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Original article

High risk of malnutrition among hospitalised coronavirus disease 2019 (COVID-19) patients is associated with mortality and other clinical outcomes

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SUMMARY

Introduction: Increasing evidence indicates an association between nutritional status and Coronavirus disease 2019 (COVID-19) disease severity. The aim of the study was to describe the risk of malnutrition, body mass index (BMI) and vitamin D status of hospitalised COVID-19 patients and assess whether they are associated with duration of hospital stay, intensive care unit (ICU) admission, mechanical ventilation, and mortality.

Methods: The study is a descriptive retrospective study of 273 patients with COVID-19 admitted to Hospital from February 2020 to March 2021. Patients were screened for risk of malnutrition using a validated screening tool. BMI was calculated from height and weight. Insufficient Vitamin D status was defined as 25(OH)vitD <50 nmol/L. Logistic regression analysis was used to assess the association between indicators of nutritional status of patients with COVID-19, and outcomes such as duration of stay >7 days, ICU admission, mechanical ventilation, and mortality. Interaction between risk of malnutrition and BMI of ≥30 kg/m^2 was assessed using the likelihood ratio test with hospital stay, ICU admission, mechanical ventilation, and mortality as outcomes.

Results: Screening for risk of malnutrition identified 201 (74%) patients at a medium to high risk of malnutrition. Patients defined as being at a medium or high risk of malnutrition were more likely to be hospitalised for >7 days compared to those defined as low risk (OR: 10.72; 95% CI: 3.9–29.46; $p < 0.001$ and OR: 61.57; 95% CI: 19.48–194.62; $p < 0.001$, respectively). All patients who were admitted to ICU ($n = 41$) and required mechanical ventilation ($n = 27$) were defined as having medium or high risk of malnutrition. High risk of malnutrition was also associated with increased odds of mortality (OR: 8.87; 955 CI 1.08–72,96; $p = 0.042$). BMI of ≥30 kg/m^2 (43%) and 25(OH)vitD <50 nmol/L (20%) were not associated with duration of stay >7 days or mortality, although BMI ≥30 kg/m^2 was associated with increased risk of ICU admission (OR: 7.12; 95% CI: 1.59–31.94; $p = 0.010$) and mechanical ventilation (OR: 8.86; 95% CI: 1.12–69.87; $p = 0.038$). Interactions between risk of malnutrition and BMI ≥30 kg/m^2 were not significant to explain the outcomes of hospital stay >7 days, ICU admission, mechanical ventilation, or mortality.

Conclusion: High risk of malnutrition among hospitalised COVID-19 patients was associated with longer duration of hospital stay, ICU admission, mechanical ventilation and mortality, and BMI ≥30 kg/m^2 was associated with ICU admission and mechanical ventilation. Insufficient Vitamin D status was not associated with duration of hospital stay, ICU admission, mechanical ventilation, or mortality.

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1. Introduction

The Coronavirus disease 2019 (COVID-19) is a pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a highly transmissible and pathogenic coronavirus [1]. The virus, which spread rapidly across the world, has had a major impact on global demography as it has caused millions of COVID-19 cases and related deaths worldwide [2]. In Iceland, the virus arrived relatively quickly after its discovery, and, as of 19th April 2022, approximately half of the population had a confirmed COVID-19 infection [3,4].

The severity of COVID-19 disease can vary widely, ranging from asymptomatic or mild symptoms to the development of severe pneumonia, acute respiratory distress syndrome, multiple organ failure, and death [5,6]. The reason for the considerable variety of symptoms among COVID-19 infected individuals is not fully known, although old age, male gender, pre-existing comorbidities and poor nutritional status are thought to increase the risk of developing a severe COVID-19 infection [7–10]. A proper nutritional status is believed to be especially important during the infection, as nutrition is vital in supporting the immune system and in modulating immune function [11,12]. Several studies, so far, have supported this, as poor nutritional status, indicated by factors such as malnutrition, obesity (body mass index, BMI, of $\geq$30 kg/m^2), and vitamin D deficiency (25 (OH)vitD <50 nmoL/l), had been shown to increase the risk of severe illness, and possibly mortality, due to COVID-19 [13–18].

In other countries, malnutrition appears to be prevalent amongst COVID-19 patients. For instance, a recent meta-analysis reported that 49% of hospitalised COVID-19 patients were malnourished, with the prevalence reaching 61% amongst ICU patients [9]. Moreover, obesity rates amongst COVID-19 patients have also been shown to be high, as a meta-analysis reported that the prevalence of obesity was 32% among hospitalised patients and 41% among ICU patients [19]. Prevalence of vitamin D deficiency amongst COVID-19 patients has been shown to range anywhere from 17% up to 82%, depending upon region [20–22]. The nutritional status of COVID-19 patients in Iceland has not previously been reported, with the exception of obesity rates among COVID-19 patients admitted to intensive care units (ICU), for which the reported obesity (BMI >30 kg/m^2) prevalence is 61% [23,24].

The aim of this study is to describe the risk of malnutrition, BMI and vitamin D status of hospitalised COVID-19 patients in Iceland and assess whether they are associated with duration of hospital stay, ICU admission, mechanical ventilation and mortality. The study included all hospitalised patients at Landspitali Hospital, from February 2020 to March 2021. All patients included in the study had a COVID-19 infection confirmed by a polymerase chain reaction (PCR) test.

2. Methods

2.1. Study population

This was a retrospective study that included all adults hospitalised with COVID-19 at Landspitali, National University Hospital, from February 2020 to March 2021 (n = 273). The COVID-19 infections were confirmed by real-time reverse-transcription PCR. A retrospective data collection from patients' electronic hospital records was carried out by a health information manager and a trained researcher. The study was approved by the hospital Bioethics Committee (reference nr. 50/2020) and by the Institutional Research Committee (Date 10.12.2020 Ref.16).

2.2. Assessment of nutritional status

A validated screening tool was used to assess risk of malnutrition [25]. The screening tool, which is routinely used at Landspitali University Hospital in Iceland, has been validated against a full nutritional assessment in different patient groups (supplementary Fig. 1) [25] and risk of malnutrition as assessed with the tool has previously been shown to be associated with mortality in COPD patients [26]. In cases where risk of malnutrition had not been assessed, upon admission to the hospital, as recommended, the screening was conducted retrospectively by a trained researcher using information obtained from medical records. The screening tool gathers the following information: Weight and height for calculation of BMI, weight loss, >65 years, vomiting, diarrhoea, loss of appetite or, nausea, hospital stay in the previous 2 months, dysphagia, recent surgeries, and disease/injuries such as burns, multiple trauma and admission due to malnutrition. Patients with Covid infection, identified with score $\geq$4 were defined as being at high risk of malnutrition while medium risk was defined as 2–3 points and low risk as 0–1 points on the screening tool [27].

2.3. Outcomes and co-variates

Additional data such as gender, C-reactive protein (CRP) concentration (the highest recorded CRP value during hospitalisation), duration of hospital stay, ICU admission, need for mechanical ventilation, pre-existing comorbidities (obesity, cardiovascular disease, respiratory system disease, and renal disease), serum 25-hydroxy vitamin D (25(OH)vitD) concentration (divided into two groups, $\geq$50 nmol/L and <50 nmol/L [15,28,29]), gastrointestinal discomfort or pain during COVID infection, and deaths within a year were collected from medical records at Landspitali Hospital from February 2020 to March 2021. A new categorical variable was derived from the duration of the patient's hospital stay by dividing the length into two groups: hospital stay of 7 days or shorter and hospital stay of longer than 7 days. This cut-off was used as there is a general attempt at Landspitali to discharge patients who are not severely ill within 7 days.

2.4. Statistical analyses

For sample size calculations and to calculate the statistical power of the research the statistical software G*Power was used [30]. Our sample size calculations were based on risk of malnutrition. It was estimated that 239 patients were needed to see an increase in duration of hospital stay (as a continuous variable) between those at a medium to high risk of malnutrition compared to those who were at low risk of malnutrition (15.4 ± 7.3 days vs 9.9 ± 11.3 days, $p < 0.001$) [31]. To see an increase in mortality between the two groups 100 patients were estimated to be needed (significance $p = 0.05$ and power 80%; OR 6.6965 CL 95% 2.048–23.961, $p = 0.002$) [32].

Data was collected and processed using Microsoft Excel, Jamovi version 1.6.23.0 [33] and Stata version 17.0 [34]. Continuous variables were expressed as mean ± standard deviation (SD) and were compared by one-way analysis of variance (ANOVA). Categorical variables were expressed as absolute values and percentages, and compared by the chi-square test, or by Fisher's exact test if the expected cell count was less than 5. Using logistic regression, we analysed the associations between indicators of nutritional status, namely risk of malnutrition, obesity, and vitamin D level, and comorbidities, gender, and age, as *a-priori* selected explanatory variables, and duration of hospital stay (whether >7 days) as the outcome. For each explanatory variable separately, a univariate logistic model was built; then, the same explanatory variables were used together in a multivariate logistic model. Other such models were also built, using ICU admission (yes/no), mechanical ventilation (yes/no), and mortality (whether dead/alive) as outcomes, and the same explanatory variables described previously. Interaction between risk of

malnutrition and obesity was assessed using the likelihood ratio test. Diagnostic tests indicated that the models were adequate. The differences were considered statistically significant at $p < 0.05$.

3. Results

3.1. General characteristics and risk of malnutrition

During the study period, 273 patients were hospitalised with COVID-19 in Iceland. No patient was excluded from the study. However, information on weight or height was missing for 25 of the patients, 25(OH)vitD concentration for 11 of the patients and weight loss information was not clear for 145 of the patients.

Table 1 represents the general characteristics according to defined risk of malnutrition. The screening identified 72 patients out of 273 (26.4%) at low risk of malnutrition, while 116 (42.5%) were at medium risk and 85 (31.1%) were at a high risk of malnutrition. Age, mortality, weight loss, gastrointestinal symptoms, CRP ($p < 0.001$), and comorbidities ($p = 0.010$) increased significantly with increased risk of malnutrition. The proportion of male gender, BMI $\geq$30 kg/m^2, insufficient vitamin D status, dysphagia, diabetes, and respiratory system disease were not significantly different between the three risk of malnutrition groups.

Table 2 shows the number of patients who were hospitalised for longer than 7 days, admitted to the ICU, and required mechanical ventilation, as well as mortality according to risk of malnutrition, BMI, and vitamin D status. As shown in Table 2, the number of patients hospitalised for longer than 7 days, who required ICU admission, who required mechanical ventilation, and who died, increased significantly with increased risk of malnutrition ($p < 0.001$).

3.2. Risk of malnutrition and outcomes

All patients who were admitted to the ICU or required mechanical ventilation were at a medium to high risk of malnutrition, with more than half of the patients at a high risk (Table 2). Following adjustment for age (grouped into <70 and $\geq$ 70 years), gender and comorbidities (i.e., diabetes, cardiovascular disease, respiratory system disease, and renal disease), the results show that the risk of a hospital stay longer than 7 days was higher for the patients at medium and high risk of malnutrition compared to those defined as low risk (OR 10.72, 95%CI 3.9; 29.46, $p < 0.001$, and OR 61.57, 95%CI 19.48; 194.62, $p < 0.001$, respectively). All patients who were admitted to the ICU and required mechanical ventilation were defined being at a medium or high risk of malnutrition and high vs. low risk of malnutrition significantly increased the odds of mortality (OR 8.87 [95%CI 1.08–72.96], $p = 0,042$).

3.3. BMI and outcomes

Almost all patients who required ICU admission or mechanical ventilation had a BMI of $\geq$25 kg/m^2, and more than half had BMI $\geq$30 kg/m^2. There was a significantly increased prevalence of BMI $\geq$30 kg/m^2 amongst patients who required ICU admission ($p < 0.001$) or mechanical ventilation ($p = 0.005$). When compared to the group with BMI <25 kg/m^2 those with BMI $\geq$30 kg/m^2 were at increased risk of ICU admission (OR: 7.12; 95% CI: 1.59–31.94; $p = 0.010$) and mechanical ventilation (OR: 8.86; 95% CI: 1.12–69.87; $p = 0.038$). No association was seen between BMI and duration of stay or mortality and interactions between risk of malnutrition and BMI $\geq$30 kg/m^2 were not significant for any of the outcome variables (Table 2).

3.4. Vitamin D and outcomes

No difference was seen in duration of stay >7 days, ICU admission, mechanical ventilation, or mortality between patients defined as having insufficient vitamin D status and those defined as being vitamin D sufficient (Table 2).

Table 1
General characteristics and indicators of nutritional status according to defined risk of malnutrition.

	All	Low risk of malnutrition	Medium risk of malnutrition	High risk of malnutrition	p value[f]
Number of patients, n	273	72	116	85	
Age (years), mean (SD)	66.5 (17.1)	54.8 (15.6)	66.9 (16.6)	76.1 (12.5)	<0.001
Male, n (%)	153 (56)	44 (61.1)	69 (59.5)	40 (47.1)	0.129
Hospital stay (days), mean (SD)	11.1 (10.6)	3.71 (2.53)	9.6 (7.1)	19.5 (12.9)	<0.001
BMI[a] (kg/m2), mean (SD)	29.9 (6.3)	30.8 (5.3)	30.7 (6.5)	28.1 (6.3)	0.008
BMI $\leq$18 kg/m^2, n (%)	15 (5.5)	0	2 (1.7)	13 (15.3)	<0.001
BMI $\geq$30 kg/m^2, n (%)	106 (42.7)	26 (36.1)	51 (44)	29 (34.1)	0.124
25(OH)vitD[b] (nmol/L)), mean (SD)	81 (34.4)	71.9 (30.1)	80.6 (37.3)	88.9 (32.1)	0.004
25(OH)vitD <50 nmol/L, n (%)	52 (19.5)	15 (20.8)	27 (23.3)	10 (11.8)	0.099
Deaths, n (%)	30 (11)	1 (1.4)	9 (7.8)	20 (23.5)	<0.001
Weight loss, n (%)	84 (30.8)	3 (4.2)	29 (25)	52 (61.2)	<0.001
Gastrointestinal symptoms[c], n (%)	192 (70.3)	35 (48.6)	75 (64.6)	82 (96.5)	<0.001
Diarrhoea, n (%)	64 (23.4)	7 (9.7)	26 (22.4)	31 (36.5)	<0.001
Constipation, n (%)	51 (18.7)	4 (5.6)	18 (15.5)	29 (34.1)	<0.001
Dysphagia, n (%)	11 (4)	1 (1.4)	4 (3.4)	6 (7.1)	0.488
Nausea, n (%)	69 (25.3)	7 (9.7)	27 (23.3)	35 (41.1)	<0.001
Persistent poor appetite, n (%)	107 (39.2)	8 (11.1)	39 (33.6)	60 (70.6)	<0.001
CRP[d] (mg/L)	103 (96)	70.1 (81)	101 (88.5)	132 (108)	<0.001
Comorbidities[e], n (%)	152 (55.7)	29 (40.3)	70 (60.3)	53 (62.4)	0.010
Cardiovascular disease, n (%)	126 (46.2)	22 (30.6)	56 (48.3)	48 (56.5)	0.004
Diabetes, n (%)	44 (16.1)	10 (13.9)	18 (15.5)	16 (18.8)	0.685
Renal disease, n (%)	21 (7.7)	1 (1.4)	8 (6.9)	12 (14.1)	0.011
Respiratory system disease, n (%)	50 (18.3)	10 (13.9)	22 (19)	18 (21.1)	0.487

[a] BMI: Body Mass Index (n = 248).
[b] Vitamin D: n = 266.
[c] Gastrointestinal symptoms: Diarrhoea, constipation, nausea, and abdominal pain or discomfort.
[d] CRP: C-reactive protein.
[e] Comorbidities: Diabetes, cardiovascular disease, respiratory system disease, and renal disease.
[f] Based on one-way analysis of variance (ANOVA) for continuous variables and chi-square test or Fisher's exact test for categorical variables. The differences between the three groups were considered statistically significant at $p < 0.05$.

Table 2
Association between indicators of nutritional status and duration of hospital stay (whether>7 days), ICU admissions (yes/no), mechanical ventilation (yes/no) and mortality (dead/alive).

	Unadjusted				Adjusted[a]			
	n, (%)	p value[b]	OR[c] [95% CI]	p value[d]	OR [95% CI]	p value[d]	LR (df)[e]	p value[f]
Duration of stay > 7 days								
Low risk of malnutrition	5 (3.6)	–	Ref.		Ref.			
Medium risk of malnutrition	59 (43.1)	–	13.87 [5.21; 36.91]	<0.001	10.72 [3.90; 29.46]	<0.001		
High risk of malnutrition	73 (53.3)	<0.001	81.52 [27.28; 243.60]	<0.001	61.58 [19.48; 194.62]	<0.001		
BMI[g] < 25 kg/m^2, n (%)	33 (24.1)	–	Ref.		Ref.			
BMI 25–29.9 kg/m^2, n (%)	48 (35)	–	0.76 [0.38; 1.52]	0.443	0.80 [0.38; 1.70]	0.564		
BMI ≥30 kg/m^2, n (%)	56 (40.9)	0.601	0.71 [0.37; 1.39]	0.320	0.80 [0.38; 1.68]	0.554		
Interaction between risk of malnutrition & BMI ≥30 kg/m^2	–	–	–	–	–		2.42 (2)	0.299
25(OH)vitD ≥50 nmol/L	111 (81)	–	Ref.		Ref.			
25(OH)vitD <50 nmol/L	23 (16.8)	0.323	0.74 [0.40; 1.35]	0.324	1.16 [0.59; 2.29]	0.665		
ICU admission								
Low risk of malnutrition	x[h]	–	x		x			
Medium risk of malnutrition	13 (31.7)	–	Ref.		Ref.			
High risk of malnutrition	28 (68.3)	<0.001	3.89 [1.87; 8.10]	<0.001	10.80 [4.08; 28.60]	<0.001		
BMI <25 kg/m^2, n (%)	2 (4.9)	–	Ref.		Ref.			
BMI 25–29.9 kg/m^2, n (%)	12 (29.3)	–	4.11 [0.88; 19.10]	0.072	3.81 [0.81; 17.97]	0.091		
BMI ≥30 kg/m^2, n (%)	27 (65.9)	<0.001	8.89 [2.03; 38.95]	0.004	7.12 [1.59; 31.94]	0.010		
Interaction between risk of malnutrition & BMI ≥30 kg/m^2	–	–	–	–	–		0,01 (1)	0.919
25(OH)vitD ≥50 nmol/L	29 (70.7)	–	Ref.		Ref.			
25(OH)vitD <50 nmol/L	11 (26.8)	0.169	1.71 [0.79; 3.70]	0.173	1.39 [0.61; 3.16]	0.428		
Mechanical ventilation								
Low risk of malnutrition	x	–	x		x			
Medium risk of malnutrition	7 (25.9)	–	Ref.		Ref.			
High risk of malnutrition	20 (74.1)	<0.001	4.79 [1.92; 11.95]	<0.001	15.45 [4.85; 49.18]	<0.001		
BMI <25 kg/m^2, n (%)	1 (3.7)	–	Ref.		Ref.			
BMI 25–29.9 kg/m^2, n (%)	7 (25.9)	–	4.58 [0.54; 38.29]	0.160	3.92 [0.46; 33.38]	0.212		
BMI ≥30 kg/m^2, n (%)	19 (70.4)	0.005	11.57 [1.51; 88.97]	0.019	8.86 [1.12; 69.87]	0.038		
Interaction between risk of malnutrition & BMI ≥30 kg/m^2	–	–	–	–	–		0.34 (1)	0.561
25(OH)vitD ≥50 nmol/L	19 (70.4)	–	Ref.		Ref.			
25(OH)vitD <50 nmol/L	7 (25.9)	0.318	1.60 [0.63; 4.03]	0.322	1.09 [0.41; 2.87]	0.865		
Mortality								
Low risk of malnutrition	1 (3.3)	–	Ref.		Ref.			
Medium risk of malnutrition	9 (30)	–	5.97 [0.74; 48.12]	0.093	3.06 [0.36; 25.97]	0.305		
High risk of malnutrition	20 (66.7)	<0.001	21.85 [2.85; 167.21]	0.003	8.87 [1.08; 72.96]	0.042		
BMI <25 kg/m^2, n (%)	9 (30)	–	Ref.		Ref.			
BMI 25–29.9 kg/m^2, n (%)	8 (26.7)	–	0.50 [0.18; 1.39]	0.183	0.51 [0.18; 1.49]	0.218		
BMI ≥30 kg/m^2, n (%)	13 (43.3)	0.404	0.70 [0.28; 1.76]	0.446	0.87 [0.32; 2.34]	0.781		
Interaction between risk of malnutrition & BMI ≥30 kg/m^2	–	–	–	–	–		1.16 (1)	0.280
25(OH)vitD ≥50 nmol/L	23 (76.7)	–	Ref.		Ref.			
25(OH)vitD <50 nmol/L	6 (20)	0.870	1.08 [0.42; 2.81]	0.870	2.19 [0.75; 6.41]	0.152		

[a] Adjusted for age, sex and comorbidities (diabetes, cardiovascular disease, respiratory system disease, and renal disease).
[b] Based on chi-square test, or Fisher's exact test if the expected cell count was less than 5.
[c] Odds ratio.
[d] A univariate and multivariate logistic regression model was used to assess the association of *a-priori* selected nutritional risk factors and COVID-19 disease severity.
[e] Likelihood ratio (degrees of freedom).
[f] Interaction between risk of malnutrition and obesity was assessed using likelihood ratio.
[g] Body mass index.
[h] x: No patients at a low risk of malnutrition.

3.5. Gender differences in risk of malnutrition, BMI, D-vitamin, and outcomes

The Association between indicators of nutritional status and duration of hospital stay, ICU admissions, mechanical ventilation, and mortality were also analysed separately by gender (see supplementary Table S1). Results were in general comparable between genders. However, the increased risk of mortality seen in those defined at risk for malnutrition seems to be driven by women rather than men.

4. Discussion

In this study, there was a high prevalence of high risk of malnutrition and BMI ≥30 kg/m^2 among adult hospitalised patients with COVID-19. Furthermore, the results also indicated that high risk of malnutrition was associated with a longer hospital stay, ICU admission, mechanical ventilation, and mortality.

4.1. Risk of malnutrition

A validated screening tool was used to screen the patients for risk of malnutrition. According to the screening, 74% were at a medium to high risk of malnutrition. Previous studies of COVID-19 patients have reported the prevalence of risk of malnutrition as 79–83% [35,36]. In the current study, all the patients who were admitted to the ICU or required mechanical ventilation, were at medium to high risk of malnutrition, with prevalence significantly increased among those at high risk. Moreover, medium to high risk of malnutrition was significantly associated with increased the risk

of a hospital stay of longer than 7 days and high risk of malnutrition was associated with increased risk of mortality. These results are in accordance with results from previous studies in which malnutrition was associated with increased risk of developing severe COVID-19 disease and with prolonged hospital stay [9,37–40], most likely due to impaired immune responses, increased pro-inflammatory responses and increased risk of sarcopenia formation [41–45]. The theory of increased pro-inflammatory production aligns with the results of this study as CRP levels increased significantly with increased risk of malnutrition. However, as there were no measurements of immune cells or muscle mass in the current study, it is not known if there were differences in immune responses or sarcopenia formation between the patient groups. Additionally, it is important to consider that the COVID-19 infection itself might increase the risk of malnutrition as, for instance, gastrointestinal symptoms and inflammatory responses may decrease food intake, cause malabsorption, and increase catabolism [46–50]. Therefore, it is not surprising that both the inflammatory marker CRP and gastrointestinal symptoms amongst the patients increased significantly with increased risk of malnutrition.

4.2. BMI

In this study, the prevalence of BMI ≥30 kg/m^2 was similar to that reported in other COVID-19 studies (42.7%) [19,51]. In addition, similar to the risk of malnutrition, the prevalence of BMI ≥30 kg/m^2 increased significantly among ICU patients (65.9%) and those who required mechanical ventilation (70.4%). This is also in accordance with previous studies which showed a higher proportion of BMI ≥30 kg/m^2 amongst critically ill COVID-19 patients [52–54]. In the current study, the high prevalence of BMI ≥30 kg/m^2 among the patients and the significantly increased prevalence of BMI ≥30 kg/m^2 in ICU patients compared to those who were not admitted to the ICU, indicates that a BMI ≥30 kg/m^2 might aggravate COVID-19 severity. The results of the study also show that a BMI ≥30 kg/m^2 significantly increased the risk of ICU admission and mechanical ventilation, which gives a further indication that BMI ≥30 kg/m^2 is associated with an increased risk of severe COVID-19 infection. Previous studies have shown similar results, where BMI ≥30 kg/m^2 was associated with an increased risk of severe COVID-19 development most likely related to impaired immune function, increased inflammatory responses, and decreased lung capacity [14,52,55,56]. In this study, BMI ≥30 kg/m^2 did not have a significant effect on duration of hospital stay. This was unexpected as other studies have reported that COVID-19 patients with BMI ≥30 kg/m^2 required a longer hospital stay compared to patients with a BMI <30 kg/m^2 [57,58]. In addition, BMI ≥30 kg/m^2 had no significant effects on mortality in this study. To date, there have been conflicting results regarding BMI and mortality amongst COVID-19 patients. Some studies have shown similar results to this study, where although BMI ≥30 kg/m^2 increased the risk of a severe COVID-19 disease it did not increase the risk of mortality [17,19,59], while other studies reported a significant association between BMI ≥30 kg/m^2 and increased risk of mortality [14,60].

4.3. Vitamin D status

Concentration of 25(OH)vitD was high in the present study, with a mean concentration of 81 nmol/L, and the prevalence of insufficient vitamin D status (25(OH)vitD <50 nmoL/l) among the patients in this study was <20%. Similar results were recently reported in a group of patients who underwent elective arthroplasty in Iceland, with a mean concentration of 80 nmol/L [61]. Vitamin D production is heavily influenced by seasons, latitude, the use of sunscreen, supplementation, and skin pigmentation, and have vitamin D levels been shown to vary greatly between studies [62,63]. The level of vitamin D supplementation is in general very high in Iceland, especially in the oldest age groups. In the latest National dietary survey the median vitamin D intake was found to be 16–18 μg/day (640–720 IU) in the age groups above 40 years of age, and 25% had intakes above 30 μg/day (1200 mcg/day) [64]. It is likely that many of the patients in this study used vitamin D supplementation in some form. In contrasts with other studies we did not see an association between vitamin D status and COVID-19 development [18,65,66].

4.4. The double burden of malnutrition

All patients that required ICU admission or mechanical ventilation in our study were at a medium to high risk of malnutrition and more than half also had a BMI ≥30 kg/m^2. This is important to note as the coexistence of malnutrition and a high BMI, defined as the double burden of malnutrition, can pose a dual nutritional challenge that may promote infections and increase disease severity [67–69]. Therefore, the results may indicate that the combination of high BMI and a medium to high risk of malnutrition, rather than risk of malnutrition or BMI alone, is associated with severe COVID-19 development. However, in this study, interaction between risk of malnutrition and BMI was not significant to explain hospital stay, ICU admission, mechanical ventilation, or mortality. This needs to be investigated in greater detail to better assess the relationship between the double burden of malnutrition and COVID-19.

4.5. Strengths and limitations

The main strength of this study is that it included all hospitalised patients at Landspitali Hospital, from February 2020 to March 2021, which reduces selection bias. In addition, all patients included in the study had a COVID-19 infection confirmed by PCR test. The study has, however, a few limitations. Firstly, it is a retrospective study, and thus, some important information was missing. For instance, weight measurements were missing for 25 patients and vitamin D values were missing for 11 patients. Secondly, we could not diagnose patients as malnourished according to the Global Leadership Initiative on Malnutrition criteria [70], as data on loss of muscle mass and function were unavailable. Thirdly, as the findings of this study are location-specific, the results are limited in terms of generalisability to different geographical locations.

5. Conclusion

The aim of this study is to describe the risk of malnutrition, BMI and vitamin D status of hospitalised COVID-19 patients in Iceland and assess whether they are associated with duration of hospital stay, ICU admission, mechanical ventilation and mortality. The results of the study showed a high prevalence of medium to high risk of malnutrition and BMI ≥30 kg/m^2 among hospital patients with COVID-19 in Iceland. High risk of malnutrition in hospitalised COVID-19 patients was associated with longer duration of hospital stay, ICU admissions, mechanical ventilation and mortality, and BMI ≥30 kg/m^2 was associated with ICU admission and mechanical ventilation. These results are in accordance with several other studies of COVID-19 patients and as COVID-19 infections are ongoing, emphasise the importance of assessment of nutritional status in hospitalised COVID-19 patients. Further research is warranted to assess the impact of nutritional care on the prognosis of COVID-19 patients.

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Author contribution

Sandra Dögg Guðnadóttir: Formal analysis, Investigation, Writing- Original Draft, Visualization, Funding acquisition. Áróra Rós Ingadóttir: Conceptualization, Methodology, Writing – Review and Editing, Visualization, Supervision, Funding acquisition. Ingibjörg Gunnarsdóttir: Writing – Review and Editing, Visualization, Supervision, Funding acquisition. Ubaldo Benitez Hernandez: Statistical consulting.

Declaration of competing interest

The authors have no conflict of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2024.02.023.

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