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Covid-19

Body mass index and Mini Nutritional Assessment-Short Form as predictors of in-geriatric hospital mortality in older adults with COVID-19

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SUMMARY

Background & aims: Overweight and obesity have been consistently reported to carry an increased risk for poorer outcomes in coronavirus disease 2019 (COVID-19) in adults. Existing reports mainly focus on in-hospital and intensive care unit mortality in patient cohorts usually not representative of the population with the highest mortality, i.e. the very old and frail patients. Accordingly, little is known about the risk patterns related to body mass and nutrition in very old patients. Our aim was to assess the relationship between body mass index (BMI), nutritional status and in-geriatric hospital mortality among geriatric patients treated for COVID-19. As a reference, the analyses were performed also in patients treated for other diagnoses than COVID-19.

Methods: We analyzed up to 10,031 geriatric patients with a median age of 83 years of which 1409 (14%) were hospitalized for COVID-19 and 8622 (86%) for other diagnoses in seven geriatric hospitals in the Stockholm region, Sweden during March 2020–January 2021. Data were available in electronic hospital records. The associations between 1) BMI and 2) nutritional status, assessed using the Mini-Nutritional Assessment - Short Form (MNA-SF) scale, and short-term in-geriatric hospital mortality were analyzed using logistic regression.

Results: After adjusting for age, sex, comorbidity, polypharmacy, frailty and the wave of the pandemic (first vs. second), underweight defined as BMI<18.5 increased the risk of in-hospital mortality in COVID-19 patients (odds ratio [OR] = 2.30; confidence interval [CI] = 1.17–4.31). Overweight and obesity were not associated with in-hospital mortality. Malnutrition; i.e. MNA-SF 0–7 points, increased the risk of in-hospital mortality in patients treated for COVID-19 (OR = 2.03; CI = 1.16–3.68) and other causes (OR = 6.01; CI = 2.73–15.91).

Conclusions: Our results indicate that obesity is not a risk factor for very old patients with COVID-19, but emphasize the role of underweight and malnutrition for in-hospital mortality in geriatric patients with COVID-19.

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1. Introduction

Globally, in April 2021, 141 million individuals have been confirmed positive of Corona virus disease-2019 (COVID-19) [1], and of these, 3 million have died [2]. Age is the most significant risk factor for severe COVID-19 infection. For example, in Sweden, through March 2021, 91% of the ~13,000 COVID-19-related deaths have occurred in individuals aged >70 years [3]. Other risk factors for adverse COVID-19 outcomes include male sex, lower socioeconomic position, obesity, hypertension, chronic kidney disease, and diabetes [4–15], In addition, a recent meta-analysis based on 76 studies suggests that in addition to age and sex, severe obesity and active cancer are the most decisive risk factors for severe outcomes of COVID-19 [6]. However, there is evidence to suggest that the risk factors for COVID-19 outcomes are not uniform with age [9,13,14], although information on age-group specific risk patterns is currently lacking. A patient group underrepresented in the literature is especially the very old i.e. aged>80 years hospitalized adults as it is likely that the care home residents have been treated at their residence rather than at hospital. Statistics from 21 countries show that 41% of all deaths have been reported in care home residents (in February 2021) [16].

During the first COVID-19 wave in the spring 2020 in Sweden, we reported that in-hospital mortality was 24% among older hospitalized geriatric patients [7]. The risk for death was almost double for patients classified as frail according to the Clinical Frailty Scale (CFS) as compared to robust older patients. In these patients, acute kidney injury was also a strong risk factor for in-hospital mortality [17]. In addition, we [7,10] and others [11] have reported that multimorbidity is associated with COVID-19 mortality in older adults.

While obesity is considered as risk factor for worse COVID-19 outcomes in community samples, the role of body composition in COVID-19 pathology has not been well characterized in hospitalized older adults (>65 years). Current knowledge indicates that overweight/obesity is a risk factor for adverse outcomes in midlife [18], but often related to reduced mortality in advanced age [19]. Due to this obesity or body mass index (BMI) paradox, it is conceivable that risk factors other than obesity may play a pivotal role for serious outcomes among older hospitalized adults. For example, underweight and malnutrition are related to a decline of immune functions [20–22]. Reduction in the capacity to mount leukocyte responses, leukocyte chemotaxis, B-lymphocyte antibody production, cytokine production is only the few of the immune aberrations taking place with aging and malnutrition [23]. Aging *per se* is also associated with compromised immune functions and increased susceptibility to various infections, aggravating the infection trajectories in older adults [24]. Furthermore, malnutrition is linked to muscle wasting, including respiratory and cardiac muscles, further jeopardizing crucial organ functions [25–29]. Thus, underweight and malnutrition are potential mortality risk factors in older patients with COVID-19, but this hypothesis is lacking empirical evidence.

The objective of this study is to assess whether 1) deviations from normal BMI and 2) nutritional status characterized by Mini-Nutritional Assessment-Short Form (MNA-SF) associate with the risk of COVID-19 mortality in hospitalized geriatric patients. For a reference, we also perform an analogous analysis in geriatric patients hospitalized for other causes than COVID-19 at the same geriatric hospitals during the same time period.

2. Material & methods

2.1. Study samples

The data were sourced from electronic medical records for 14,014 patients older than 65 years who were admitted to one of the seven geriatric hospitals in the Stockholm region, Sweden between March 2, 2020 and January 5, 2021. Patients without date of death or discharge were excluded from the analysis. In patients hospitalized for COVID-19, 2741 (20%) were diagnosed for COVID-19 based on ICD-10-codes U07.1 or U07.2, and 11,273 patients were hospitalized for other causes. 94% of the COVID-19 patients were admitted to hospital once, 5.8% twice and 0.2% three times. Three out of four of the non-COVID patients were admitted to hospital once, 16% two times and 8% from three to 13 times. Study samples in the main analysis comprised electronic records only from the first hospital admission. A sensitivity analysis was performed using data only from the last admission to a hospital (see Statistical analysis). The median (interquartile range) duration of a hospital visit was 9 (8) days in COVID-19 patients, and 7 (5) days in non-COVID patients.

Of the 14,014 patients, BMI was available for 1409 COVID-19 patients and 8622 non-COVID patients. MNA-SF score was available for 1297 COVID-19 patients and 6942 non-COVID patients (Supporting information Table S1). A flowchart showing the selection of the samples for the analysis is shown in Supporting information Figure S1. Proportion of patients with both BMI and MNA-SF information available was 34% (n = 934) for the 2741 COVID-19, and 52% (n = 5823) for the 11,273 non-COVID-19 patients (Supporting information, Figure S2). Because the number of patients with both BMI and MNA-SF information available was limited, the analyses were performed in four separate samples: COVID-19 patients and non-COVID-19 patients with BMI available and COVID-19 patients and non-COVID-19 patients with MNA-SF available.

2.2. Assessment of COVID-19 diagnosis

Clinical COVID-19 diagnosis was determined as described previously [7]. Briefly, diagnosis was determined in extracts from nasopharyngeal swabs using reverse transcriptase polymerase chain reaction (RT-PCR). If the patient had a negative RT-PCR but typical symptoms and findings on a computed tomography scan with no other explanation for the symptoms, a clinical COVID-19 diagnosis was made in collaboration with infection disease specialists.

2.3. Body mass index and Mini Nutritional Assessment-Short Form

BMI was calculated as weight (kg)/height $(m)^2$. Weight and height and the MNA-SF were assessed by nurses and assistant nurses after admission to the hospital. Outlier values of BMI (<10, n = 22 and > 70, n = 154) were excluded from the analysis. The MNA-SF score was the sum of the scores across six items in the MNA-SF [30,31]. These items indicate decrease in the food intake, weight loss, psychological stress or acute disease during the past three months, and current mobility, and current BMI.

2.4. Other study variables

All information on the study variables was retrieved from the medical records, including age, sex and date of death or discharge. Number of diseases was defined as the sum of individual ICD-codes. Charlson comorbidity index (CCI) [32] was calculated using ICD-codes with ICD-9 scoring system. Hospital frailty risk score (HFRS) [33] was used as an indicator of frailty and it was calculated using ICD-codes that are over-represented in the more frail individuals. Polypharmacy was defined as the sum of individual ATC-codes after one day of admission. The pandemic waves (1st vs. 2nd) were considered in the analysis so that the 1st wave was defined as

the period from March 2, 2020 until August 31, 2020, and the second wave starting from September 1 2020.

2.5. Statistical analysis

The associations between BMI, MNA-SF and the outcome, in-hospital-mortality were assessed using logistic regressions, fitting separate models for BMI and MNA-SF. The multivariate models adjusting for age, sex, number of diseases, CCI, HFRS, number of drugs, and the pandemic wave in a multivariate model were termed as the fully adjusted models. Age, number of diseases, CCI, HFRS, and number of drugs were used as continuous variables. For sex, women was used as the reference, and for the pandemic wave, the 1st wave was set as the reference category.

In the main analysis (Analysis strategy in Supporting information, Figure S1), BMI and the MNA-SF score were analyzed as categorized variables. BMI was categorized as follows according to World Health Organization standards: 'Underweight' = BMI < 18.5, 'Normal weight' = 18.5 ≤ BMI<25, 'Overweight' 25 ≤BMI<30 and 'Obesity' = BMI ≥ 30. MNA-SF was categorized according the guidelines of the assessment as follows: 'Malnutrition' = MNA-SF score 0–7 points, 'At risk of malnutrition' = MNA-SF score 8–11 points, 'Normal nutrition' = 12–14 points. For both variables, the category 'Normal' was set as the reference category.

We performed several sensitivity analyses. The first sensitivity analysis was performed on the COVID-19 patients stratifying the fully adjusted models by the pandemic wave. The second sensitivity analysis was performed using the last hospital admission for all patients. MNA-SF and BMI score were additionally analyzed as continuous variables in the fully adjusted models. To assess how the risk of death varies at different levels of nutritional status, MNA-SF was analyzed as a continuous variable in the model and the relationship was visualized as a scatterplot and loess-fitted splines. BMI was also analyzed using age-specific BMI categories [34]: 'Underweight' = BMI < 22 if age≥70 years and BMI<20 if age <70 years, 'Normal weight' = 22≤BMI<30 if age≥70 years and 20≤BMI < 25 if age<70 years, 'Overweight' = 30≤BMI<35 if age≥70 years, and 25≤BMI<30 if age<70 years, 'Obese' = BMI≥35 if age≥70 years, BMI≥30 if age<70 years.

Analyses and visualizations were performed using R software version 4.0.3. Results from the logistic models were visualized using R-package forestmodel and loess-fitted splines were produced using DescTools.

3. Results

3.1. BMI and mortality in geriatric hospitals

Sample characteristics of the patients with BMI available (1409 COVID-19 and 8622 non-COVID-19 patients) are shown in Table 1. Mortality rates in these samples were 7.9% and 0.8%, and the age range was 65–104 and 65–105 years, respectively. Eighty percent of patients in the samples were at least 75 years old. Median length of hospital stay was 9 and 7 days in COVID-19 and non-COVID-19 patients, respectively.

Results from the fully adjusted model for the BMI categories are shown in Fig. 1. Underweight (BMI<18.5) was associated with a higher mortality in COVID-19 patients (OR = 2.30; CI = 1.17–4.31). The cut-offs for underweight at BMI <20 or <22 for patients <70 and ≥70 years of age, respectively, did not discriminate the mortality risk (results from the logistic regression shown in Supporting information, Figure S3) as the associations were non-significant. BMI as a continuous (linear) variable was likewise not associated with mortality in patients hospitalized for COVID-19 (OR = 0.97; CI = 0.93–1.02) or other causes (OR = 0.95; CI = 0.89–1.00) in the fully adjusted models.

In the sensitivity analysis stratified by the pandemic wave (Supporting information, Figure S4), in the fully adjusted model, in patients hospitalized for COVID-19, underweight was associated with higher mortality in the 2nd pandemic wave data (OR = 3.19; CI = 1.13–8.42), but not in the 1st wave (OR = 1.83; CI = 0.72–4.27). In the sensitivity analysis using the records from the last hospital admission (in Supporting information; sample characteristics presented in Table S2 and results from the logistic regression in Figure S5), the association of underweight with mortality was statistically significant (OR = 2.26; CI = 1.15–4.26) in COVID-19 patients, but not in the non-COVID-19 patients.

3.2. MNA-SF and and mortality in geriatric hospitals

Sample characteristics of the patients in the MNA-SF analysis (1297 COVID-19 and 6942 non-COVID-19 patients) are shown in Table 2. Mortality rates were in these samples, 11.2% and 1.2%, respectively, and the age range was 65–104 and 65–105 years, respectively. Eighty percent of patients in the samples were at least 75 years old. Median length of hospital stay was 9 and 7 days in COVID-19 and non-COVID-19 patients, respectively.

Results from the fully adjusted mortality risk model in the MNA-SF analysis are shown in Fig. 2. Malnutrition, i.e. MNA-SF 0–7 points, was associated with higher mortality in COVID-19 patients (OR = 2.03; CI = 1.16–3.68), and in patients hospitalized for other causes (OR = 6.01; CI = 2.73–15.91). MNA-SF score as a continuous variable was significantly associated with mortality in COVID-19 (OR = 0.85; CI = 0.79–0.92), and non-COVID-19 patients (OR = 0.76; CI = 0.70–0.82) in the fully adjusted models. The relationship between continuous MNA-SF score and mortality risk is presented in Fig. 3.

When compared to normal nutritional status, the OR of malnutrition with the risk of mortality in the 1st pandemic wave 1 was 1.93 (CI = 0.97–4.04) and in the 2nd wave it was 2.43 (CI = 0.94–7.19) (Supporting information, Figure S6). In the sensitivity analysis where the hospital records from the last admission were used instead of the 1st admission (Supporting information; sample characteristics in Table S3 and results from the logistic regression in Figure S7), the OR of malnutrition in patients hospitalized for COVID-19 was 1.88 (CI = 1.08–3.37) and in patients hospitalized for other causes the OR was 5.34 (CI = 2.64–12.33).

4. Discussion

In this study, we assessed the associations of 1) BMI and 2) nutritional status according to the MNA-SF with in-hospital mortality in geriatric patients with a median age of 83 years in seven geriatric hospitals in the region of Stockholm, Sweden. The electronic hospital records were obtained between March 2020 and January 2021. In COVID-19 patients, very low BMI, but not obesity or overweight, was associated with an increased risk of in-geriatric hospital mortality after adjusting for other risk factors; i.e. age, sex, multimorbidity, frailty, and polypharmacy. The associations were similar when using either the 1st or last hospital admission data. In contrast, in patients hospitalized for other causes than COVID-19, BMI was not associated with in-hospital mortality in any of the analyses. MNA-SF scores indicating malnutrition were strongly associated with a higher risk of in-hospital mortality in both COVID-19 patients and patients hospitalized for other causes after adjusting for age, sex, multimorbidity, frailty, polypharmacy, and when using either the 1st or last hospital admission data.

Table 1
Sample characteristics of geriatric patients hospitalized for COVID-19 (A) and other causes (B) in the BMI analysis.

	Sample in BMI analysis					
	A. COVID-19			B. Non-COVID-19		
	All	Died	Survived	All	Died	Survived
n (%)	1409 (100)	112 (8)	1297 (92)	8622 (100)	67 (0.8)	8555 (99.2)
Age, median (IQR)	83 (12)	88 (10.3)	83 (12)	84 (12)	91 (9)	84 (12)
Men, n (%)	644 (45.7)	64 (57.1)	580 (44.7)	3375 (39.1)	34 (50.8)	3341 (39.1)
BMI, median (IQR)	24.2 (6.2)	23.3 (6.0)	24.2 (6.3)	23.7 (6.2)	22.7 (4.9)	23.7 (6.24)
BMI, categorised						
<18.5, n (%)	112 (8.0)	16 (14.3)	96 (7.4)	847 (9.8)	6 (9.0)	841 (9.8)
18.5–25, n (%)	709 (50.3)	56 (50)	653 (50.4)	4408 (51.1)	43 (64.2)	4365 (51.0)
25–30, n (%)	394 (28.0)	29 (25.9)	365 (28.1)	2228 (25.8)	12 (17.9)	2216 (25.9)
>30, n (%)	194 (13.8)	11 (9.8)	183 (14.1)	1139 (13.2)	6 (9.0)	1133 (13.2)
Number of diseases, median (IQR, Min, Max)	6 (2,1,24)	6.5 (3,2,17)	6 (2,1,24)	5 (2,1,17)	7 (2.5,1,12)	5 (2,1,17)
CCI, median (IQR, Min, Max)	1 (2,0,9)	2 (2,0,7)	1 (2,0,9)	1 (2,0,9)	2 (2,0,8)	1 (2,0,9)
HFRS, median (IQR, Min, Max)	1 (1,0,8)	2 (2,0,8)	1 (1,0,8)	2 (2,0,12)	2 (2,0,7)	2 (2,0,12)
Number of drugs, median (IQR, Min, Max)	10 (7,1,29)	11 (7,2,29)	10 (6,1,29)	9 (6,1,40)	12 (7.5,1,27)	9 (6,1,40)
1st wave: prior to September 1st 2020, n (% within the 1st wave)	846 (100)	69 (8.2)	777 (91.8)	5484 (100)	50 (0.9)	5434 (99.1)
2nd wave: after September 1st 2020, n (% within the 2nd wave)	563 (100)	43 (7.6)	520 (92.4)	3138 (100)	17 (0.5)	3121 (99.5)

Abbreviations: BMI = body mass index (m/kg^2), CCI = Charlson comorbidity index, HFRS = Hospital Frailty Risk Score, IQR = interquartile range.

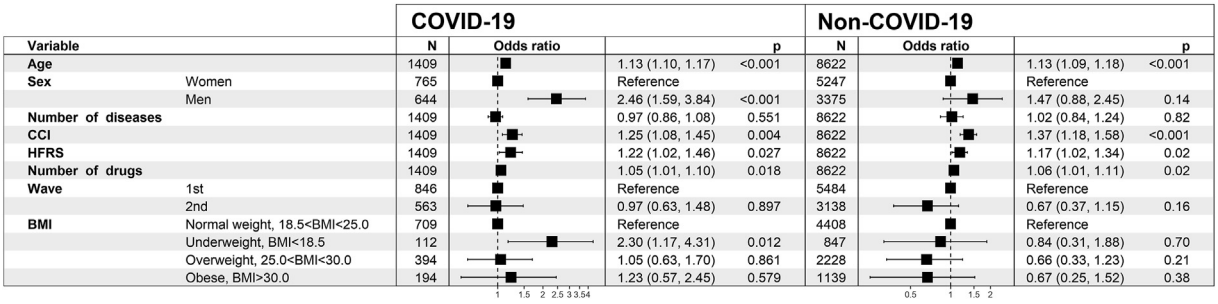

Fig. 1. The fully adjusted mortality risk model for the BMI analysis in geriatric patients hospitalized for COVID-19 (n = 1409, 112 died) and other causes (n = 8622, 67 died). Abbreviations: BMI = body mass index, CCI = Charlson comorbidity index, HFRS = Hospital Frailty Risk Score.

Table 2
Descriptive statistics of geriatric patients hospitalized for COVID-19 (A) and for other causes (B) in the MNA-SF analysis.

	Sample in MNA-SF analysis					
	A. COVID-19			B. Non-COVID-19		
	All	Died	Survived	All	Died	Survived
n (%)	1297 (100)	145 (11.2)	1152 (88.8)	6942 (100)	85 (1.2)	6857 (98.8)
Age, median (IQR)	83 (12)	88 (11)	83 (12)	84 (12)	90 (10)	84 (11)
Men, n (%)	592 (45.6)	79 (54.5)	513 (44.5)	2746 (39.6)	41 (48.2)	2705 (39.5)
MNA-SF score, median (IQR)	9 (4)	8 (4)	9 (4)	9 (3)	7 (4)	9 (3)
MNA-SF score, categorised						
Normal: 12–14, n (%)	227 (17.5)	19 (13.1)	208 (18.1)	1612 (23.2)	6 (7.06)	1606 (23.4)
At risk: 8–11, n (%)	690 (53.2)	59 (40.7)	631 (54.8)	3634 (52.4)	29 (34.1)	3605 (52.6)
Malnourished: 0–7, n (%)	380 (29.3)	67 (46.2)	313 (27.2)	1696 (24.4)	50 (58.8)	1646 (24.0)
Number of diseases, median (IQR, Min, Max)	6 (3,1,24)	7 (2,3,14)	6 (2,1,24)	5 (2,1,17)	6 (2,1,14)	5 (2,1,17)
CCI, median (IQR, Min, Max)	1 (2,0,9)	2 (2,0,7)	1 (2,0,9)	1 (2,0,9)	2 (2,0,8)	1 (2,0,9)
HFRS, median (IQR, Min, Max)	1 (1,0,8)	2 (1,0,8)	1 (1,0,8)	2 (1,0,12)	2 (2,0,6)	2 (1,0,12)
Number of drugs, median (IQR, Min, Max)	10 (7,1,33)	11 (7,1,33)	10 (7,1,29)	9 (6,1,40)	11 (7,1,24)	9 (6,1,40)
1st wave: prior to September 1st 2020, n (% within the 1st wave)	818 (100)	104 (12.7)	714 (87.3)	4501 (100)	61 (1.4)	4440 (98.6)
2nd wave: after September 1st 2020, n (% within the 2nd wave)	479 (100)	41 (8.6)	438 (91.4)	2441 (100)	24 (1.0)	2417 (99.0)

Abbreviations: CCI = Charlson comorbidity index, HFRS = Hospital Frailty Risk Score, IQR = interquartile range, MNA-SF = Mini Nutritional Assessment Short Form.

4.1. Body mass index and mortality

Considerable overweight is a risk factor for poor health outcomes [18] including COVID-19 disease [6]. In older adults, the association between body composition and adverse health events is complex [35]. After the age 65, obesity is less common than in midlife [36], possibly due to high mortality rates in late midlife (i.e., selection) because of cardio-metabolic risk and subsequent risk of death among obese and overweight individuals. Furthermore, obese and overweight older survivors may display metabolically healthier fat tissue [37], and obesity or overweight in older people may rather be related to a reduced risk than being a risk factor in itself. Accordingly, low body weight becomes a risk factor for mortality at older age [38]. We have also reported that underweight is a significant risk factor for frailty, whereas overweight might confer some protection against the progression of frailty in very old

		COVID-19			Non-COVID-19		
Variable		N	Odds ratio	p	N	Odds ratio	p
Age		1297	1.10 (1.07, 1.12)	<0.001	6942	1.12 (1.09, 1.16)	<0.001
Sex	Women	705	Reference		4196	Reference	
	Men	592	1.84 (1.26, 2.69)	0.002	2746	1.49 (0.94, 2.34)	0.09
Number of diseases		1297	1.02 (0.92, 1.12)	0.751	6942	1.10 (0.97, 1.25)	0.11
CCI		1297	1.19 (1.04, 1.37)	0.009	6942	1.34 (1.16, 1.53)	<0.001
HFRS		1297	1.04 (0.88, 1.22)	0.642	6942	1.05 (0.88, 1.25)	0.56
Number of drugs		1297	1.05 (1.01, 1.09)	0.024	6942	1.04 (0.99, 1.09)	0.15
Wave	1st	818	Reference		4501	Reference	
	2nd	479	0.72 (0.48, 1.08)	0.116	2441	0.83 (0.50, 1.32)	0.44
MNA-SF	Normal nutritional status, 12-14	227	Reference		1612	Reference	
	At risk of malnutrition, 8-11	690	0.94 (0.55, 1.69)	0.837	3634	1.80 (0.79, 4.84)	0.19
	Malnourished, 0-7	380	2.03 (1.16, 3.68)	0.016	1696	6.01 (2.73, 15.91)	<0.001

Fig. 2. The fully adjusted mortality risk model in the MNA-SF analysis in geriatric patients hospitalized for COVID-19 (n = 1297, 145 died) and patients hospitalized for other causes (n = 6942, 85 died). Abbreviations: CCI = Charlson comorbidity index, HFRS = Hospital Frailty Risk Score, MNA-SF = Mini Nutritional Assessment Short Form.

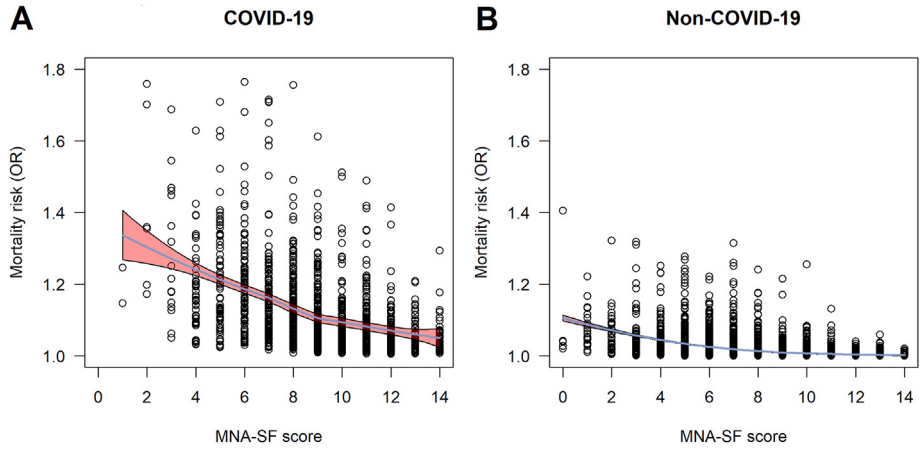

Fig. 3. The risk of all-cause in-hospital mortality and the MNA-SF scores. The odds ratios (ORs) for the risk of death in the fully adjusted mortality model are shown in the y-axis and MNA-SF score in x-axis in patients hospitalized for COVID-19 (A) and for other diagnoses (B). The blue line represents a loess fitted and the red-shaded area represents 95% confidence intervals. Abbreviations: MNA-SF = Mini Nutritional Assessment Short Form, OR = odds ratio. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

ages [39]. Our current findings and previous findings by others [40] on the association between very low body weight and in-hospital mortality in COVID-19 patients is thus expected. Nevertheless, these findings are important as reports on body weight and the risk for serious outcomes in very old patients with COVID-19 are scarce. The results indicate that, perhaps contrary to a general perception, obesity is not a risk factor for serious outcomes in COVID-19 across the whole life span. Noticeably, we found no association between underweight and in-hospital mortality in patients hospitalized for other causes, or association between age group specific BMI categories in either of the patient groups. Potential reasons for the inconsistency with the findings by others [41] are that we lacked statistical power due to low number of deaths across the short observation period in our data. Moreover, a potential selection bias cannot be overruled due to missing BMI data.

4.2. Mini Nutritional Assessment Short Form and mortality

We show that malnutrition is strongly associated with an increased risk of in-hospital mortality in COVID-19 patients, independent of other risk factors. To the best of our knowledge, only few previous studies have analyzed malnutrition in relation to COVID-19 disease pathology and outcomes using smaller groups of older individuals (n < 300) in the first wave of the pandemic. In addition to MNA-SF, also other assessments, including Nutrition Risk Screening 2002 and Nutritional Risk Index (NRI) are used as parallel tools to identify COVID-19 patients at nutritional risk [42]. In studies performed in Spain and China, malnutrition indicated by the MNA [43] and by Nutritional risk in critically ill score [40], was associated with higher in-hospital-mortality. In studies performed in China, more than 50% of the patients were categorized as malnourished by MNA [44], and by other measures [40], and in France, assessment by the NRI indicated that 40% of the patients with COVID-19 were malnourished [45]. In addition, the hospitalization period appears to be longer in malnourished COVID-19 patients [42,46]. The observations by us and others thus underline that malnutrition, a common problem in very old age, is a risk factor for severe outcomes in old COVID-19 patients in different societies.

4.3. Potential mechanisms for the excess COVID-19 mortality related to undernutrition

The major finding of this study is that indicators of undernutrition; i.e., underweight and low MNA-SF scores, are strongly related to short-term mortality. The observation periods were on average less than 10 days. It could be speculated that in-hospital mortality would be more strongly related to the severity of the infection, rather than to other mechanisms. However, as already indicated, undernutrition is linked to impairments of the immune system [23]. In addition, muscle wasting deranges respiratory muscle function [26–29]. As the MNA-SF partially indexes frailty through weight loss and physical functioning (mobility), it is possible that a certain degree of the risk conferred by worse MNA-SF is explained by frailty. This hypothesis is supported by the finding that the effect of the HFRS attenuated in the MNA-SF model,

whereas in the BMI model the HFRS was significant. Thus, the combined effect of old age and undernutrition likely undermine the immune system capacity to protect from infections in general and specifically in COVID-19.

In our analysis, MNA-SF predicted mortality also in patients hospitalized for other causes. This is in line with previous studies [47], as for example MNA is associated with in-hospital mortality in geriatric patients [48], and in patients aged 27–56 years [49], and also with 10-years-mortality in community-living older women [50]. Particularly notable in this study is that MNA-SF was able to predict mortality in a setting where the mortality rate was very low and the observation period very short.

4.4. Strengths and limitations

The strengths of the study were a large collection of data over a long period of time during the pandemic and inclusion of several geriatric hospitals and a study population of very old hospitalized individuals that are underpresented in the current literature. This study has also limitations that need to be acknowledged. One is that information on many mortality risk factors e.g. smoking, and socioeconomic position was missing. In the electronic medical records, a substantially high proportion of patients had missing information on BMI and MNA-SF. The overlap between those who had data on both BMI and MNA-SF was moderate. Thus, to increase the statistical power, the analyses were performed separately for BMI and MNA. The proportion of missing data on BMI and MNA-SF was higher in COVID-19 patients and patients who died. This is probably an effect of e.g. difficulties to examine and communicate with patients with a more severe COVID-19 condition. The implication of this is unclear, but our results may indicate that the relationship between underweight/malnutrition and mortality might have been even stronger if data would have been more complete. We also acknowledge that our follow-up time was relatively short and analyses on long-term mortality after hospitalization are thus needed.

4.5. Conclusion

In geriatric patients hospitalized for COVID-19, the MNA-SF appears as a powerful tool to assess short-term prognosis. In COVID-19 patients, very low BMI is associated with higher in-geriatric hospital mortality. No evidence was found that high BMI would confer an increased risk of death due to COVID-19 in very old patients admitted and treated in geriatric settings.

Ethical statement

The study was approved by the Swedish Ethical Review Authority in Stockholm Dnr 2020-02146, 2020-03345 and 2021-00595.

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Author contribution

L.K. and J.J. and T.C. conceived and designed the analysis. L.K. processed and analysed the data. L.K. and J.J and T.C. wrote the manuscript. All authors gave analysis suggestions, participated in writing and reviewing of the manuscript.

Conflict of interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnu.2021.07.025.

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