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Applied nutritional investigation

Food intake and weight loss of surviving inpatients in the course of COVID-19 infection: A longitudinal study of the multicenter NutriCoviD30 cohort

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ARTICLE INFO

Article History:
Received 18 March 2021
Received in revised form 6 July 2021
Accepted 18 July 2021

Keywords:
COVID-19
Pneumonia
Malnutrition
Weight loss
Food intake

ABSTRACT

Objectives: NutriCoviD30 is a longitudinal multicenter cohort study that aimed to provide nutritional objective data of inpatients during COVID-19 infection. The aims of this study were to describe the nutritional effects of COVID-19 infection on adult inpatients on the short- to mid-term (≤30 d after hospital discharge), using food intake and weight measurements and to identify factors associated with a decrease in food intake and weight.

Methods: Food intake and weight trajectories, as well as clinical signs of the disease, preexisting chronic diseases, and nutritional strategies were collected and analyzed during the course of the disease. Their association was estimated using mixed-effect regression modeling. Patients were recruited from French university hospitals from May to July 2020. For the 403 included patients (mean 62.2 ± 14.2 y of age; 63% men), median (interquartile range [IQR]) hospital length of stay was 13 d (IQR = 8, 20), and 30% of patients were admitted to the intensive care unit.

Results: Patients declared a median 70% food intake decrease in the acute phase, and the disease resulted in an average loss of 8% of predisease weight (corresponding to −6.5 kg). Although most patients recovered their usual food intake 1 month after hospital discharge, they only regained half of their weight loss, such that malnutrition, which affected 67% of patients during hospitalization, persisted in 41%. Patients with overweight, obesity, and diabetes reported an additional weight loss of >1.5% of their initial bodyweight during hospitalization and recovery phase.

This study was funded by Nutricia nutrition Clinique. The funding sources had no role in the design and conduct of the study; collection, management, analysis, or interpretation of the data; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication. All authors received a donation from Nutricia Nutrition clinique for the study.

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https://doi.org/10.1016/j.nut.2021.111433
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Introduction

The sudden onset of the coronavirus SARS-CoV-2 has caused organizational upheavals and challenges in managing the current COVID-19 epidemics worldwide. Nutritional care is one of the key aspects of patient management in situations of serious infection. In community-acquired pneumonia for example, malnutrition is known to affect long-term recovery and to increase 1- and 2-y mortality in surviving patients, especially for older patients [1]. Given the effect of SARS-CoV-2 on patient taste and appetite [2], as well as on anosmia, ageusia, diarrhea, odynophagia, and anorexia [3,4], patients with COVID-19 are particularly at risk for undernutrition. This risk is often heightened by hospitalization [5, 6].

Reports of dramatic weight loss during this epidemic have led the European [7], American [8], and French-speaking [9] learned societies of nutrition to issue expert opinions and recommendations for the nutritional management of patients. Despite this advice, and in the face of the short-term respiratory emergency, nutritional care has received limited attention from clinicians during the initial pandemic wave of infection.

The aim of this study was to describe the nutritional effects of COVID-19 infection on adult inpatients on the short- to mid-term (≤30 d after hospital discharge), using food intake and weight measurements. It also aimed to identify factors associated with a decrease in food intake and weight. Although SARS-CoV-2 is an emerging and developing disease, this study is expected to improve the understanding of malnutrition in COVID-19 inpatients, and to help clinicians preventing the occurrence and long-term effects of this side effect of the disease.

Methods

Study design

The NutriCoviD30 study was designed as a prospective multicenter cohort of adult inpatients who were hospitalized with a confirmed COVID-19 infection, and who returned home after hospitalization. Patients were recruited from 11 French university hospitals from May 7 to July 10, 2020, after ethical clearance from the French Committee for the Protection of Persons North West IV.

Patients were called by a nutritionist, medical doctor, or dietician, 30 d after hospital discharge. Data was collected from the medical records or during the phone interview, regarding the following:

- Prior chronic disease, lifestyle, and eating habits before the disease (referred to as t0);
- COVID-19 symptoms, hospital length of stay (LOS), and nutritional care characteristics during hospitalization (referred to as t1);
- World Health Organization performance status score, persistence of symptoms, and nutritional outcomes 1 mo after hospital discharge (referred to as t2). Appetite assessment can be evaluated with a 10-point visual analog scale [10,11].

Food intake was assessed at t1 and t2 using the verbal form of the Self-Evaluation of Food Intake scale (SEFI) scored from 0 (“I eat nothing”) to 10 (“I eat as usual”). This scale has been validated and showed good reliability for the assessment of food and energy intake, and malnutrition among adults [12–14].

Weight assessment was based on patient declaration at t0 (considered as the reference weight) and t2. The lowest weight during the acute phase of the disease (reported by the patient or during hospitalization) was used as weight at t1. Weight loss at t1 and t2 were defined in terms of proportion of the reference weight at t0.

Conclusions: To prevent malnutrition and its long-term effects, mainly combined with a rapid weight loss predominantly affecting lean body mass, implementation of nutritional support is needed for COVID-19 inpatients. It should be started early in the course of the infection, and be extended up to the recovery phase.

Statistical analysis

Quantitative parameters were described by their mean ± SD, or by their median [25th; 75th] percentiles, depending on the normality of the data. Qualitative parameters were expressed in numbers and percentages. A two-sided P ≤ 0.05 was considered statistically significant.

SEFI and weight were compared between two time points, between two groups, and between more than two groups

1. If the variable was normally distributed using Student’s paired test, Student’s t test, and analysis of variance, respectively; and
2. If the variable was not normally distributed using Wilcoxon matched-pairs signed-rank tests, Wilcoxon signed-rank tests, and Kruskal–Wallis tests, respectively.

Mixed-effect regression modeling was used to study the evolution of SEFI at t1 and t2, with subjects nested within centers being modeled as random effects. Data from the Parisian hospital centers of Saint-Antoine, Tenon, and Paul Brousse were aggregated owing to their small population sizes. Measures at t0 were not included in the model because they were considered constant among patients and equal to 10 (i.e., “I eat as usual”).

Weight loss at t1 and t2 was analyzed similarly (weight loss at t0 was null for all patients), with the following adjustment factors being additionally included in the model: the number of days in the intensive care unit (ICU) (coded as “0 d,” “1–7 d,” “8–15 d,” and “>15 d”) and the admission in post-acute rehabilitation (PAR) unit (yes/no), which are expected to efficiently reflect disease severity; and edema status (coded as “appeared,” “disappeared,” or “did not change” since the previous period) which has a direct effect on weight. Adjustment factors were implemented with independent fixed effects at t1 and t2.

Mixed modeling can cope with partly missing data at the individual level. The analyses were ran on 402 (99.7%) patients for SEFI (including 2 patients with one missing data at t1 or t2); and on 386 (95.8%) patients for weight loss (including 86 patients with one missing data).

The following COVID-19 potentially influential factors were further tested one by one for their association with SEFI and with weight loss evolution, preexisting chronic conditions, clinical signs of the disease, and implementation of nutritional strategies. Alike adjustment factors, they were modeled with an independent fixed effect at t1 and t2. If the factor only referred to one period (e.g., to the hospitalization period), the model was fitted only over this period, without a subject random effect.

All data were processed and analyzed using Stata version 15.1 (StataCorp, College Station, TX, USA) and R version 3.3.3 (https://cran.r-project.org/).

Results

Population characteristics

In all, 1584 adult inpatients were screened in COVID units. Of these, 945 were eligible and 403 were finally recruited in the present study. Of those not included, half did not answer our call or message. Other reasons are listed in Supplementary Figure 1.

Results

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$t_0$: Before the COVID-19 infection

On average, patients were 62.2 ±14.2 y of age; 63% were men (Table 1). Eighty percent of the patients presented with one or more chronic conditions (Table 2).

The study population had an average reference weight (i.e., before the disease) of 83.4 ±17.3 kg, and an average body mass index (BMI) of 28.8 ±5.3 kg/m². Of the patients, 311 (80%) considered their weight stable before the disease. Less than 3% of patients were at risk for malnutrition, based on BMI <18.5 kg/m² for patients <70 y of age, and BMI<21 kg/m² for patients >70 y.
During hospitalization for COVID-19 infection

Patients were hospitalized for a median duration of 13 d. One-third were admitted to the ICU (median duration: 10 d). Regarding oxygen requirement, 20% of patients did not receive oxygen therapy; 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1). As expected, 34% had oxygen therapy <3l/min, 27% had oxygen therapy >3l/min, and 19% were intubated (Table 1).
SEFI analyses were performed using a mixed-effect regression model, with an individual random effect nested in a center random effect, and an independent BMI, body mass index; ONS, oral nutrition supplement; SEFI, Self-Evaluation of Food Intake

patients who received oxygen during their hospitalization had long-term effects. Fatigue persisted in 39% of the patients; other symptoms persisted in 10% to 27% of affected patients.

Patients massively reported COVID-19 symptoms (Table 2).

t2: 1 mo after returning home

Only 5% of patients were still on oxygen therapy 1 mo after hospital discharge. Fatigue persisted in 39% of the patients; other symptoms persisted in 10% to 27% of affected patients.

Changes in diet were reported by one-third of patients, mainly toward a balanced diet or a diet adapted to COVID-19 symptoms (i.e., split, enriched, or adapted meals to the patient's taste modifications).

General recovery was assessed using WHO performance status score. The median score was 1 (IQR = 0.25–2), corresponding to patients who were restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature (Table 3).

### Table 2

| COVID-19 symptoms | SEFI at t1* | SEFI at t2* |
|-------------------|------------|------------|
| N (nb of non-missing data (%)) | Coefficient [95% CI] | P value | Coefficient [95% CI] | P value |
| Anorexia/Early feeling of fullness/Long satiation | 314/401 (78) | −3.6 [−4.2 to −3.1] | <0.001 | −0.7 [−1.2 to −0.2] | 0.010 |
| Anosmia/Agenesis or dysgeusia/Change in taste | 225/307 (58) | −1.4 [−1.9 to −0.9] | <0.001 | 0.1 [−0.4 to 0.5] | 0.801 |
| Nausea/Vomiting | 133/401 (33) | −1.1 [−1.6 to −0.6] | <0.001 | −0.5 [−0.9 to 0] | 0.067 |
| Difficulties swallowing/Pharyngeal or esophageal pain | 88/398 (22) | −0.7 [−1.2 to −0.1] | 0.021 | −0.3 [−0.9 to 0.3] | 0.307 |
| Painful mouth/White, pasty tongue | 146/387 (38) | −0.9 [−1.4 to −0.4] | <0.001 | −0.7 [−1.1 to −0.2] | 0.007 |
| Difficulties drinking | 76/396 (19) | −1.6 [−2.2 to −1] | <0.001 | −0.8 [−1.4 to −0.2] | 0.006 |
| Food disgust | 187/397 (47) | −1.4 [−1.9 to −1] | <0.001 | −0.5 [−1 to −0.1] | 0.023 |
| Fever | 309/395 (78) | −1.5 [−2 to −0.9] | <0.001 | 0.5 [0.1 to 1] | 0.090 |
| Dyspnea/Coughing | 314/401 (78) | −0.9 [−1.4 to −0.3] | 0.002 | 0.1 [−0.5 to 0.6] | 0.850 |
| Pain (muscular, cranial, headaches, etc.) | 249/394 (63) | −0.8 [−1.2 to −0.3] | 0.002 | −0.1 [−0.5 to 0.4] | 0.850 |
| Fatigue | 352/402 (88) | −2.1 [−2.8 to −1.4] | <0.001 | −0.1 [−0.8 to 0.6] | 0.830 |
| Digestive or transit disorders | 287/400 (72) | −0.5 [−1.1 to 0] | 0.044 | −0.2 [−0.7 to 0.3] | 0.425 |
| Preexisting chronic diseases | 13/403 (3) | −0.3 [−1.6 to 0] | 0.609 | −0.8 [−2.1 to 0.5] | 0.212 |
| Chronic respiratory disease (with chronic medication/home oxygen therapy/sleep apnea) | 72/403 (18) | 0.1 [−0.5 to 0.7] | 0.648 | −0.7 [−1.3 to −0.1] | 0.026 |
| Immunodepression/cancer (presently treated) | 51/403 (13) | 0.1 [0.6 to 0.8] | 0.869 | 0.0 [−0.8 to 0.7] | 0.894 |
| Hypertension | 169/403 (42) | 0.4 [−0.1 to 0.9] | 0.091 | 0.1 [−0.5 to 0.4] | 0.836 |
| Heart failure | 19/403 (5) | 0.7 [−0.4 to 1.9] | 0.191 | −1.1 [−2.2 to 0] | 0.054 |
| Diabetes (all types) | 92/403 (23) | 0.2 [−0.3 to 0.8] | 0.464 | −0.1 [−0.6 to 0.5] | 0.821 |
| Chronic inflammatory bowel diseases (Crohn’s disease, etc.) | 5/403 (1) | 0.9 [−1 to 1.3] | 0.378 | −0.2 [−2.3 to 1.9] | 0.829 |
| Inflammatory rheumatic diseases (lupus, rheumatoid arthritis, etc.) | 17/403 (4) | 0.2 [−0.9 to 1.4] | 0.694 | −0.4 [−1.6 to 0.7] | 0.486 |
| BMI before COVID-19 infection, kg/m² | | | | |
| <18.5 | 3/393 (1) | 1.6 [−1 to 4.2] | 0.256 | 0.4 [−2.3 to 3.1] | 0.761 |
| ≥18.5–25 | 92/393 (23) | (ref) | (ref) | (ref) | (ref) |
| ≥25–30 | 147/393 (37) | −0.1 [−0.6 to 0.6] | 0.933 | 0.4 [−0.2 to 1] | 0.237 |
| >30 kg/m² | 151/393 (38) | −0.3 [−0.9 to 0.4] | 0.412 | 0.2 [−0.5 to 0.8] | 0.621 |
| Nutritional strategies and difficulties | | | | |
| Food supply difficulties related to home confinement | 16/401 (4) | −1.2 [−2.3 to 0] | 0.055 | −0.4 [−1.6 to 0.8] | 0.512 |
| Incentives to eat, and if needed, help given by caregivers or a relative | 132/379 (35) at t1, 196/398 (49) at t2 | −0.2 [−0.7 to 0.3] | 0.415 | −0.1 [−0.6 to 0.4] | 0.640 |
| Advice given by a nutritionist | 105/366 (29) at t1, 93/395 (24) at t2 | −0.2 [−0.8 to 0.3] | 0.378 | 0.2 [−0.3 to 0.8] | 0.406 |
| Adapted meals during hospitalization | 235/387 (61) at t1 | −0.1 [−1.1 to 0.2] | 0.139 | / | / |
| Snacking during hospitalization | 189/386 (49) at t1 | 0.4 [−0.2 to 1] | 0.197 | / | / |
| ONS (yes/no, patient declaration) | 196/385 (51) taken at t1, 120/400 taken at t2 | −0.4 [−0.9 to 0.1] | 0.104 | −0.2 [−0.8 to 0.3] | 0.336 |
| Total ONS (units, patient declaration) | 30 prescribed at t2 | | | |
| 14 (4.5–22.5) taken at t1, 60 (15–60) prescribed at t2 | −0.0 [−0.01 to 0.02] | 0.921 | 0.00 [−0.01 to 0.00] | 0.248 |

BMI, body mass index; ONS, oral nutrition supplement; SEFI, Self-Evaluation of Food Intake
*SEFI analyses were performed using a mixed-effect regression model, with an individual random effect nested in a center random effect, and an independent fixed effect at t1 and t2 for the variable of interest

1P < 0.01

2P < 0.05

3Variable affecting only the hospitalization period: Analysis was performed at t1 only

460 (15%) missing data at t1, 18 (4%) missing data at t2

Food intake and weight effects of COVID-19

SEFI and weight trajectories are illustrated in Figure 1. Five percent of patients reported neither a weight loss >5% of their reference weight before the disease, nor a food intake decrease >30% of usual food intake during the course of the disease.

At t1, the median (IQR) SEFI was 3 (1; 5) (representing a decrease of 70% of patients’ usual food intake), and the average weight decreased to 77 ± 16 kg. This represents a weight loss of 6.5 ± 4.4 kg (maximum of 30 kg), and a 7.6% ± 5.9% decrease compared with the reference weight (maximum of 32%). Based on etiologic and phenotypic diagnosis criteria (i.e., acute disease and weight loss) from the International Global Leadership Initiative on Malnutrition (GLIM)15 and French Health Authorities guidelines, 67% of patients were malnourished. Of these patients, 42% were severely malnourished.

During the recovery phase (t2), 62% of patients recovered their initial SEFI (i.e., a score of 10), and 19% reported better appetite.
than before the disease. Yet 25% of patients were not hungry when lunch or dinnertime came (Table 3).

Although the majority of patients regained weight during recovery, the study population still recorded an average weight loss of 4.2% ± 5% of their reference weight 1 mo after hospital discharge (i.e., -3.8 ± 4.7 kg; Table 1), indicating that 41% of patients remained malnourished. Of these patients, 25% were severely malnourished.

Among the 49% patients who did not recover their initial weight, 62% declared they did so voluntarily.

Association between potentially influential factors and food intake or weight

Mixed models confirmed a significant difference between t1 and t2 in SEFI, and in weight loss, after adjusting for patients and recruitment center variability, and the selected set of adjustment factors: SEFI regression coefficient was 3.4 at t1 and 8.9 at t2; weight loss coefficient was 6.1% at t1 and 3.4% at t2. As per the adjustment factors, ICU LOS displayed a significant association with a greater weight loss (6.9% at t1 and of 4.3% at t2 for patients who spent >15 d in the ICU compared with those who were not admitted to the ICU; both P < 0.001); while PAR stay and edema status were in global not further associated with weight loss at t1 and t2 (Supplementary Table 2). In the present study population, age was not associated with differences in weight loss (Supplementary Table 3).

We further screened for an additional effect of COVID-19 potentially influential factors, one by one (Tables 2 and 4). Regarding SEFI, chronic diseases had no effect at t1 and t2, except for chronic respiratory diseases, which were associated with a 0.7-point decrease in SEFI at t2 (P = 0.026).

All the symptoms of COVID-19 were associated with a statistically significant decrease in SEFI at t1 (0.5–3.6 points, all P < 0.045). The strongest associations were observed for anorexia and fatigue (Table 2). Difficulties drinking, food disgust, anorexia, and painful mouth remained associated with a significant decrease in SEFI at t2, but of lower magnitude compared to t1 (0.5–0.8 points, all P < 0.025).

Regarding weight loss, only fatigue (P = 0.003), anorexia (P = 0.006), and food disgust (P = 0.013) were significantly associated with a weight loss at t1 (with, respectively, a 2.3%, 1.8%, and 1.3% greater weight loss compared with patients who did not display such symptoms). None were significantly associated with weight loss at t2.

Among the chronic diseases, diabetes was significantly associated with a 1.8% (P = 0.004) and 1.5% (P = 0.026) increased weight loss at t1 and t2, respectively; hypertension was associated with a 1.4% increased weight loss at t2 (P = 0.018). Overweight (BMI between 25 and 30 kg/m²) and obesity (BMI >30 kg/m²) were associated with a greater weight loss compared with patients with a normal BMI (18.5–25 kg/m²), of respectively 1.6% and 2.2% at t1, and 1.7% and 3.7% at t2 (all P < 0.020).

Nutritional strategies during COVID-19 infection and recovery phases

In terms of nutritional strategies, half of the population took oral nutritional supplements (ONS) during their hospitalization, for a median of 8 d, and 14 units in total; and 30% of the patients were prescribed ONS after returning home, for a median 60 units in total. During their hospitalization, 61% of patients received adapted meals (i.e., different from the standard meal, corresponding to enriched meals or texture-modified food) and 49% received snacks.

Nutritional care data during hospitalization and the recovery phase does not include artificial nutrition owing to their non-exhaustive collection in several centers.

Using mixed models (Tables 3 and 4), none of these strategies were found to be significantly associated with SEFI or weight loss, except for advice given by a nutritionist that were associated at t1 with a 1.2% increased weight loss (P = 0.007), and ONS that were
associated with a 1.6% weight gain at t2 for patients who were pre-
scribed ONS at home \((P = 0.001)\).

Despite the fact that there was no interventional group, we
compared patients who did or did not receive ONS during their
hospitalization (Table 5). The 196 patients who were prescribed
ONS lost more weight at t1 than the 189 patients who did not
receive ONS \((P < 0.001)\). However, they recovered better at hospi-
tal discharge and at 1 mo after hospital discharge \((P = 0.0005\) and
0.009, respectively). Note that the two groups did not differ in
terms of sex ratio, predisease weight, or SEFI at t1, whereas the
ONS group was older.

Discussion

In the present population of 403 inpatients who survived the
COVID-19 infection, 67% had malnutrition (defined by a weight
loss >5% within the past 6 mo in a population of infected patients).
Other studies \([11,16]\) using the same malnutrition definition
reported an overall prevalence of malnutrition of 31% and 42.1%,
respectively. Another study \([6]\) reported 52.7% malnutrition based
on Mini Nutritional Assessment score. These differences result in
great part from differences in the study populations, typically in
terms of gravity of the disease. For example, 3% of the 156 inpa-
tients were admitted to the ICU in the Di Filippo et al. study \([11]\),
as were 16% of the 114 inpatients in the Bedock et al. study \([16]\),
whereas it affected 30% of the 403 inpatients in the present study
(data not available for Li et al. \([6]\)).

As previously reported \([17,18]\), we found that anorexia, fever,
dyspnea, and fatigue were the most prevalent clinical features of
COVID-19. Fatigue, anorexia, and food disgust were major aggra-
vating factors for weight loss in the acute phase of the disease,
along with chronic diabetes, overweight, and obesity. Not
surprisingly, we found that the more severe the disease (as reflected by the number of days spent in the ICU), the greater the weight loss.

Distinguishing our work from previous studies, we aimed to estimate the effects of nutritional strategies and difficulties in food intake is likely an immediate consequence of the infection-related anorexia and food disgust but it was transient; unlike the COVID-19 effects on weight.

One month after returning home, 41% of the present study patients still suffered from malnutrition. This suggests that rapid weight loss is a major side effect that likely affects muscle mass. Interestingly, a substantial proportion of our patients voluntarily did not aim to recover their initial weight. These were predominantly patients with overweight or obesity, who were happy with their weight loss. This observation highlights the risk for patients with obesity and sarcopenia, as warned by Barazzoni et al. [19], to be more conscious of public health messages regarding the benefits of losing weight, than of the importance of preserving their muscle mass and function. In line with the European Society for Clinical Nutrition and Metabolism and the European Association for the Study of Obesity [19], and the European Society of Endocrinology [20], this leads us to call for particular attention to this population. Adults with diabetes should also benefit from an acute surveillance, as they tend to lose more weight than other patients [21].

Table 4: Association between COVID-19 potentially influential factors and the evolution of weight at t1 and t2, estimated independently for each symptom using linear mixed-effect regression modeling

| Variable affecting only the hospitalization period; analysis was performed at t1 only. | Weight at t1 vs. t0 (%)* | Weight at t2 vs. t0 (%)* |
|---|---|---|
| N/ob of non-missing data (%) | Coefficient [95% CI] | P value | Coefficient [95% CI] | P value |
| COVID-19 SYMPTOMS symptom | | | | |
| Anorexia/Early feeling of fullness/Long satiation | 314/401 (78) | −1.6 [−3.1 to −0.1] | 0.0061 | −1.2 [−2.6 to 0.2] | 0.082 |
| Anemia/Agorusia or dysgeusia/Change in taste | 225/387 (58) | −0.2 [−0.9 to 1.3] | 0.678 | 0.2 [−1.0 to 1.3] | 0.768 |
| Nausea/Vomiting | 131/401 (33) | −0.4 [−1.6 to 0.7] | 0.431 | 0.2 [−0.9 to 1.4] | 0.683 |
| Difficulties swallowing/Pharyngeal or esophageal pain | 88/398 (22) | −0.8 [−2.1 to 0.5] | 0.221 | −0.2 [−1.5 to 1.2] | 0.809 |
| Painful mouth/White, pasty tongue | 146/387 (38) | −0.5 [−1.6 to 0.6] | 0.376 | 0.4 [−0.8 to 1.8] | 0.511 |
| Difficulties drinking | 76/396 (19) | −0.4 [−1.7 to 0.9] | 0.578 | 0.1 [−1.5 to 1.3] | 0.930 |
| Food disgust | 187/397 (47) | −1.3 [−2.4 to −0.3] | 0.0131 | −0.1 [−1.8 to 0.4] | 0.196 |
| Fever | 309/395 (78) | −0.2 [−1.5 to 1.1] | 0.769 | −0.1 [−1.5 to 1.2] | 0.863 |
| Dypsnea/Coughing | 314/401 (78) | −0.2 [−1.5 to 1] | 0.721 | 0.0 [−1.3 to 1.4] | 0.948 |
| Pain (muscular, cranial, headaches, etc.) | 249/394 (63) | −0.7 [−1.8 to 0.4] | 0.195 | −0.3 [−1.5 to 0.9] | 0.608 |
| Fatigue | 352/402 (88) | −2.3 [−3.9 to −0.8] | 0.0031 | −1 [−2.7 to 0.6] | 0.227 |
| Digestive or transit disorders | 287/400 (72) | 0.3 [−0.9 to 1.4] | 0.661 | −0.7 [−2.0 to 0.5] | 0.238 |
| Preexisting chronic diseases | | | | |
| Cognitive disorders | 13/403 (3) | −1.8 [−4.7 to 1.1] | 0.223 | 0.0 [−3.1 to 3.2] | 0.980 |
| Chronic respiratory disease (with chronic medication/home oxygen therapy/sleep apnea) | 72/403 (18) | 0.8 [−0.6 to 2.1] | 0.275 | 0.7 [−0.8 to 2.1] | 0.384 |
| Inflammatory rheumatic diseases (lupus, rheumatoid arthritis, etc.) | 17/403 (4) | 0 [−2.7 to 2.7] | 0.994 | 1.6 [−1.3 to 4.4] | 0.275 |
| BMI, kg/m², before COVID-19 infection (in categories) | | | | |
| <18.5 | 3/393 (1) | −4.8 [−10.6 to 1] | 0.105 | −0.5 [−6.3 to 5.4] | 0.879 |
| 18.5–25 | 92/393 (23) | (ref) | (ref) | (ref) | (ref) |
| 25–30 | 147/393 (37) | −1.6 [−3 to −0.3] | 0.0181 | −1.7 [−3.1 to −0.3] | 0.0181 |
| ≥30 kg/m² | 151/393 (38) | −2.2 [−3.5 to −0.9] | 0.0011 | −3.7 [−5.1 to −2.3] < 0.0011 |
| Nutritional strategies and difficulties | | | | |
| Food supply difficulties related to home confinement | 16/401 (4) | −1.8 [−4.6 to 1] | 0.216 | −1.4 [−4.3 to 1.4] | 0.327 |
| Incentives to eat, and if needed, help given by caregivers or a relative | 132/379 (35) at t1. | | | |
| 196/398 (49) at t2 | −0.5 [−1.3 to 0.4] | 0.270 | −0.1 [−0.9 to 0.7] | 0.839 |
| Advice given by a nutritionists | 105/366 (29) at t1, 93/395 (24) at t2 | −1.2 [−2.1 to −0.3] | 0.0071 | −0.5 [−1.5 to 0.5] | 0.307 |
| Adapted meals during hospitalization | 233/387 (61) at t1 | −0.7 [−1.9 to 0.5] | 0.239 | / | / |
| Snacking during hospitalization | 189/386 (49) at t1 | −1 [−2.1 to 0.1] | 0.087 | / | / |
| ONS (yes/no, patient declaration) | 196/385 (51) taken at t1, 120/400 (30) prescribed at t2 | −0.6 [−1.5 to 0.2] | 0.150 | 1.6 [0.6–2.5] | 0.001 |
| Total ONS* (units, patient declaration) | 14 [4.5; 22.5] taken at t1, 60<sup>15,60</sup> prescribed at t2 | −0.01 [−0.04 to 0.01] | 0.325 | 0.02 [0.01–0.04] | 0.001 |

BMI, body mass index; ONS, Oral nutritional supplements
*Weight analyses were performed using a mixed-effect regression model, with an individual random effect nested in a center random effect, and an independent fixed effect at t1 and at t2 for the variable of interest and for the adjustment factors (the number of days in intensive care, admission to post-acute and rehabilitation and edema status).
<sup>1</sup>P < 0.01.
<sup>2</sup>Variable affecting only the hospitalization period; analysis was performed at t1 only.
<sup>3</sup>60 (13%) missing data at t1, 18 (4%) missing data at t2.
The benefit of nutritional strategies during hospitalization (encouragement to eat, fortified food, etc.) is likely biased by the fact that nutritional supports were predominantly given to the patients most affected by the disease (i.e., those who had the greatest drop in appetite and weight). For example, patients receiving ONS had lost more weight than patients without ONS.

Disentangling this confounding effect from the effect of a nutritional strategy would have required an intensive follow-up of patients during the acute phase (i.e., routine measures of weight and energy intake), which was not possible during the first pandemic wave when health professionals were overloaded. Consequently, the results at t1 should be interpreted with great caution.

On the contrary, the results obtained during the recovery phase are probably not affected by this confounding effect (all patients were in recovery during this period). Interestingly, ONS were significantly associated with a weight gain at t2. This observation is in favor of guidelines for COVID-19 [22] stating that meals and snacks should be adapted to patients’ disgusts and capabilities [23] and combined with resistance physical exercise [24]. This is also in agreement with Caccialanza et al. [25] who recommended two or three bottles of ONS for non-critically ill patients as a systematic prescription for patients with nutritional risk. Note, however, that this study was not randomized. Consequently, further interventional studies are needed to confirm our results.

Strengths and limitations

The strength of the NutriCoviD30 study design lies in collecting repeated SEFI and body weight measures during the course of the COVID-19 infection (i.e., before the disease, during hospitalization, and 1 mo after hospital discharge). When analyzing food intake and weight loss trajectories using linear mixed models, individual characteristics affecting the measure (e.g., educational status) are accounted for by the individual random effect, as long as they do not differentially affect the three periods.

There were, however, several limitations to the present study. First, the study population consisted only of inpatient survivors. This excludes the most severe inpatients who were still hospitalized or in PAR units at the time of the study, and the less severe patients who did not require hospitalization.

A second limitation relates to weight measurements. Its assessment was not complete. At the highest, 98 patients did not provide a weight measurement at t2 because they did not have a bathroom scale at home, or because they refused to weigh themselves. Additionally, weight accuracy depends on the scale’s tuning, which is expectedly equally affected by positive and negative calibration fluctuations. Hence, weights are measured with a between-person random error, resulting in unbiased estimates of the average weight [26]. Yet, the variance is inflated, which can lower statistical power in mixed models. Finally, the consistency observed between weight measurements (Supplementary Table 4) lends confidence in the data and analyses we reported.

The use of SEFI relies on declarative assessment, which is less precise than a professional evaluation or measuring energy intake. Yet, our interest lies in the SEFI trajectories, and was investigated using models that account for interindividual differences and focuses on intraindividual variations between measures. For individuals with moderate cognitive decline (3: Table 2), a family member helped answer the questionnaire during the interview.

Conclusion

To our knowledge, NutriCoviD30 was the largest multicenter longitudinal cohort studying the nutrition of hospitalized patients with COVID-19 infection to date. Its main interest lies in assessing malnutrition on the mid-term (i.e., including the recovery phase up to 1 mo after hospital discharge). This study provided a description of COVID-19 symptoms and preexisting chronic conditions, as well as their potential effects on patients’ food intake and weight loss. It also describes and investigates the nutritional interventions implemented during the infection and recovery phase.

COVID-19 resulted in a substantial weight loss in inpatients, which infers that it affected the muscle mass much more than the fat mass. Patients only regained half of their weight loss 1 mo after hospital discharge, despite their food intake returning to normal. Malnutrition affected 67% of patients during hospitalization and persisted for 41% of them 1 mo after hospital discharge. This is partly due to patients not being aware of the severity of muscle wasting during rapid weight loss. The mid- to long-term effects of COVID-19 infection have been widely demonstrated to date; yet, avoiding important weight loss during the acute phase would help to limit these effects. On this goal, nutritional support is needed for COVID-19 inpatients. It should start early in the course of the infection, and should be extended up to the recovery phase. Prevention messages should be delivered regarding the importance of maintaining muscle mass and function.

Author contributions

MF Vaillant had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: Vaillant, Agier, Albaladejo, Lathière, Fontaine. Acquisition of data: Vaillant, Martineau, Philipponneau, Romand, Madoua, Behar, Nessler, Achamrah, Laubé.
Lambert, Duquesnoy. Analysis, or interpretation of data: Vaillant, Agier, Lathière, Fontaine. Drafting of the manuscript: Vaillant, Agier, Lathière, Fontaine. Critical revision of the manuscript for important intellectual content: All authors. Statistical analysis: Vaillant, Agier, Fontaine. Administrative, technical, or material support: Vaillant, Albaladejo, Lathière. Supervision: Bosson, Fontaine.

Declaration of interests

M.F.V. received support from Fresenius, Nestlé; D.R. from Nutricia, Nestlé, and Fresenius; and V.M. from Nutricia for congress participations. V.M. was an employee of Lactalis International (Medical Nutrition) 2017-2019. E.F. received personal fees for teaching from Baxter, B Braun, Nutricia, and P(Medical Nutrition) 2017-2019. E.F. received personal fees for Coline Quehen, Lise Joly, Clara Meyer, all of the dietitian team, members of participating centers: Reine-Marie Nunzi, Carole Neveu, Mireille Philibert, Didier Barnoud, C Bertrand, Patrick Ritz (Toulouse), Aline Auzeric, Estelle Bovier, line Gagliotta, Catherine Le Saux, all of the dietitian team, Monelle chez, Agathe Raynaud-Simon, Francisca Joly, Nicole Courrède, Jean-Claude Melchior (Paris), Mathilde G histoire (SFNCM) for their scienti

Acknowledgments

The authors acknowledge the NutriCoviD30 participants for their time and commitment to the study and the following members of participating centers: Reine-Marie Nunzi, Carole Neveu, Coline Quehen, Lise Joly, Clara Meyer, all of the dietitian team, Stéphanie Schmitt, Aida Mandzo, Cyrielle Clapé (Grenoble), Carole Gagliotta, Catherine Le Saux, all of the dietitian team, Monelle Bertrand, Patrick Ritz (Toulouse), Aline Auzeric, Estelle Bovier, Marie Dragon, Karin Montagut, Maxime Paturel, Brigitte Boniteau, Mireille Philibert, Didier Barnoud, Cécile Chambrier (Lyon), Coralie Prebet, Edith Marchesi-Samed, all of the dietitian teams of Pitié-Salpêtrière, Tenon, Saint-Antoine, Marion Thompson, Manuel Sanchez, Agathe Raynaud-Simon, Francisca Joly, Nicole Courrède, Jean-Claude Melchior (Paris), Mathilde Gâte, Pierre Déchelotte (Rouen), Ronan Thibault (Rennes). The authors also acknowledge Didier Quilliot and the French-speaking Society for Clinical Nutrition and Metabolism (SFNCM) for their scientific contributions. We obtained permission to name them.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2021.111433.

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