with or without protective device. In full agreement with the above observations, increased prevalence of malnutrition according to GLIM criteria was documented during hospital stay from 18 to 79% in one study, with 55% characterized as severe [68], and up to 80% malnutrition prevalence was reported at discharge from ICU also in another study [67].

3.2. COVID-19-INDUCED malnutrition: clinical impact and long COVID

COVID-19-induced impairment of nutritional status was associated with negative impact on patient clinical outcomes. Weight loss was associated with longer disease duration and hospital stay [63,64,69] as well as risk of ICU transfer [66]. Impaired functional status was reported at discharge based on Barthel score in a non-ICU group [64] and lower mobility and ability to perform usual daily activities were observed at discharge in 70% of ICU patients [67]. A few studies documented follow-up of nutritional parameters for up to six months. Low appetite and gastro-intestinal complaints were reported in approximately one third of patients up to 5 months after discharge with parallel continuing weight loss

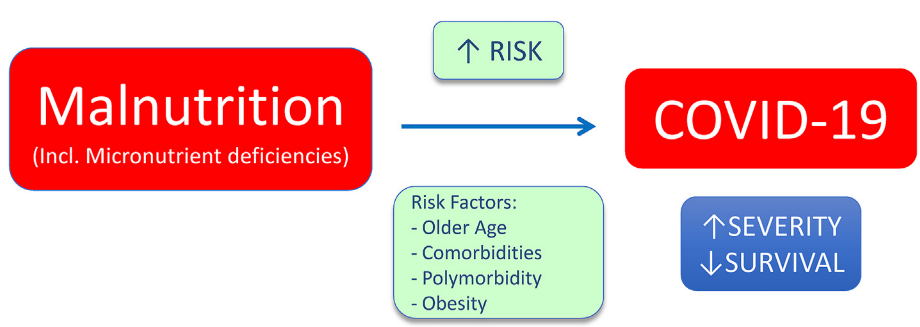

Fig. 1. Schematic representation of the potential causal link between malnutrition and Covid-19.

in 28% of patients [66]. Malnutrition according to GLIM criteria was also reported to be persistently high with more than 50% prevalence and approximately one third severe cases three months after ICU discharge [68]. Impaired functional status was also not completely recovered six months after discharge in a general hospital cohort particularly in the presence of in-hospital dysphagia [64].

Taken together, the above summarized reports provide support for COVID-19 infection as a strong risk factor for the deterioration of the nutritional status and the development of malnutrition (Fig. 2).

4. Obesity and malnutrition in COVID-19 and their clinical impact

Early evidence from COVID-19 cohorts has shown that persons with obesity are at high risk for severe disease and mortality [78–83]. Obesity-induced metabolic derangements including hypertension, insulin resistance and hyperglycemia and the metabolic syndrome (MS) have been reported to worsen COVID-19 severity and prognosis and may partly explain obesity-associated clinical risk [84–86]. Pre-existing systemic and tissue low-grade inflammation may also contribute to impaired immune function in persons with obesity with enhanced risk for organ damage and failure in the presence of COVID-19 [87]. From the nutritional standpoint, obesity with metabolic complications, comorbidities and older age also increased risk for loss of skeletal muscle mass and function, which may lead to a double burden of over-nutrition and malnutrition [88–92]. Also importantly, obesity is a strong risk factor for many diseases and for chronic and acute organ failures [93–95], with additional independent negative impact on muscle mass and nutritional status [96–99]. It should be further pointed out that obesity is commonly associated with micronutrient deficiencies that may negatively affect both skeletal muscle protein metabolism and immune function [100,101], thereby enhancing risk of infection and loss of skeletal muscle mass. The concept of the double burden of obesity and malnutrition is still underappreciated, but efforts are being made to enhance awareness on this topic. The recent GLIM criteria for malnutrition diagnosis allow for practical detection of malnutrition when involuntary weight loss or low muscle mass are observed at any level of body mass index (BMI), provided that low food intake or disease are also present (GLIM). Most importantly, when malnutrition or malnutrition risk are detected, nutritional care should be implemented also in persons with obesity. ESPEN has issued in 2021 a guidance paper for nutritional management of persons with obesity and COVID-19 endorsed by the ESPEN Council, suggesting malnutrition screening for all patients with obesity and risk factors for malnutrition and muscle loss, with particular regard to comorbidities and older age [1].

The ESPEN WHO Europe call has enhanced available evidence for a negative clinical impact of concomitant malnutrition in patients with obesity and COVID-19. Indeed, several studies on the prevalence of malnutrition and micronutrient deficiencies reported on clinical cohorts with overall average BMI in the overweight and obesity range, that were also affected by malnutrition or malnutrition risk [25,32–34,37,51]. These findings confirm that malnutrition is also a risk factor for infection and severe COVID-19 in persons with obesity. Also important, most studies on COVID-19-induced malnutrition similarly include overweight and obese subgroups, representing up to more than 90% of the study cohort [63,64,66–68], confirming that persons with obesity are prone to the negative nutritional impact of COVID-19. Moreover, studies on altered body composition showing a specific negative impact on lean body mass also reported on patient groups with average BMI in the obesity range [41,70], supporting the concept that loss of skeletal muscle mass may be the most prominent feature of malnutrition in persons with obesity. Additional papers reported on negative outcomes in COVID-19 patients with obesity and metabolic syndrome or elevated inflammation markers, that may also impair nutritional status [102–104]. Patients with high visceral adiposity, also a major risk factor for inflammation and low muscle mass, were found to also have higher risk for severe COVID-19 in a systematic review and meta-analysis [105].

Taken together, these findings provided strong support for a close nutritional screening and assessment of COVID-19 patients with overweight and obesity for early detection of malnutrition which may enhance obesity-associated risk of poor COVID-19 outcomes and requires nutritional treatment (Fig. 3).

5. Nutritional treatment to improve COVID-19 outcomes: benefits and hurdles

As malnutrition has been gradually established as both a consequence of COVID-19 infection and a risk factor for COVID-19 infection and severity in the past two years, studies on the clinical impact of nutritional treatment to improve COVID-19 outcomes are less numerous. Evidence is however increasingly available to indicate beneficial clinical effects of medical nutrition.

5.1. Benefits: acute setting (hospital and ICU)

Several papers on from the ESPEN-WHO Europe call for COVID-19 papers have reported on the impact medical nutrition in critically ill patients that are at highest nutritional risk. Earlier implementation of nutritional care within 48 h of ICU admission was associated with survival in two studies [26,106]. In another study [71], ICU patients reaching satisfactory caloric intake through any route similarly had lower mortality compared to those not reaching nutritional targets. In a Brazilian ICU cohort, protein provision above 0.8 g/Ideal Body Weight/day was also associated with lower mortality [107]. A protective impact was also reported in a mixed cohort of non-ICU and ICU patients [108] for reaching overall adequacy of calorie and protein provision at 25 kcal and 1.2–1.5 g per kg/day,

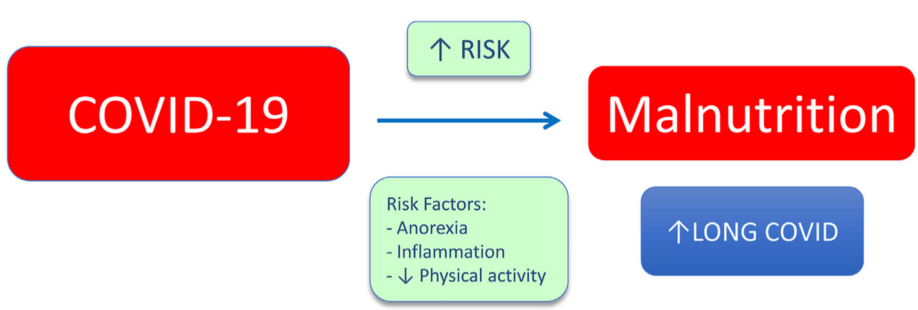

Fig. 2. Schematic representation of the link between Covid-19 and malnutrition development.

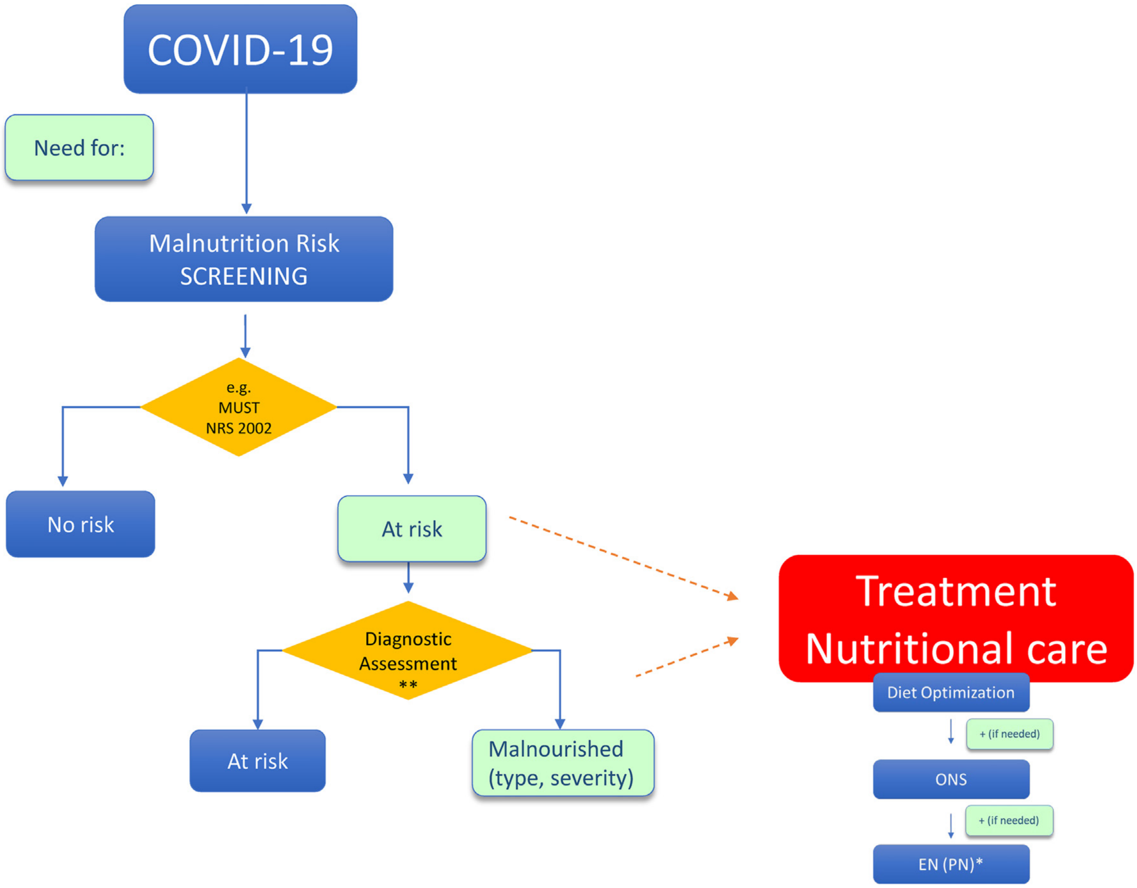

Fig. 3. Schematic representation of the proposed nutritional screening and treatment algorithm in Covid-19 patients.

respectively. Conversely, in a study from the United States, intolerance to enteral nutrition in ICU was associated with nutritional complications including higher risk of malnutrition, higher risk of organ failure and overall mortality [109]. Also in the ICU setting [110], parenteral nutrition in patients receiving non-invasive ventilation was per se associated with lower odds of oxygen escalation. Consistent with high prevalence of malnutrition in COVID-19 patients with overweight and obesity, and with high risk of developing malnutrition during the course of COVID-19 [2], most of the above reports on nutritional treatment included large subgroups of patients with overweight and obesity.

It should be pointed out that evidence on potential beneficial effects of micronutrient supplementation is less conclusive. With regard to oral supplements, a systematic review of 12 randomized controlled trials on use of dietary herbal supplements to increase micronutrient provision [111] showed that high risk of bias makes it difficult to interpret results; the authors conclude that some promising effects were suggested in improving recovery, and zinc supplements could lead to faster recovery from olfactory dysfunction. A meta-analysis focusing on vitamin C, vitamin D and zinc reported beneficial effects of vitamin D supplementation in reducing risk of intubation during COVID-19 illness, whereas no significant impact was detected for vitamin C and zinc on mortality, intubation risk and length of hospital stay [112].

5.2. *Benefits: post discharge*

Evidence of nutritional derangements and high risk of malnutrition following COVID-19 infection strongly support continuing nutritional follow-up and treatment for several months after infection resolution, to potentially prevent or treat nutritional components of long COVID. Very few reports are however available on sustained nutritional treatment in this setting. In the setting of the ESPEN-WHO call for papers, one study from Italy in non-ICU patients reporting post-COVID fatigue investigated the impact of a commercial oral supplement including vitamins, minerals, amino acids and plant extracts [113]. Questionnaire-based improvements of quality of life, fatigue and global health status were reported after 14 and 28 days [113]. Another study described the effects of a multidisciplinary rehabilitation program for patients discharged from acute COVID hospitals in northern Italy after worsening of nutritional status [62]. 61% of patients had developed malnutrition during hospitalization according to GLIM criteria, despite average BMI in the overweight range [62]. Four-week interventions including diet optimization (27–30 kcal and 1–1.3 g protein per kg/day) and controlled aerobic and resistance exercise were reported to improve body composition with increased phase angle and muscle strength [62]. Further studies are clearly needed to assess the potential positive clinical impact of rigorous comprehensive nutritional intervention programmes on nutritional sequelae of COVID-19.

5.3. *Hurdles: awareness*

Since the start of the pandemic, ESPEN and other scientific Societies have issued guidance papers on implementation of nutritional care for prevention and treatment of malnutrition in patients with COVID-19 [1,2], aimed at reducing morbidity and mortality as well as infection risk particularly in high-risk patients with older age and pre-existing comorbidities [1,2]. ESPEN also specifically addressed the issue of obesity [2], with largely similar recommendations. Guidance for pediatric patients is also available [114] for specific needs of this age group [115]. Despite early availability of guidance documents, several hurdles may however impair implementation of nutritional care in routine clinical practice. Low awareness of the negative impact of malnutrition and the importance of nutritional care in virtually any acute disease conditions is a pre-existing hurdle [116–120]. Even in tertiary care centers, inadequate implementation of nutritional care in patients with COVID-19 has been documented when compared to malnutrition prevalence [28,67]. In surveys from South-East Asia, limitations were confirmed in implementation of nutrition guidelines in COVID-19 patients, with reasons including lack of confidence as well as budget limitations [121]. Similarly, insufficient knowledge of nutrition management was self-reported by ICU personnel in a Swiss survey [122]. Importantly, low adherence to nutritional guidelines was associated with negative clinical outcomes including higher length of stay in ICU and mortality [121]. On the other hand, studies reporting adequate implementation of nutritional care in ICU to reach nutritional targets also reported good access to healthcare professionals such as nutritionists and dietitians [123–126]. The ESPEN-WHO Europe call for papers on COVID-19 therefore also contributes to highlight the need for action to increase awareness on the importance of nutritional care in this setting, both for healthcare professionals and policy-makers.

5.4. Hurdles: practical COVID-related issues

The onset of the COVID-19 pandemic and pandemic waves at different times around the world have also posed huge practical hurdles to implementation of nutritional care, as priorities and resources for healthcare systems had to shift towards COVID-19. Negative consequences included limitation of workforce, need for changes in hospital organization and limited physical access to patients for examination and monitoring. The ESPEN-WHO Europe call for papers has also allowed to collect reports on potential approaches to mitigate practical hurdles to nutritional care. Simplified organization of nutrition protocols for ICU healthcare providers to COVID-19 patient has been proposed and implemented [122], with higher adherence to nutritional targets reported in a subsequent study in the same setting [127]. Reports on re-organizations of nutrition support activities, and the specific role of different professional components of the nutritional team have been also provided [128]. Limited or no patient contact has been also addressed both in the hospital and home care settings. Recommendations have been proposed for remote evaluation of the anthropometric component of nutritional assessment in ambulatory settings [129], and a pilot study reported good performance of an abridged format of Subjective Global Assessment without physical examination [130]. Results of the latter study appeared to support the use of the abridged format, with good comparison in detection of malnutrition with the complete form [130]. A remote nutritional screening tool suitable for app implementation has been also proposed [131]. The ESPEN Special Interest group for Home Artificial Nutrition issued early during the pandemic a position paper with considerations on the potentially problematic topic of management of home parenteral nutrition in the setting of pandemic-related limitations [132], with additional statements coming from a network of home nutrition centers in Poland [133]. Altogether, the above reports have started to provide guidance and practical examples for effective implementation of nutritional care in COVID-19 patients.

6. Lifestyle and public health nutritional implications

The COVID-19 pandemic also created fundamental challenges through profound limitations in social interactions with potential negative impact on individual lifestyle habits and nutrition. Variable reduction of economic activities with loss of income may have also directly and negatively affected food quality and security; to this regard the pandemic also exacerbated or unveiled social and regional inequalities in terms of food habits and access to balanced and adequate nutrition. The ESPEN-WHO Europe call for papers also addressed these topics, and several studies have been published on these important issues.

6.1. Lifestyle

Measures to limit the spread of the COVID-19 pandemic have included strong limitations to usual activities and social confinement, up to general lockdowns. Changes in dietary habits and their impact on body weight have been investigated in original studies and systematic reviews. Different patterns of dietary changes have been reported, indicating heterogeneous responses to lockdowns in the general population. In a large sample of >22.000 UK adults, 64% of participants reported no modifications in nutrition quantity [134], whereas two alternative minority trajectories emerged, with reductions or increments in food intake. Other studies reported a majority of individuals with overall increasing food intake [135,136]. Interestingly, emotional eating defined as food consumption in response to stress was reported to be higher under lockdown conditions in one survey, with more common emotional eating in persons with obesity and overweight [137]. A systematic review of 32 studies also reported increments in snacking and alcohol consumption (10–51%) [138], and number of snacks also increased in an Iranian cohort in all body weight categories [135]. A sizable fraction of studied populations (15–41%) intriguingly reported reduced consumption of fast food and ordered food, with a counterintuitive adaptation to lockdown conditions that could favor consumption of more healthy home-prepared meals, also suggested by a subsequent report [138]. Also interestingly, an urban household survey suggested that consumption of fresh, minimally processed food is associated with lower prevalence of anxiety or depression compared to ultra-processed food [139]. More studies are needed to further investigate the potential role of healthy food consumption to prevent nutritional and mental negative consequences during lockdown conditions. Body weight changes during lockdowns were investigated in a systematic review of 36 studies that reported an overall trend for increments (11–72%) although this was accompanied by a sizable fraction of the overall population reporting weight loss (7–52% in different studies) [140]. Interestingly, the only study from this review reporting overall weight loss was characterized by older age >60 [141], suggesting a potential negative impact of aging on weight maintenance during the COVID-19 pandemic. Another study in older adults did not report lockdown-induced BMI changes, but it confirmed a reduction in physical activity, associated with worsening of mental health parameters [142]. Changes in body composition should be directly investigated in future studies, since reduction of physical activity during lockdowns could favor reduction in muscle mass and function, with ensuing malnutrition and sarcopenia [143]. Since low physical activity also potentially affects intestinal transit and bowel rhythm, these parameters were investigated in a specific survey in an adult cohort; while a majority of responders reported adequate transit, approximately one quarter reported altered rhythm with either faster or slower transit [144]. Patients with eating disorders (ED) represent an additional at-risk group with potential more profound negative impact of lockdown conditions on eating behavior patterns. A meta-analysis focusing on this patient group confirmed a high risk of worsening of ED symptoms and mental health, with potential negative impact on nutritional status during the pandemic [145]. The impact of lockdowns was also studied on additional behavioral and lifestyle components. One report from Peru found increments in body weight in a cohort of young university students [146], and this change was associated with reduced physical activity, light exposure and sleep duration. Other studies however suggested that changes in sleep duration may vary in different populations with reported no change or increase in up to 90% of participants in a study from Turkey [137].

Taken together, the above reports from the ESPEN-WHO Europe call for papers contribute to identify potential negative changes in eating behavior that may enhance the risk to develop or worsen overweight and obesity, with potential for associated reduction in muscle mass that should be specifically investigated.

6.2. Public health nutrition

Nutrition patterns and diet quality, as well as levels of food security may on one hand influence the risk of developing severe infections including COVID-19 by modulating nutritional state and immune function. On the other hand, the COVID-19 pandemic may worsen economic conditions, individual income and food security with synergistic impact on infection risk. Selected reports from the ESPEN-WHO Europe call have addressed these important issues. One study analyzed the impact of food supply available in 170 different Countries from Food and Agriculture Organization of the United Nations data on rates of recovery from COVID-19 [147]. The study demonstrated that recovery rates were highest in countries stratified as having eradicated hunger, and lowest in those with moderate or high global hunger index [147], although the potential impact of healthcare quality and accessibility should also be considered since this is a relevant potential factor that could affect study results. Major benefits from individual nutrients were attributed to animal-derived food while sources of immune-modulating micronutrients were also beneficial [147]. The potential relevance of habitual dietary patterns was further suggested in a study from South Korea showing that population groups stratified as having high risk to develop COVID-19 also had higher risk of having nutritional deficiencies, with particular regard to multiple vitamins [148]. On the other hand, higher adherence to diet rich in antioxidants, anti-inflammatory and micronutrients such as the Mediterranean diet was associated with lower risk to develop COVID-19 in a Spanish cohort [149]. Two additional studies addressed the impact of COVID-19 on food security. In one report from Jordan using a web-based validated questionnaire, 60% of participants were identified as having severe or moderate food insecurity, associated with reduced monthly income and number of family members [150]. In another paper, a systematic review was performed on the impact of COVID-19 on food systems and security [151]. Findings from 35 studies confirmed adverse effects of the pandemic that were modulated by timing, intensity and duration of social restrictions as well as by existence of social and government safety nets [151]. Inequalities in negative impact also emerged along lines of female gender, age and low socio-economic status without stable employment [151]. Concern for high risk categories was further expressed in additional papers focusing on high risk of food insecurity in children [152] and on pregnant women with diabetes mellitus [153].

Overall, the above reports from the ESPEN-WHO call contributed to confirm the extended COVID-19 challenge for public health through potentially deleterious changes in lifestyle and food security, with a strong risk for enhancement of inequalities within and among countries and world regions.

7. Conclusions

ESPEN and WHO Europe have strongly supported the collection of scientific evidence on the role of nutrition and nutritional care to effectively address the challenges and consequences of the COVID-19 pandemic. At the time of submission of this paper more than 260.000 publications are retrievable in PubMed using COVID as keyword. The total number of publications is however substantially lower (5705 - approximately 2%) when COVID and nutrition are both used for publications search. When COVID and malnutrition are used for publications search, only 898 publications are retrieved (less than 0.4%). We are pleased to offer more than 120 publications in ESPEN journals on these important topics and hope that these findings will contribute to enhance awareness on the importance of nutrition in prevention, treatment and post-infection care of COVID-19. As we join the universal hope that the impact of the COVID-19 pandemic will decline as soon as possible through vaccinations and potential new treatments, we believe and advocate that optimal nutritional care may provide important contributions to reach this goal.

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Rocco Barazzoni*
Department of Medical, Surgical and Health Sciences, University of Trieste, Italy

Joao Breda
World Health Organization (WHO) Regional Office for Europe, Athens, Greece

Cristina Cuerda
Departamento de Medicina, Universidad Complutense de Madrid, Nutrition Unit, Hospital General Universitario Gregorio Marañón, Madrid, Spain

Stephane Schneider
Gastroenterology and Nutrition, Nice University Hospital, Université Côte d'Azur, Nice, France

Nicolaas E. Deutz
Center for Translational Research in Aging and Longevity, Texas A&M University, College Station, TX, USA

Kremlin Wickramasinghe
World Health Organization European Office for the Prevention and Control of Noncommunicable Diseases, Moscow, Russian Federation

the COVID-19 Call Editorial Board

* Corresponding author. Department of Medical, Surgical and Health Sciences, Cattinara University Hospital, Strada di Fiume 447, 34149 Trieste, Italy.
E-mail address: barazzon@units.it (R. Barazzoni).

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