Original Article

Evaluation of malnutrition by objective nutritional indexes and predictors in hospitalized patients with COVID-19

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(Received 29 April, 2024; Accepted 3 June, 2024; Released online in J-STAGE as advance publication 28 June, 2024)

Nutritional information on hospitalized patients with COVID-19 is limited. We aimed to (1) investigate the prevalence of nutrition risk defined by the Scored Nutritional Risk Screening (NRS 2002) and malnutrition assessed by prognostic nutritional index (PNI) and controlling nutritional status score (CONUT), (2) observe the nutritional intervention, and (3) explore the predictors of critical condition and mortality. Nutritional risk was 53.00% and the prevalence of malnutrition was 79.09% and 88.79% among 464 patients based on PNI and CONUT, respectively. The area under the receiver operating characteristic curve for hypersensitivity C-reactive protein (hs-CRP), platelet-to-lymphocyte ratio (PLR), PNI, neutrophil/lymphocyte ratio (NLR), systemic immune-inflammation index (SII), and CONUT were 0.714, 0.677, 0.243, 0.778, 0.742, and 0.743, respectively, in discerning critical patients. The mortality-related area under the curve of hs-CRP, PLR, PNI, NLR, SII, and CONUT were 0.740, 0.647, 0.247, 0.814, 0.758, and 0.767, respectively. The results showed that CONUT and NLR were significantly correlated with the critical conditions. Our study revealed a high prevalence of nutritional risk and malnutrition among hospitalized patients with COVID-19. NLR, PLR, hs-CRP, SII, and CONUT are independent predictors of critical conditions and mortality. CONUT and NLR could assist clinicians in discerning critical cases.

***Key Words*: malnutrition, COVID-19, objective nutritional indexes, predictors**

The infection of the novel coronavirus SARS-CoV-2 (COVID-19) primarily affects the respiratory system, as well as other organs, especially the digestive system. Gastrointestinal symptoms, including nausea, diarrhea, hypoxia, and so on, are important factors leading to insufficient intake and decreased digestive function among infected patients.[1] Moreover, in severe and critically ill patients, excessive inflammatory reactions caused by viruses and secondary infections, secondary protein decomposition, and metabolic imbalance lead to the occurrence and development of malnutrition.[2,3]

Expert statements and practical guidance for the nutritional management of patients with COVID-19 have been devised by the European Society for Clinical Nutrition and Metabolism (ESPEN) and Beijing Quality Control and Improvement Center for Clinical Nutrition Therapy in China successively.[4,5] Although no specific malnutrition assessment tool has been recommended, they encourage the use of effective and validated tools, including the Global Leadership Initiative on Malnutrition (GLIM), Subjective Global Assessment criteria (SGA), and Mini Nutritional Assessment (MNA) in elderly patients and the Nutrition Risk In Critically Ill score (NUTRIC) criteria for patients in the intensive care unit (ICU). While these are subjective tools based on recent weight loss and reduced food intake, which must be collected by professional dietitians. Face-to-face assessments may increase the risk of infection by COVID-19. Instead, the controlling nutritional status score (CONUT), prognostic nutritional index (PNI), neutrophil-to-lymphocyte ratio (NLR), systemic immune-inflammation index (SII), and platelet-to-lymphocyte ratio (PLR) are objective indices and biomarkers based on inflammation and nutritional status, which can be easily and quickly calculated from the results of routine blood tests.

A recent scoping review showed that there are still many gaps in the clinical evidence for the nutritional assessment and therapy for hospitalized patients with COVID-19.[6] Therefore, this study aimed to (1) investigate the prevalence of nutritional risk defined by the Nutritional Risk Screening 2002 (NRS2002) guidelines and malnutrition assessed by objective tools (PNI and CONUT) in hospitalized patients with COVID-19, (2) observe the corresponding nutritional intervention, and (3) explore the predictors of the critical condition and mortality of this population. In summary, the original intention of our research was to provide new data to further guide and enhance the nutritional care process and clinical outcomes of hospitalized COVID-19 patients.

Methods

Data acquisition. This was a single-center, retrospective study. We included 464 hospitalized patients with confirmed COVID-19 between December 2022 and January 2023 at the Ningbo Medical Center Lihuili Hospital, China (Fig. 1). All patients had clear clinical outcomes, including hospital discharge or death. Nutritional Risk Screening was performed by a trained nutritionist using the NRS2002 on the first day after admission. An NRS2002 score ≥3 stated that the patient was at nutritional risk. Data were extracted from patients' medical charts by a trained team of medical dieticians. We focused on the following: (1) general data, including name, age, gender, height, body weight, body mass index (BMI), smoking and alcohol habits, length of stay (LOS), and death; (2) medical personal history, including diabetes, hypertension, cardiovascular, chronic kidney disease and malignancy, which were mentioned in the electronic medical record system; and (3) laboratory data, including total protein, serum albumin (ALB), creatinine, triglycerides, cholesterol, hemoglobin, leukocyte count, neutrophil lymphocyte count, and hypersensitivity C-reactive protein (hs-CRP). The study was approved by the ethics committee of the Ningbo Medical Center Lihuili Hospital.

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doi: 10.3164/jcbn.24-73

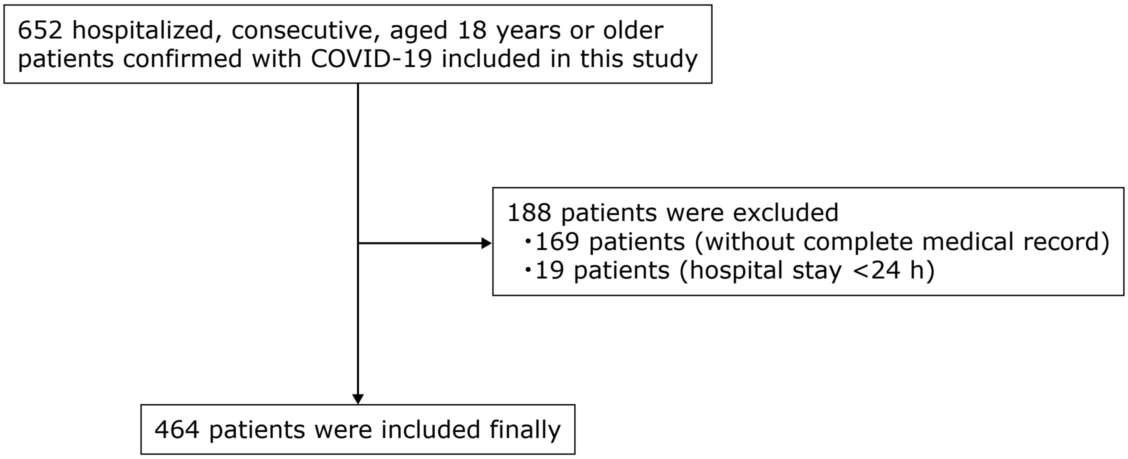

Fig. 1. Study population inclusion/exclusion flow chart.

Category of COVID-19. COVID-19 was categorized into mild, common, severe and critical based on the 10th edition of the Chinese National Health Commission.[7] Patients were considered severely ill if they met any of the following criteria: (a) respiratory distress and respiratory rate ≥30 times/min; (b) oxygen saturation in a resting state ≤93%; (c) arterial partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2) ≤300 mm Hg; and (d) progressively worsening clinical symptoms, as well as lung imaging showing that the lesion significantly developed by more than 50% of its original size within 24–48 h. Critically ill patients met any of the following criteria: (a) respiratory insufficiency requiring mechanical ventilation, (b) susceptibility to shock, or (c) multiple organ failure requiring treatment in the ICU.

Objective nutritional index. The prognostic nutritional index (PNI) was calculated using serum ALB and total lymphocyte count. PNI was calculated as follows: PNI = serum ALB (g/L) + 5 × total lymphocyte count (109/L). According to standards formulated by Onodera *et al.*,[8] a PNI <45 was considered indicative of malnutrition.

CONUT was developed as a tool to assess the nutrient status from 3 biological indexes—serum album, total lymphocytes and total cholesterol—comprehensively and multifacetedly.[9] A total score ≥2 was defined as malnutrition, 2–4 as light, 5–8 as moderate, and 9–12 as severe.

SII was calculated as follows: SII = neutrophil count × platelet count/lymphocyte count. It has been reported as a relatively new inflammatory index for predicting the clinical course of patients with COVID-19 based on peripheral lymphocyte, neutrophil, and platelet counts.[10]

NLR was calculated using the following formula: NLR = neutrophil/lymphocyte. PLR was calculated as follows: PLR = platelets/lymphocytes. Prior studies demonstrated that NLR and PLR may be independent risk factors for mortality in patients with COVID-19.[11]

Statistical analysis. Continuous variables are expressed as mean ± SD. Differences between groups were measured using the *t* test. Categorical variables are expressed as numbers (percentages), and differences between groups were measured using the chi-square test. Receiver operating characteristic (ROC) curves were used to assess the predictive value of indices. The optimal critical value of each index was determined by calculating the Youden index (Youden Index = Sensitivity + Specificity − 1, which ranges from 0 to 1). Logistic regression analysis was performed to determine possible risk factors. All statistical analyses were performed using SPSS ver. 25.0, and a *p* value <0.05 was deemed statistically significant.

Results

Study characteristics. Finally, 464 hospitalized patients with COVID-19 were included. The patients' clinical characteristics are presented in Table 1. The average age of the population was 68.28 ± 14.12 years old, and 65–74-year-old patients were the most dominant (32.8%). There were 262 men (56.5%) and 202 women (43.5%). According to the 10th edition of the Chinese National Health Commission,[7] we divided the patients into two groups: non-severe cases (mild and common) and severe cases (severe and critically ill). There were 376 patients (81.03%) and 88 patients (18.97%) in the former and latter groups, respectively. Fourteen patients (3.02%) died during hospitalization. The most common comorbidities were hypertension (218/464; 47.0%), diabetes (111/464; 23.9%), and Malignancy (96/464; 20.7%). Our results also showed that the severe group was older and had longer LOS, lower BMI, lower serum ALB, cholesterol, and hemoglobin levels, and higher hs-CRP levels than had the non-severe group.

Prevalence of nutritional risk and malnutrition assessed by the objective indexes (PNI and CONUT). Of the 464 patients, 246 were defined as having nutritional risk according to the NRS2002, with an incidence rate of 53.0% at the time of admission. The prevalence of malnutrition was 79.09% and 88.79% according to PNI and CONUT, respectively (Table 2).

Nutrition intervention for hospitalized COVID-19 patients. We observed the nutritional intervention outcomes for hospitalized patients with COVID-19 based on the principles of the five-step nutritional treatment (Table 2). Most patients (357 of 464; 76.9%) did not receive nutritional support. Oral nutritional supplements (ONS) were administered to 72 (15.5%) patients, total enteral nutrition support (TEN) to 23 (5.0%), partial enteral and parenteral nutrition support to four (0.9%), and total parenteral nutrition support to eight (1.7%).

Correlations between the nutrition-related indicators and two objective diagnostic tools (PNI and CONUT). Table 3 shows the correlations between the two objective diagnostic tools (PNI and CONUT) and nutrition-related indicators. Malnutrition diagnosed using the PNI and CONUT was significantly associated with older age, longer LOS, lower serum ALB and cholesterol levels, and higher hs-CRP levels. Malnutrition diagnosed using PNI was also significantly associated with lower BMI and higher creatinine levels, which were associated with lower serum triglyceride levels.

Single-variable analysis of risk factors for nutritional risk and malnutrition. We also The chi-square test was used to analyze the risk factors for nutritional risk and malnutrition

doi: 10.3164/jcbn.24-73

Table 1. Clinical characteristics of the hospitalized patients with COVID-19

	Total cases (n = 464)	No-severe cases (n = 376)	Severe cases (n = 88)	p value
Age (years, $\bar{x} \pm s$)	68.28 ± 14.12	66.73 ± 14.28	74.88 ± 11.29	0.000
Age Range				
<55	70 (15.1%)	67 (95.7%)	3 (4.3%)	0.000
55–64	76 (16.4%)	67 (88.2%)	9 (11.8%)	
65–74	152 (32.8%)	126 (82.9%)	26 (17.1%)	
75–84	122 (26.3%)	87 (71.3%)	35 (28.7%)	
≥85	44 (9.5%)	29 (65.9%)	15 (34.1%)	
Sex				
Males	262 (56.5%)	204 (77.9%)	58 (22.1%)	0.056
Females	202 (43.5%)	172 (85.1%)	30 (14.9%)	
Comorbidity				
Smoking	50 (10.8%)	38 (76.0%)	12 (24.0%)	0.342
Drinking	44 (9.5%)	32 (72.7%)	12 (27.3%)	0.157
Diabetes	111 (23.9%)	88 (79.3%)	23 (20.7%)	0.581
Hypertension	218 (47.0%)	171 (78.4%)	47 (21.6%)	0.193
Cardiovascular	47 (10.1%)	33 (70.2%)	14 (29.8%)	0.051
Chronic kidney disease	49 (10.6%)	35 (71.4%)	14 (28.6%)	0.082
Malignancy	96 (20.7%)	75 (78.1%)	21 (21.9%)	0.465
LOS	10.08 ± 8.16	8.38 ± 5.95	17.33 ± 11.65	0.000
BMI	23.27 ± 3.58	23.49 ± 3.46	22.33 ± 3.92	0.006
Albumin	34.79 ± 6.33	35.56 ± 6.46	31.46 ± 4.44	0.000
Creatinine	81.03 ± 86.13	81.31 ± 93.46	79.82 ± 42.73	0.884
Triglyceride	1.39 ± 0.93	1.40 ± 0.99	1.33 ± 0.63	0.536
Cholesterol	4.01 ± 1.09	4.07 ± 1.12	3.75 ± 0.93	0.014
Hemoglobin	117.85 ± 20.30	119.18 ± 20.00	112.19 ± 20.70	0.004
Hs-CRP	42.90 ± 50.49	34.84 ± 40.77	77.33 ± 70.16	0.000
Lymphocyte	1.13 ± 1.69	1.19 ± 1.72	0.86 ± 1.51	0.097
Leukocyte	6.39 ± 4.18	5.97 ± 3.76	8.19 ± 5.29	0.000
Neutrophil	4.94 ± 4.35	4.46 ± 4.02	6.98 ± 5.07	0.000
Platelet	211.24 ± 93.23	210.80 ± 92.49	213.10 ± 96.87	0.835
Nutritional therapy				
No	357 (76.9%)	320 (89.6%)	37 (10.4%)	0.000
YES	107 (23.1%)	56 (52.3%)	51 (47.7%)	

Data are reported as n (%).

according to sociodemographic characteristics and comorbidities. Table 4 reveals that age, BMI, and comorbidities, including diabetes, hypertension, and cardiovascular disease, were risk factors for nutritional risk. Table 5 reveals that sex, age, BMI, and smoking were risk factors for malnutrition diagnosed using PNI, while sex, drinking, and comorbidities with hypertension were risk factors for malnutrition diagnosed using CONUT.

ROC analysis of the objective nutritional indexes to predict critical conditions and mortality. ROC curve analysis was used to predict critical condition. The AUC for hs-CRP, PLR, PNI, NLR, SII, and CONUT were 0.714, 0.677, 0.243, 0.778, 0.742, and 0.743, respectively. The optimal cut-off values relative to the indicators of critical patients were 39.45, 180.71, 4.89, 817.54, and 5.50, respectively (Table 6).

ROC curve analysis was used to predict patient mortality. The AUC for hs-CRP, PLR, PNI, NLR, SII, and CONUT were 0.740, 0.647, 0.247, 0.814, 0.758, and 0.767, respectively. The optimal cut-off values relative to the indicators of mortality were 519.58, 30.55, 8.54, 3,274.34, and 5.50, respectively (Table 7).

Logistic regression analysis of the objective nutritional indexes. To further identify the predictive value of the objective nutritional indexes, the logistic regression analysis was conducted. The crude odds ratio (OR), and the adjusted OR with age, BMI and sex were calculated (Table 8 and 9). The results showed that CONUT and NLR were significantly correlated with the critical conditions, while the five indexes were all not significantly correlated with the mortality with the adjustment for age, BMI and sex.

Discussion

Nutrition is an often-neglected factor in infectious diseases. There is a relatively increased risk of malnutrition in hospitalized or critically ill patients. Meanwhile, the clinical outcomes of patients may be affected by the quick assessment and standard therapy of poor nutritional status. A recent narrative review showed that COVID-19 patients have a high prevalence rate of malnutrition (14–70%).[12] Our study also showed a high proportion of 464 hospitalized patients with a nutritional risk of 53.0% and a prevalence of malnutrition of 79.09% and 88.79% when calculated using PNI and CONUT, respectively. Li *et al.*[13] used the Mini Nutritional Assessment (MNA) to diagnose malnutrition, and the rate of malnutrition was 52.7% in elderly inpatients with COVID-19. Meanwhile, Allard *et al.*[14] demonstrated a prevalence of 38.9% in 108 inpatients with COVID-19. The proportion of malnutrition in our study was higher than that in pre-

Table 2. Nutritional risk and assessment of the hospitalized patients with COVID-19

	Total (n = 464)
NRS-2002 score	
<3	218 (47.0%)
≥3	246 (53.0%)
BMI	
Underweight (<18.5)	47 (10.1%)
Normal weight (18.5–23.9)	211 (45.5%)
Overweight and obesity (≥24)	206 (44.4%)
PNI	
<45 (Malnutrition)	367 (79.1%)
≥45 (Normal)	97 (20.9%)
CONUT	
<2 (Normal)	52 (11.2%)
≥2 (Malnutrition)	412 (88.8%)
2–4 (Mild malnutrition)	185 (39.9%)
5–8 (Moderate malnutrition)	201 (43.3%)
9–12 (Severe malnutrition)	26 (5.6%)
Nutritional therapy	
No Nutritional Support	357 (76.9%)
ONS	72 (15.5%)
TEN	23 (5.0%)
PEN + PPN	4 (0.9%)
TPN	8 (1.7%)

Data are reported as n (%).

vious studies, mainly due to the diagnostic cut-off points of PNI and CONUT. In the present study, the mortality rate was 3.02%, which was relatively lower than that reported in previous studies (4.3%–28.3%).[15–17] This may be attributed to the COVID-19 pandemic in the past three years, level of medical resources and treatment, and the heterogeneity of the included patients. Moreover, older age and lower BMI were risk factors for both nutritional risk and malnutrition. The comorbidities with diabetes, hypertension, and cardiovascular disease may increase the nutritional risk. Smoking and alcohol consumption are risk factors for malnutrition.

Previous studies have used various diagnostic tools to investigate the incidence of malnutrition in hospitalized patients with COVID-19. Some have used the MNA tool to diagnose malnutrition,[13,18,19] some selected the GLIM criteria,[20,21] and some defined malnutrition based on the French definition[22] combined with low BMI and the fulfilment of other weight loss criteria.[14] For patients in the ICU, researchers also used the modified NUTRIC score to diagnose malnutrition.[23] To our knowledge, our study was the first attempt to perform diagnosis using two objective nutritional assessment tools (PNI and CONUT). We have chosen to do so due to the following reasons: (1) Subjective tools such as MNA, SGA, and GLIM are needed to assess the patients' BMI, weight loss, and reduced food intake, while our study was retrospective, and data on these tools were mostly incomplete. (2) The assessment of PNI and CONUT was based on blood tests, and blood indicators could be easily and rapidly detected and calculated. (3) Objective nutritional assessment reduced direct contact between COVID-19 patients and dieticians, which may help reduce the spread of the virus and COVID-19 infectiveness.

Standardized nutritional support therapy has the potential to improve nutritional status, immunity, quality of life, and clinical outcomes of COVID-19 infected patients. It is also clear from the latest Chinese government policy that nutrition support therapy should be included in the entire treatment and recovery process of patients with COVID-19.[5] We showed a low proportion of nutritional support (107/464; 23.06%) in the current sample. These results are similar with those of previous studies. Pironi *et al.*[21] investigated nutritional therapy in 268 patients with COVID-19 and found that 63 patients (23.51%) received nutritional support (ONS, EN, and PN were prescribed to 6%, 13%, and 5% of patients, respectively). Zhao *et al.*[24] reported that only 25% of patients received nutritional support. The importance of nutritional support has been highlighted in recent expert COVID-19 guidance (ESPEN, ASPEN/SCCM, and so on).[4,25] However, there is still a gap between the guidelines and clinical nutritional practice.

The early diagnosis and prediction of COVID-19 are especially critical, as they can improve prognosis and reduce the occurrence of complications. Blood examinations and simple scoring tools play essential roles in early disease diagnosis. Previous studies have reported numerous predictors of the outcome and mortality of patients with COVID-19 in the last two years.[26–38] Most of the results of our study were consistent with these findings. PNI showed a different result in our study: the predictive value of PNI in the prognostication of mortality and disease severity was highlighted in a systematic review and meta-analysis of 504 inpatients with COVID-19.[27] Nevertheless, our results showed that the area under the curve (AUC) of PNI in discerning critical patients and mortality was 0.243 and 0.247, respectively, which may indicate that PNI was not a reliable predictor.

The results of the predictive value of the SII are inconsistent with those of previous studies. Most studies affirmed the predictive value of SII,[28–30] but it was not suggested to be a sensitive

Table 3. Nutritional characteristics of the study population stratified by the PNI and CONUT

Characteristics	PNI				CONUT			
	Malnourished (n = 367)	Well-nourished (n = 97)	t	p	Malnourished (n = 412)	Well-nourished (n = 52)	t	p
Age	69.95 ± 13.12	62.15 ± 15.41	5.01	0.000	68.95 ± 13.84	62.98 ± 15.31	2.89	0.004
LOS	10.95 ± 8.39	6.78 ± 6.20	5.43	0.000	10.59 ± 8.39	6.00 ± 4.17	6.46	0.000
BMI	22.99 ± 3.65	24.28 ± 3.14	3.46	0.001	23.18 ± 3.65	24.03 ± 2.83	1.98	0.051
Albumin	33.15 ± 4.36	41.07 ± 8.42	12.7	0.000	34.11 ± 6.28	40.18 ± 3.58	6.83	0.000
Creatinine	84.91 ± 95.76	66.60 ± 23.37	3.31	0.001	64.30 ± 84.10	61.67 ± 19.22	0.22	0.823
Triglyceride	1.35 ± 0.97	1.53 ± 0.76	1.67	0.096	1.34 ± 0.94	1.69 ± 0.83	2.51	0.013
Cholesterol	3.95 ± 1.06	4.31 ± 1.15	2.93	0.004	3.87 ± 1.03	5.02 ± 1.17	7.46	0.000
hs-CRP	51.86 ± 53.05	12.95 ± 19.83	11.37	0.000	50.90 ± 56.11	11.85 ± 21.35	9.64	0.000

doi: 10.3164/jcbn.24-73

Table 4. The univariate analysis of risk factors for nutritional risk

		NRS2002 ≥3 (*n* = 246)	NRS2002 <3 (*n* = 218)	X^2	*p*
Sex	Male	146 (55.7%)	116 (44.3%)	1.772	0.190
	Female	100 (49.5%)	102 (47.0%)		
Age	≥65	236 (74.2%)	82 (25.8%)	182.293	0.000
	<65	10 (6.8%)	136 (93.2%)		
BMI	<18.5	45 (95.7%)	2 (4.3%)	38.533	0.000
	18.5–23.9	104 (49.3%)	107 (50.7%)		
	≥24	97 (47.1%)	109 (52.9%)		
Smoking	Yes	28 (56.0%)	22 (44.0%)	0.200	0.764
	No	218 (52.7%)	196 (47.3%)		
Drinking	Yes	25 (56.8%)	19 (43.2%)	0.282	0.636
	No	221 (52.6%)	199 (47.4%)		
Diabetes	Yes	74 (66.7%)	37 (33.3%)	10.913	0.001
	No	172 (48.7%)	181 (51.3%)		
Hypertension	Yes	143 (65.6%)	75 (34.4%)	26.121	0.000
	No	103 (41.95%)	143 (58.1%)		
Cardiovascular	Yes	34 (72.3%)	13 (27.7%)	7.839	0.005
	No	212 (50.8%)	205 (49.2%)		
Chronic kidney disease	Yes	30 (61.2%)	19 (38.8%)	1.482	0.231
	No	216 (52.0%)	199 (48.0%)		
Malignancy	Yes	56 (58.3%)	40 (41.7%)	1.373	0.253
	No	190 (51.6%)	178 (48.4%)		

Table 5. The univariate analysis of risk factors for malnutrition

		PNI <45 (*n* = 367)	PNI ≥45 (n = 97)	X^2	*p*	CONUT <2 (*n* = 52)	CONUT ≥2 (*n* = 412)	X^2	*p*
Sex	Male	224 (85.8%)	37 (14.2%)	16.336	0.000	15 (5.7%)	247 (94.3%)	18.173	0.000
	Female	143 (70.4%)	60 (29.6%)			37 (18.3%)	165 (81.7%)		
Age	≥65	262 (82.1%)	57 (17.9%)	5.694	0.019	31 (9.7%)	287 (90.3%)	2.160	0.155
	<65	105 (72.4%)	40 (27.6%)			21 (14.4%)	125 (85.6%)		
BMI	<18.5	44 (93.6%)	3 (6.4%)	15.828	0.000	1 (2.1%)	47 (97.9%)	4.773	0.092
	18.5–23.9	176 (83.4%)	35 (16.6%)			24 (11.4%)	186 (88.6%)		
	≥24	147 (71.4%)	59 (28.6%)			27 (13.1%)	179 (86.9%)		
Smoking	Yes	45 (90.0%)	5 (10.0%)	4.030	0.044	3 (6.0%)	47 (94.0%)	1.527	0.340
	No	322 (77.8%)	92 (22.2%)			49 (11.8%)	365 (88.2%)		
Drinking	Yes	39 (90.7%)	4 (9.3%)	3.859	0.050	1 (2.3%)	43 (97.7%)	3.899	0.045
	No	328 (77.9%)	93 (22.1%)			51 (12.1%)	369 (87.9%)		
Diabetes	Yes	92 (82.9%)	19 (17.1%)	1.266	0.287	8 (7.2%)	103 (92.8%)	2.346	0.167
	No	275 (77.9%)	78 (22.1%)			44 (12.5%)	309 (87.5%)		
Hypertension	Yes	178 (81.7%)	40 (18.3%)	1.625	0.210	16 (7.3%)	202 (92.7%)	6.180	0.018
	No	189 (76.8%)	57 (23.2%)			36 (14.6%)	210 (85.4%)		
Cardiovascular	Yes	43 (89.6%)	5 (10.4%)	3.562	0.062	2 (4.3%)	45 (95.7%)	2.540	0.143
	No	324 (77.9%)	92 (22.1%)			50 (12.0%)	367 (88.0%)		
Chronic kidney disease	Yes	43 (86.0%)	7 (14.0%)	1.616	0.269	5 (10.2%)	44 (89.8%)	0.055	1.000
	No	324 (78.3%)	90 (21.7%)			47 (11.3%)	368 (88.7%)		
Malignancy	Yes	76 (78.4%)	21 (21.6%)	0.041	0.888	10 (10.4%)	86 (89.6%)	0.076	0.858
	No	291 (79.3%)	76 (20.7%)			42 (11.4%)	326 (88.6%)		

prognostic tool in patients with COVID-19 with malignancy in the Muge Bilge' study.[31] Our result showed that the AUC of SII in discerning critical patients and mortality was 0.742 and 0.758, respectively, and that the corresponding cutoff values of SII were 817.54 and 3,274.34, respectively, indicating that SII is a credible predictor.

CONUT has been reported to be an effective predictor in esophageal cancers and pulmonary tuberculosis.[32,33] We found only two reports on the predictive value of CONUT in patients with COVID-19 published in 2022.[34,35] Bodolea *et al.*[34] stated that a CONUT score >7.5 was associated with mortality in 90 patients with severe COVID-19. The cut-off values of CONUT in discerning critical patients and mortality were both 5.5 in our study.

The optimal cut-off values of NLR as a predictor of mortality were 9.1, 11.38, and 11.57 in the studies of Citu *et al.*,[36] Rose

Table 6. ROC analysis of each index to discern critical patients with COVID-19

Predictors	AUC	Optimal cutoff value	Sensitivity%	Specificity%	95% CI	*p* value
CONUT	0.743	5.50	65.90	75.00	0.686–0.799	0.000
SII	0.742	817.54	81.80	55.90	0.686–0.798	0.000
NLR	0.778	4.89	80.70	63.80	0.726–0.830	0.000
PLR	0.677	180.71	80.69	46.28	0.618–0.737	0.000
hs-CRP	0.714	39.45	67.00	68.40	0.652–0.775	0.000

Table 7. ROC analysis of each index to predict the mortality of the patients with COVID-19

Predictors	AUC	Optimal cutoff value	Sensitivity%	Specificity%	95% CI	*p* value
CONUT	0.767	5.50	78.60	68.70	0.652–0.883	0.000
SII	0.758	3,274.34	57.10	91.10	0.615–0.900	0.000
NLR	0.814	8.54	85.70	77.60	0.688–0.939	0.000
PLR	0.647	30.55	100.00	55.80	0.485–0.808	0.000
hs-CRP	0.740	519.58	42.90	92.40	0.649–0.830	0.000

Table 8. Logistic regression analysis of the association of each index and critical patients with COVID-19

Predictors	OR (95% CI)	*p* value	Adjusted OR (95% CI)	*p* value
CONUT	1.198 (1.050–1.366)	0.007	1.234 (1.053–1.447)	0.009
SII	1.000 (1.000–1.000)	0.606	1.000 (1.000–1.000)	0.410
NLR	1.101 (1.027–1.181)	0.007	1.099 (1.012–1.195)	0.025
PLR	1.001 (0.999–1.003)	0.383	1.001 (0.999–1.004)	0.216
hs-CRP	1.006 (1.001–1.012)	0.024	1.007 (1.000–1.014)	0.065

Adjusted OR means adjustment for age, BMI, and sex.

Table 9. Logistic regression analysis of the association of each index and the mortality of the patients with COVID-19

Predictors	OR (95% CI)	*p* value	Adjusted OR (95% CI)	*p* value
CONUT	1.374 (1.051–1.796)	0.020	1.247 (0.932–1.688)	0.137
SII	1.000 (1.000–1.001)	0.321	1.000 (1.000–1.001)	0.543
NLR	1.030 (0.944–1.123)	0.506	1.036 (0.936–1.147)	0.497
PLR	1.000 (0.997–1.003)	0.987	1.000 (0.997–1.003)	0.921
hs-CRP	0.996 (0.986–1.007)	0.472	0.998 (0.987–1.010)	0.735

Adjusted OR means adjustment for age, BMI, and sex.

et al.,[37] and Kudlinski *et al.*[38] Our cutoff value for NLR was 8.54, which was relatively lower than the cutoff value. Furthermore, we found that the AUC of NLR for discerning critical patients and mortality was the largest among the five predictors. As for PLR, the AUC was the smallest, and its cut-off value was 180.71 for discerning critical patients and 30.55 for mortality.

An important strength of our study is that we first attempted to use two objective tools to diagnose malnutrition among 464 hospitalized patients with COVID-19 patients. The PNI and CONUT can be simply calculated based on blood tests, which may reduce the contact between patients with COVID-19 and dieticians and, consequently, COVID-19 infectiveness. We further explored the biomarkers for identifying critically ill patients and predicting the mortality of patients with COVID-19.

However, this study had some limitations. First, the study design was retrospective, and medical records were used; moreover, selection bias risk was significant. Second, we did not report detailed nutritional intake, including energy and protein intakes, in the present study. Third, some clinical data were incomplete, and other relevant predictors, including early warning score (ANDC) and D-dimer levels, could not be incorporated into the analysis of risk factors. Therefore, further validation of these findings in a larger population with longer follow-up periods is required.

In conclusion, we observed that the prevalence of nutritional risk in hospitalized patients with COVID-19 was 53% and that the prevalence of malnutrition was 79.09% and 88.79% according to PNI and CONUT, respectively. There is still a low proportion of nutritional support for patients with COVID-19. Nutritional intervention support may not have been implemented in accordance with the guidelines for the present population. NLR, PLR, hs-CRP, SII, and CONUT were independent predictors of disease severity and mortality in hospitalized patients with COVID-19. As the reinfection of COVID-19 epidemic is progressively arising in China, we hope that our research can provide new data to further guide and enhance the nutrition care process and clinical outcomes of hospitalized patients with COVID-19.

doi: 10.3164/jcbn.24-73

Author Contributions

LZ contributed to conception, administration, writing, and editing of the manuscript. KJ, ZD, and RW contributed to nutritional risk screening and assessment of malnutrition, QW contributed to data collection including disease diagnosis, age, sex, height, BMI, LOS, and laboratory data. All authors contributed to the article and approved the submitted version.

Acknowledgments

We thank all members for their support in data collection. We acknowledge all the people who participated in this study. This work was supported by the Medical Health Science and Technology Project of Zhejiang Provincial Health Commission (2024KY285).

Conflict of Interest

No potential conflicts of interest were disclosed.

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doi: 10.3164/jcbn.24-73