Progress in Nutrition 2025; Vol. 27, N. 3: 17215 DOI: 10.23751/pn.v27i3.17215

Original article

Nutritional risk at hospital admission and its long-term impact on COVID-19 survivors in Ha'il region, Saudi Arabia

Albandari Bin Ammar[1], Nagat Eltoum[1], Abd Elmoneim Elkhalifa[1], Sayeda Fatima[1], Nagwan Elhussein[2], Leo Rathinaraj Antony Soundararajan[3], Majid Alkhalaf[4], Momen Elshazley[5], Rola Jalloun[6], Sara Seifeldin[7], Ghosoun Al-Faqiri[1], Ritaj Al Shammari[1]

[1]Department of Clinical Nutrition, College of Applied Medical Sciences, University of Ha'il, Hail, KSA; [2]Radiology department, College of Applied Medical Sciences, University of Ha'il, Hail, KSA; [3]Physiotherapy School of Health and Social Care Profession, Buckinghamshire New University, UK; [4]Public Health Improvement and Promotion Sector, Public Health Authority, Riyadh, KSA; [5]Pulmonology Unit, Department of Internal Medicine, King Salman Specialist Hospital, Hail Health Cluster, Hail, KSA; [6]Nutrition and Food Science Department, College of Family Sciences, Taibah University, Madinah, KSA; [7]Department of Clinical Laboratory Sciences, College of Applied Medical Sciences, University of Ha'il, Hail, KSA

Abstract. *Background and aim:* This study aims to investigate the relationship between nutritional risk at hospital admission and its effect on severe outcomes and length of hospital stay in hospitalized COVID-19 patients, both with and without comorbidities. *Methods:* This prospective cohort study included 103 COVID-19 patients hospitalized at King Salman Specialist Hospital in the Ha'il region of Saudi Arabia. Of 600 eligible patients contacted, 103 consented to participate, representing one of the first comprehensive investigations of nutritional risk in COVID-19 survivors in this region. Retrospective data were obtained from patient records at admission, covering sociodemographic details, clinical characteristics, symptoms, anthropometric measurements, nutrition-related laboratory results, and length of hospital stay. The Malnutrition Screening Tool was used to evaluate malnutrition risk at admission and follow-up, while body mass index was calculated using height and weight measurements taken at these time points. *Results:* Body mass index was not uniformly observed across all categories. Significant increase in Calcium (p-value 0.0001) was noted between admission and follow-up visits in COVID-19 patients. Ferritin levels were significantly decreased and associated with admission and follow-up only in patients without comorbidities (p-value 0.002). Although albumin levels differed significantly across all participants (p-value 0.0001), total protein levels did not show significant variation in comorbidities group. Additionally, moderate disease severity was strongly associated with longer hospital stays (p-value 0.0001). *Conclusion:* Several factors, including abnormal biomarkers and moderate case severity, were identified as potential influences on nutritional risk at hospital admission and its long-term effects on COVID-19 survivors.

Key words: COVID-19, malnutrition, comorbidities, intensive care unit, body mass index

Introduction

On March 11, 2020, the World Health Organization (WHO) declared Coronavirus Disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus (SARS-CoV-2) as a global pandemic (1) Coronavirus has had a significant impact on global demography with millions of COVID-19 cases

and associated deaths by spreading quickly throughout the world (2). COVID-19 is a contagious respiratory illness characterized by fever, exhaustion, coughing, and elevated breathing rates (3). In addition to the respiratory system, it can affect other organs, which impairs mental and nutritional health and lowers the patients' quality of life. Infectious disease outcomes may ultimately be influenced by the nutritional status of those affected (4). In COVID-19, the symptoms may vary from asymptomatic to mild with pneumonia and can extend to acute respiratory distress syndrome to multiple organ failure and, in later stages, can be fatal (5,6). Fever, sore throat, coughing, nasal cold, shortness of breath, pain during breathing, general malaise, fatigue, headache, muscle ache, stomachache, decreased appetite (anorexia), altered taste (ageusia), decreased smell (anosmia), nausea, vomiting, and diarrhoea are just a few of the symptoms and complications that patients with COVID-19 infections may experience (7,8) .The exact cause of this wide range of symptoms among COVID-19 patients is unknown, but old age, male gender, pre-existing comorbidities, and poor nutritional status are thought to increase the risk of developing a severe COVID-19 infection (9,10). Additionally, some sociodemographic traits such as educational attainment, along with nutrition-related traits such as appetite loss and overweight/obesity, have been linked in studies to negative health outcomes in COVID patients (11,12). In COVID-19 infection, acute pulmonary complications require hospitalization in most cases and in the case of severe symptoms, management in an intensive care unit (ICU) is often required (13). Globally, malnutrition, especially protein-energy deficiency, is the main contributor to immunodeficiency (14). Nutritional status is crucial in all stages of COVID-19, particularly in people who are prone to experiencing adverse effects such as the elderly or patients with comorbidities (15). The incidence of COVID-19 is high in people with poor nutrition or malnutrition (16). The in-patient population faces a significant threat from malnutrition. Research indicates that almost all hospitalized patients, including those with COVID-19, exhibit inadequate nutritional status upon admission (17,18). In a study conducted recently, it was found that 42% of the patients in the nursing ward and 67% of the patients in the ICU who were admitted to the hospital due to COVID-19 were malnourished (19). During an infection, maintaining a proper nutritional status is considered crucial because nutrition plays a vital role in supporting the immune system and regulating immune function (20).

Malnutrition in patients is associated with reduced levels of lymphocytes, prealbumin, and albumin (20), and is strongly correlated with a heightened likelihood of ICU transfer (21), compromised immune function, increased susceptibility to infections (18), prolonged hospital stays (22), and a poor prognosis (23). During an infection, maintaining a proper nutritional status is crucial because nutrition plays a vital role in supporting the immune system and regulating immune function (24,25). Despite research addressing the possible mechanisms and associations between malnutrition and COVID-19 (26,27), nutritional assessment has not been widely included in the clinical practice or the official guidelines of COVID-19 care (28,29), There are little data on the prevalence of malnutrition or risk of malnutrition among patients with COVID-19, depending on various population settings, despite the fact that characterising malnourished patients with the virus is essential for managing the diagnosis, treatment, and overall patient care. Thus, the objective of this study is to investigate the relationship between nutritional risk at hospital admission and its impact on COVID-19 survivors.

Materials and Methods

Study design

This prospective cohort study enrolled 103 COVID-19 patients hospitalized at King Salman Specialist Hospital in Ha'il region, KSA, between January 2021 and July 2023. Patients were confirmed with SARS-CoV-2 infection through the polymerase chain reaction (PCR) testing. A comprehensive screening of 2700 electronic medical records identified eligible participants based on inclusion criteria, such as age, residence, and medical history. Exclusion criteria included pregnancy, age under 18, pre-existing conditions such as cancer, immunodeficiency, or renal failure,

and any other condition deemed unsuitable by the investigators. A total of 600 eligible patients were invited via phone call, with 103 consenting to participate. Data on hospital admission was retrospectively collected from patient records, about sociodemographic information, clinical details, symptoms, anthropometric measurements, nutrition- related laboratory tests, diet, and length of hospital stay. Patients who agreed to participate were invited for a post-COVID-19 follow-up visit, during which anthropometric measurements and nutritional laboratory tests were repeated. The MST is specifically designed as a screening tool for nutritional risk rather than a comprehensive nutritional assessment, focusing on recent unintentional weight loss and reduced food intake due to poor appetite. This approach aligns with European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines, which recommend validated screening tools like MST for initial nutritional risk assessment in hospitalized patients (30). Body mass index (BMI) was calculated from height and weight measurements taken at admission and follow-up of COVID-19 nutritional research (31). A recent systematic review and meta-analysis by Feng X et al. (2022) examining malnutrition risk in hospitalized COVID-19 patients analyzed 17 studies that used the Nutrition Risk Score (NRS-2002) as the assessment tool, with sample sizes ranging from 27 to 760 participants. Notably, 41% of studies included in this high-quality systematic review had sample sizes of 101 or fewer participants, demonstrating that studies of our size have made meaningful contributions to literature (32). Our sample size falls within the established range and provides adequate power for detecting clinically meaningful differences, as evidenced by the successful detection of significant associations in the meta-analysis pooled data. Furthermore, the systematic review identified a significant geographical research gap in Middle Eastern populations, making our study a valuable contribution to addressing this limitation in the global COVID-19 malnutrition literature (32).

Statistical analysis

Data were analyzed using IBM SPSS Statistical software for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics including means, standard deviations, frequencies, and percentages were used to describe the quantitative and categorical variables. The student's t-test for paired samples was used to compare the mean values of quantitative variables (such as weight, BMI, and all clinical parameters) between two observation points (at admission and during the follow-up visit). McNemar's Chi-square test was utilized to compare the paired proportions. The statistical significance and precision of results were reported using a p-value of <0.05 and 95% confidence intervals. Multivariate regression analysis was not performed due to sample size limitations. According to Green's (1991) guidelines for regression analysis, our sample size of 103 participants, when stratified by comorbidity status (71 vs 32), would risk overfitting and unstable estimates if multiple predictors were included in regression models. The descriptive and bivariate analyses provide essential foundational data for this understudied population (33).

Ethical consideration

This study has been approved by the Research Ethics Standing Committee (REC) at University of Ha'il (H-2021-251). Participants provided informed consent prior to participating. This ensured that they fully understood the study's purpose, procedures, potential risks, and benefits. To safeguard participant privacy, all data collected are kept strictly confidential and anonymized. Access to the data is restricted to authorized researchers, and appropriate measures were implemented to protect it from unauthorized access or disclosure.

Results

Table 1 presents the sociodemographic characteristics of the 103 study subjects infected with COVID-19, categorized by the presence or absence of comorbidities. Among these subjects, 58.3% were over 50 years of age. Of the 71 subjects with comorbidities, 70.4% were over 50 years. Gender distribution was even, but males with comorbidities (53.5%) outnumbered females with comorbidities (46.5%).

Table 1. Distribution of sociodemographic characteristics of study subjects infected with COVID-19 (n=103)

Characteristics	With Comorbidities (n=71)	Without comorbidity conditions (n=32)	All participants (n=103)
Age groups (years)			
18-29	3 (4.2)	3 (9.4)	6 (5.8)
30-39	6 (8.5)	6 (18.8)	12 (11.7)
40-49	12 (16.9)	13 (40.6)	25 (24.3)
50-59	23 (32.4)	6 (18.8)	29 (28.2)
60-74	22 (31.0)	3 (9.4)	25 (24.3)
75 and above	5 (7.0)	1 (3.1)	6 (5.8)
Gender			
Male	38 (53.5)	14 (43.8)	52 (50.5)
Female	33 (46.5)	18 (56.3)	51 (49.5)
Education Level			
None	19 (26.8)	4 (12.5)	23 (22.3)
Primary	11 (15.5)	2 (6.3)	13 (12.6)
Intermediate	6 (8.5)	5 (15.6)	11 (10.7)
High school	16 (22.5)	6 (18.8)	22 (221.5)
College/University	16 (22.5)	12 (37.5)	28 (27.2)
Postgraduate	3 (4.4)	3 (9.4)	6 (5.8)
Marital status			
Married	62 (87.3)	24 (75.0)	86 (83.5)
Divorced	1 (1.4)	4 (12.5)	5 (4.9)
Widowed	5 (7.0)	2 (6.3)	7 (6.8)
Never married	3 (4.2)	2 (6.3)	5 (4.9)
Working status			
Government employee	16 (22.5)	13 (40.6)	29 (28.2)
Non-government employee	5 (7.0)	7 (21.9)	12 (11.7)
Self-employed	2 (2.8)	2 (6.3)	4(3.9)
Retired	15 (21.1)	2 (6.3)	17 (16.5)
Unemployed	33 (46.5)	8 (25.0)	41 (39.8)
Monthly income (in SR)			
<=10,000	46 (64.8)	21 (65.6)	67 (65.0)
10,001 to 15,000	21 (29.6)	10 (31.3)	31 (30.1)
>20,00	4 (5.6)	1 (3.1)	5 (4.9)

Data was represented as frequencies and percentages, n (%).

A higher proportion (83.5%) of subjects were married, with an even greater proportion (87.3%) among those with comorbidities. Education level data revealed that 26.8% of participants with comorbidities had no formal education, compared to 12.5% of those without comorbidities. College/university education was more common among participants without comorbidities (37.5%) than those with comorbidities (22.5%). Regarding employment status, unemployed participants with comorbidities were observed to be

Table 2. Distribution of characteristics related to COVID-19 in study subjects

Characteristics	With comorbidities (n=71)	Without comorbidities (n=32)	All participants (n=103)
No. of times of COVID-19 diagnosed			
1	64 (90.1)	26 (81.3)	90 (87.4)
2	5 (7.0)	4 (12.5)	9 (8.7)
3	2 (2.8)	2 (6.3)	4 (3.9)
Admission Unit			
Medical	66 (93.0)	30 (93.8)	96 (93.2)
ICU	5 (7.0)	2 (6.3)	7 (6.8)
Length of Hospital stay (in days)			
≤14	54 (76.1)	30 (93.8)	84 (81.6)
>14	17 (23.9)	2 (6.3)	19 (18.4)
Case Severity			
Moderate	58 (81.7)	27 (84.4)	85 (82.5)
Severe	13 (18.3)	5(15.6)	18 (17.5)
Smoking			
Yes	7 (9.9)	2 (6.3)	9 (8.7)
No	64 (90.1)	30 (93.8)	94 (91.3)

Data was represented as frequencies and percentages, n (%).

of significant proportion of subjects (46.5%), while both self-employed and retired were the least (6.3%). Additionally, two-thirds (65%) of the subjects had a monthly income of ≤ 10,000 SR.

Insights into how COVID-19 affected participants are shown in Table 2. Among the 103 study subjects, (87.4%) were diagnosed with COVID-19 once, while (12.6%) experienced multiple infections. Only seven participants required ICU admission, five of them had comorbidities. A prolonged hospital stay (more than 14 days) was reported in 19 (18.4%) of the total subjects, with 17 of these cases (23.9%) occurring among those with comorbidities. In terms of disease severity, the majority of participants (82.5%) experienced moderate COVID-19, with similar rates observed across both groups. Severe cases were reported in 18 participants (17.5%), including only five individuals (15.6%) without comorbidities. Most participants were non-smokers, accounting for 94 individuals (91.3%), including 64 (90.1%) among those with comorbidities.

Figure 1 shows the prevalence of chronic diseases and comorbidities among participants, diabetes being the most prevalent condition, affecting 57 participants (43.85%), followed by hypertension, Asthma, hypothyroidism, and Cardiovascular were reported in (27.69%, 10.77%, 9.23%, and 6.92%) respectively. While hyperthyroidism was the least prevalent condition, recorded in only 2 participants (1.54%).

Table 3 compares the anthropometrics and malnutrition scores of all subjects at their admission and follow-up visits. In patients with comorbidities, the mean weight at admission was 84.08 ± 16.80 kg, which decreased to 82.53 ± 16.75 kg during follow-up, although this change was not statistically significant ($p = 0.415$). Moreover, the mean BMI remained constant at 31.28 ± 6.57 kg/m² ($p = 0.463$). In contrast, patients without comorbidities, the mean weight increased slightly from 82.58 ± 19.42 kg at admission to 84.65 ± 18.98 kg during follow-up, but this variation was also not statistically significant ($p = 0.411$). The mean BMI increased insignificantly from 29.68 ± 6.67 kg/m² to 30.35 ± 6.29 kg/m², without statistical significance ($p = 0.461$). Further analysis of weight status revealed notable shifts between admission and follow-up.

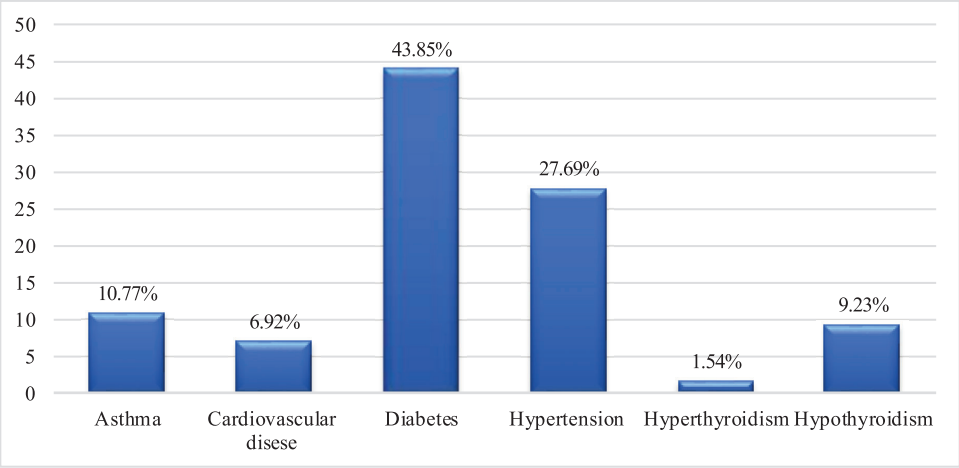

Figure 1. Types of chronic diseases and comorbidities prevalent among the participants (n=130)

Among participants with comorbidities, none were classified as underweight at admission; however, this increased to 2.8% at follow-up. Additionally, the proportion of individuals with obesity decreased from 66.2% to 54.9%. In contrast, among participants without comorbidities, no underweight individuals were observed at either time point, while the prevalence of obesity increased from 43.8% to 53.1%. The risk of malnutrition was evaluated among the participants at admission and during the follow-up visits. Among patients with comorbidities, the percentage of individuals at risk of malnutrition increased at time of admission from (23.9%) to (46.5%) at follow-up, while the proportion of patients not at risk of malnutrition declined from (76.1%) to (53.5%). In contrast, for patients without comorbidities, the likelihood of malnutrition risk decreased from (50.0%) at admission to (34.4%) during follow-up. The proportion of patients not at risk of malnutrition increased from (50.0%) to (65.6%).

As shown in Tables 4 and 5, the comparison of mean clinical parameters at admission and follow-up for participants with and without comorbidities revealed several statistically significant differences. Key parameters that increased included potassium, calcium, blood urea nitrogen (BUN), albumin, bilirubin, lymphocytes, haematocrit and platelet count. Conversely, HbA1c, ferritin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), and neutrophils showed significant decreases.

Table 6 presents the association between length of hospital stay and various clinical and demographic variables. Analysis revealed that COVID-19 patients who remained hospitalized for more than 14 days were significantly older, with a mean age of 61.84 years, compared to 50.39 years for those with hospital stays of 14 days or less ($p = 0.001$). In contrast, there were no statistically significant differences in BMI at admission or gender between the two groups. Case severity played a major role in determining hospital stay duration. Among patients with moderate severity cases, 91.8% had shorter hospital stays, while only 8.2% experienced prolonged stays. Conversely, among patients with severe COVID-19, 66.7% had longer stays, and only 33.3% had shorter stays. association was highly significant ($p < 0.0001$). The presence of comorbid conditions also influenced hospital stay length. Patients with comorbidities were more likely to have extended hospitalizations (23.9%) compared to those without comorbidities (6.3%), a difference that was statistically significant ($p = 0.032$). Interestingly, the risk of malnutrition at admission didn't show a significant association with hospital stay length. Among patients not at risk of malnutrition, 80.0% had shorter hospital stays, while 84.8% of those at risk also experienced shorter stays. This difference was not statistically significant ($p = 0.554$).

Table 3. Comparison of weight, BMI, weight status, and malnutrition risk between admission and follow-up in COVID-19 patients with and without co-morbidities

Study variables	At the time of admission	During follow-up visit	p-value
WITH COMORBIDITIES			
Weight* Kg	84.08 ± 16.80	82.53 ± 16.75	0.415
BMI*	31.28 ± 6.57	31.28 ± 6.57	0.463
Weight status			
Underweight	--	2 (2.8)	--
Normal	10 (14.1)	11 (15.5)	--
Overweight	14 (19.7)	19 (26.8)	--
Obesity	47 (66.2)	39 (54.9)	--
Risk of malnutrition (using MST score)			
At malnutrition risk	17 (23.9)	33 (46.5)	--
Not at malnutrition risk	54 (76.1)	38 (53.5)	--
WITHOUT COMORBIDITIES			
Weight* Kg	82.58 ± 19.42	84.65 ± 18.98	0.411
BMI*	29.68 ± 6.67	30.35 ± 6.29	0.461
Weight status			
Under weight	--	--	--
Normal	7 (21.9)	7 (21.9)	--
Overweight	11 (34.4)	8 (25.0)	--
Obesity	14 (43.8)	17 (53.1)	--
Risk of malnutrition (using MST score)			
At malnutrition risk	16 (50.0)	11 (34.4)	--
Not at malnutrition risk	16 (50.0)	21 (65.6)	--

Data are represented as frequencies and percentages, n (%).
*Data are represented as mean ±SD.
P values less than 0.05 are considered statistically significant.

Discussion

This prospective cohort study examined the relationship between nutritional risk at hospital admission and its impact on COVID-19 survivors. Our findings revealed the presence of malnutrition among participants during hospitalization, though it was not significantly correlated with BMI. Notably, we observed statistically significant changes in the average values of specific clinical parameters between admission and follow-up visits in 71 COVID-19 patients with pre-existing health conditions. Key factors such as length of hospital stay, disease severity, and the presence of comorbidities were identified as significant risk factors associated with increased mortality rates and prolonged hospitalization. Our methodological approach using the MST for nutritional risk screening without detailed dietary assessment is well-supported in the literature. Several COVID-19 nutritional studies have successfully utilized screening tools without detailed dietary assessment, including Mancin et al. (2021) who used nutritional risk screening to predict COVID-19 outcomes (9). This approach reflects real-world clinical practice where MST screening is performed as part of routine care without comprehensive dietary evaluation. In a previous study, patients critically ill with COVID-19 were found to have higher BMIs compared to the patients who were COVID-19 negative

Table 4. Comparison of clinical parameters between the time of admission and follow-up visit of study subjects infected in COVID-19 patients with comorbidities

Clinical parameters	Time points of observation		p-value
	At the time of admission	During follow-up visit	
HbA1c (%)	8.99 ± 1.99	8.26 ± 2.14	0.027
Vitamins and minerals			
Sodium (mmol/L)	136.32 ± 4.81	137.32 ± 4.81	0.321
Potassium (mmol/L)	3.91 ± 0.62	4.15 ± 0.52	0.017
Magnesium (mmol/L)	0.79 ± 0.16	0.76 ± 0.16	0.541
Calcium (mmol/L)	2.05 ± 0.30	2.34 ± 0.22	<0.0001
Ferritin (ng/mL)	324.80 ± 421.88	106.67 ± 154.17	0.110
Vitamin D 25(OH) (ng/mL)	22.52 ± 14.04	28.91± 9.08	0.493
Protein status			
BUN (mmol/L)	4.74 ± 2.71	7.09 ± 7.14	0.025
Creatinine (umol/L)	81.28 ± 27.42	88.61 ± 50.75	0.315
Albumin (g/L)	28.95 ± 6.23	41.77 ± 4.67	<0.0001
Total protein (g/L)	66.06 ± 5.85	68.56 ± 11.03	0.193
Liver enzymes			
Alkaline phosphatase (U/L)	79.08 ± 30.50	83.78 ± 26.72	0.270
ALT (U/L)	47.74 ± 28.31	24.71 ± 14.28	<0.0001
AST (U/L)	44.67 ± 34.78	20.64 ± 6.19	<0.0001
GGT (U/L)	81.28 ± 67.43	29.03 ± 15.71	<0.0001
Bilirubin (umol/L)	7.61± 3.35	10.40 ± 6.46	0.009
Complete Blood Count			
Red Blood Cell Count (x10^6/uL)	5.01 ± 1.64	5.04 ± 0.63	0.894
Hemoglobin (g/dL)	14.18 ± 5.40	14.40 ± 1.73	0.774
Hematocrit (%)	40.81 ± 6.11	43.22 ± 6.54	0.025
Platelet count (x10^3/uL)	216.52 ± 89.12	243.21 ± 52.50	0.063
Neutrophils (x10^3/uL)	51.12 ± 33.39	40.68 ± 22.76	0.006
Lymphocytes (x10^3/uL)	14.90 ± 14.34	26.81 ± 17.42	<0.0001
Monocytes (x10^3/uL)	3.64 ± 2.82	4.21 ± 2.71	0.331

Data are represented as mean ±SD. P values less than 0.05 are considered statistically significant.

or the normal population (32). This reiterates the occurrence of high BMI rates among the COVID-19 patients in our study. Similarly, in a systematic review, the 19 studies included showed a significantly higher prevalence of individuals with obesity among hospitalized patients than among patients not hospitalized or the general population (34). Another study suggested that the relationship between BMI and outcomes during admission and follow-up in COVID-19 patients, with or without comorbidities, was stronger in individuals aged 70 years or younger compared to older individuals (31). This discrepancy may be due to the small size of our sample, which limited our ability to explore other potential interactions such as the length of the stay. Additionally, malnutrition risk, as indicated by MST scores, was particularly prevalent among patients with comorbidities, suggesting that higher BMI is associated with an increased likelihood of developing

Table 5. Comparison of clinical parameters between the time of admission and follow-up visit of study subjects infected with COVID-19 patients without comorbidities

Clinical parameters	Time points of observation		p-value
	At the time of admission	During follow-up visit	
HbA1c (%)	6.52 ± 1.25	6.39 ± 1.25	0.724
Vitamins and minerals			
Sodium (mmol/L)	138.74 ± 3.05	139.96 ± 3.08	0.216
Potassium (mmol/L)	3.80 ± 0.76	4.19 ± 0.26	0.026
Magnesium (mmol/L)	0.80 ± 0.09	0.8 ± 0.07	0.499
Calcium (mmol/L)	2.03 ± 0.15	2.31 ± 0.11	<0.0001
Ferritin (ng/mL)	374.61 ± 261.45	109.82 ± 98.41	0.002
Vitamin D 25(OH) (ng/mL)	18.47 ± 7.88	22.50 ± 10.28	0.293
Protein status			
BUN (mmol/L)	3.83 ± 1.44	4.66 ± 2.08	0.054
Creatinine (umol/L)	80.10 ± 14.80	80.13 ± 15.75	0.994
Albumin (g/L)	32.30 ± 4.74	43.90 ± 3.14	<0.0001
Total protein (g/L)	69.47 ± 5.89	73.16 ± 5.17	0.014
Liver enzymes			
Alkaline phosphatase (U/L)	81.61 ± 34.19	89.50 ± 13.72	0.300
ALT (U/L)	55.68 ± 34.14	32.50 ±17.66	0.001
AST (U/L)	46.74 ± 33.78	29.96 ± 22.89	0.051
GGT (U/L)	62.87 ± 27.79	28.50 ± 12.43	0.002
Bilirubin (umol/L)	7.79 ± 2.99	14.10 ± 7.20)	<0.0001
Complete Blood Count			
Red Blood Cell Count (x10^6/uL)	5.01 ± 0.44	5.19 ± 0.55	0.012
Hemoglobin (g/dL)	13.89 ± 1.48	14.87 ± 1.76	<0.0001
Hematocrit (%)	42.74 ± 4.10	45 ± 4.97	0.001
Platelet count (x10^3/uL)	170 ± 49.48	243.32 ± 51.82	<0.0001
Neutrophils (x10^3/uL)	35.26 ± 39.57	25.53 ± 28.47	0.116
Lymphocytes (x10^3/uL)	7.06 ± 8.44	14.50 ± 16.05	0.086
Monocytes (x10^3/L)	1.57 ± 1.76	2.85 ± 3.77	0.187

Data is represented in frequencies and percentages. *Data is represented in mean ±SD. P values less than 0.05 are considered statistically significant.

malnutrition during hospitalization. This finding aligns with earlier studies, which showed that higher BMI and obesity are linked to malnutrition in critically ill COVID-19 patients, potentially contributing to poor prognosis. Furthermore, the adverse effects of obesity and elevated BMI in critically ill COVID-19 patients are likely driven by altered immune responses and malnutrition resulting from obesity-related pathological changes. Strong evidence demonstrates that hormone and nutrient dysregulation in individuals with obesity can impair the response to infection (31,34). Electrolyte imbalances are frequently associated with significant comorbidities and can influence the duration of hospital stays. For instance, hypokalemia is associated with malnutrition, chronic diuretic use, or diarrhea, while hyperkalemia is linked to acidosis and renal dysfunction (35). Our findings are consistent with those of studies conducted in Iraq (36) and India (37).

Table 6. Association between length of hospital stay and other variables of study subjects

Variables	Length of hospital stay (in days)		p-value
	≤14	>14	
Age at admission*	50.39 ± 12.9	61.84 ± 16.8	0.001
BMI at admission*	30.86 ± 6.4	32.33 ± 6.2	0.365
Gender			
Male	42 (82.4)	9 (17.6)	0.836
Female	42 (80.8)	10 (19.2)	--
Case severity			
Moderate	78 (91.8)	7 (8.2)	<0.0001
Severe	6 (33.3)	12 (66.7)	--
Comorbid conditions at admission			
Yes	54 (76.1)	17 (23.9)	0.032
No	30 (93.8)	2 (6.3)	--
Risk of malnutrition on admission using MST score			
Not at malnutrition risk	56 (80.0)	14 (20.0)	0.554
At malnutrition risk	28 (84.8)	5 (15.2)	--

Data is represented in frequencies and percentages. *Data is represented in mean ±SD. P values less than 0.05 are considered statistically significant.

The biochemical profile exhibited the potassium levels to be within normal range in our study population and the values slightly increased in the follow-up visit, however, it wasn't a significant difference. In a similar study, significantly higher serum potassium was linked to increased mortality rate among COVID-19 cases than the survivors (35). These findings agree with a study that reported a negative correlation of potassium with disease severity in COVID-19 cases (38). On the other hand, studies have shown that hypokalemia resulting from a higher level of Angiotensin-converting enzyme 2 (ACE2) degradation impairs renal control of potassium in patients with SARS-COV-2. Normal levels of serum Potassium may have a role in the survival of these patients (38). This study indicates that comorbidities such as diabetes and hypertension may significantly influence the severity of COVID-19. A notably high prevalence of diabetes (43.85%) was observed among patients, followed by hypertension (27.69%). These findings are consistent with those of a 2020 study conducted at Harran University in Turkey, which reported similar trends (38).

Serum ferritin levels of the participants were within the normal range; however, they dropped substantially in the follow-up visits with a significant difference in patients without comorbidities (P= 0.002). Serum ferritin is a prognostic measure that predicts the progression of illness to more severe types. A hyperinflammatory state with elevated ferritin develops in severe COVID-19, which is associated with higher death rates, multiple organ failures, and the necessity for admission to critical care units. Literature is evident that Ferritin is an early, nonspecific marker that increases in the early stages of the illness and falls after approximately a month (14) . In another case-control research of 93 patients, their COVID-19 cases also had greater ferritin levels than the controls without COVID-19 (39). The importance of ferritin can be explained in two ways. Shoenfeld *et al*. suggest that the clinical progression of severe COVID-19 resembles macrophage activation syndrome, characterized by high ferritin levels and a cytokine storm. The H-chain of ferritin activates macrophages, leading to increased secretion of inflammatory cytokines in COVID-19 patients (40). Alternatively, elevated ferritin may indicate how iron metabolism supports the immune response to infections, including viral ones, as effective cellular metabolism and adequate iron levels

in host cells are essential for viral replication (41). Nonetheless, current research implies that increased levels of circulating ferritin may not only reflect an acute phase response but also play a critical role in inflammation by contributing to the development of a cytokine storm (39) Perhaps this justifies the initial ferritin levels at the higher end followed by a drastic decline later in our COVID-19 survivors. Our findings emphasized the substantial influence of hospital stay duration on clinical parameters, including ferritin and hemoglobin, in patients both with and without comorbidities. It has been reported that analyzing ferritin levels early in COVID-19 patients may serve as an effective predictor of disease severity (39,42). In terms of hemoglobin levels, these were found to significantly ($p<0.0001$) improve in the COVID survivors in patients without comorbidities during the course of the disease. In similar studies, sizable direct drifts were acknowledged for mean hemoglobin levels declining with deteriorating health parameters and the presence of comorbidities (43). Furthermore, compared to moderate COVID-19 cases, severe cases had lower hemoglobin levels. Hence, this elucidates, as a previous study does, that the patients could suffer from a decreased capability of hemoglobin to support the increased peripheral tissue demands for oxygen due to the hyper-metabolic states during infection, especially in populations at risk of complications and mortality (44). We observed significant differences in total protein and hemoglobin levels among severe COVID-19 patients without comorbidities, but these differences were not present in patients with comorbidities. The findings stress the need for continuous monitoring, interventions, and further research in this area. Additionally, albumin levels were significantly different between the two groups. Previous studies have identified total protein (45), albumin (46,47), and hemoglobin (40) as factors influencing hospitalization due to COVID-19. Importantly, incorporating proteins such as albumin into clinical decision-making may offer a more accurate assessment of ionized calcium and total calcium levels in the blood (42,46). Despite the significant vitamin D deficiency observed in hospitalized patients, particularly those with sarcopenic obesity, vitamin D levels were not restored to normal in 43% patients during follow-up (8% showed deficient levels, and 35% had insufficient levels). This highlights the need for intensive monitoring and treatment, especially in patients with obesity who may require higher supplementation doses. Vitamin D plays a crucial role in reducing systemic inflammation and maintaining metabolic homeostasis, both of which are critical for the recovery of patients from severe illnesses such as COVID-19. It helps controls inflammation, particularly in individuals with underlying inflammatory or infectious conditions, and supports glycemic control in patients with diabetes (48). These findings are aligned in parallel with our results. Nearly 91.8% of the included participants were experiencing moderate severity. A systematic review conducted in 2022 reported that age (46), along with comorbid conditions, is a crucial factor to consider when examining the impact of COVID-19 on the length of hospital stay and case severity. Older patients are generally associated with higher mortality rates and longer hospital stays. This study reinforces previous findings in literature, with the increased risks potentially linked to weaker immune systems and specific behavioral responses to implemented measures (47). In our study, the majority (58.3%) of patients were over 50 years old, a finding consistent with results from other studies conducted in the Netherlands (49) and Spain (50). This trend may be attributed to fewer elderly patients being referred to hospitals, likely due to the overwhelming pressure on healthcare systems during the first wave of COVID-19. Despite the participation rate of 17%, our findings demonstrate clinical relevance and align with international COVID-19 literature. The demographic and clinical characteristics of our participants are consistent with broader COVID-19 populations, suggesting reasonable representativeness within the regional context. The challenges in participant recruitment reflect common issues in post-COVID-19 follow-up studies globally, including ongoing symptoms, geographic barriers, and pandemic-related concerns.

Limitations

Several limitations should be acknowledged in this study. To begin with, the sample size of 103 participants, while comparable to similar regional COVID-19 nutritional studies and falling within the

range established by systematic reviews, may limit the generalizability of findings and restrict more complex statistical modeling. In addition to that, the participation rate of approximately 17% raises potential selection bias concerns. This participation rate reflects common challenges in post-COVID-19 follow-up studies, including post-COVID fatigue, geographic accessibility issues in the Ha'il region, and ongoing pandemic concerns during the study period. However, our participants' demographic and clinical characteristics align with broader COVID-19 populations reported in the literature. The nutritional assessment was limited to MST screening without detailed dietary intake evaluation. This reflects the retrospective nature of admission data from patient medical records, where detailed dietary intake information was not systematically collected as part of routine clinical care. MST is designed as a screening tool for nutritional risk rather than comprehensive nutritional assessment, which is appropriate for the study's scope and objectives. Finally, the study was conducted in a single region of Saudi Arabia, which may limit broader generalizability to other populations and healthcare settings. Despite these limitations, this study provides important baseline data for future larger-scale investigations in the region.

Conclusion

This study represents one of the first comprehensive investigations of nutritional risk and long-term outcomes in COVID-19 survivors in the Ha'il region, providing essential baseline data for future larger-scale investigations and offering clinically relevant insights for healthcare providers managing COVID-19 survivors in similar settings. By addressing these metabolic disturbances, healthcare providers can improve the overall care for post-COVID-19 patients by focusing on these issues. Considering the exponential rise in the prevalence of obesity, diabetes, and hypertension, understanding how being an individual with comorbidities increases the risk of severe COVID-19 is critical to ensure appropriate interventional and prophylactic measures against this viral infection.

Acknowledgements: The authors extend their appreciation to Scientific Research Deanship at the University of Hail, Hail, Saudi Arabia, for supporting this research through project number (RG-21 132). The authors also express their sincere gratitude to all the contributors, healthcare assistants, and doctors who played an essential role in data collecting for this study. Their dedication, hard work, and commitment were invaluable to the success of this research.

Funding: This research has been funded by the Scientific Research Deanship at the University of Hail, Saudi Arabia, through project number RG-21 132.

Conflicts of Interest: Each author declares that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement, etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contributions: All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

References

1. Janiaud P, Axfors C, van't Hooft J, et al. The worldwide clinical trial research response to the COVID-19 pandemic - the first 100 days. F1000Research. 2020;9: 1193. doi: 10.12688/f1000research.26707.2
2. Myoung J. Two years of COVID-19 pandemic: where are we now? J Microbiol. 2022;60(3): 235–237. doi: 10.1007/s12275-022-1679-x
3. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA. 2020;323(20): 2052. doi: 10.1001/jama.2020.6775
4. Calder P, Carr A, Gombart A, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. Nutrients. 2020;12(4): 1181. doi: 10.3390/nu12041181
5. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China. JAMA. 2020;323(13): 1239. doi: 10.1001/jama.2020.2648
6. Hu B, Guo H, Zhou P, Shi ZL. Characteristics of SARS-CoV-2 and COVID-19. Nat Rev Microbiol. 2021;19(3): 141–154. doi: 10.1038/s41579-020-00459-7

7. Dhama K, Khan S, Tiwari R, et al. Coronavirus disease 2019–COVID-19. Clin Microbiol Rev. 2020;33(4). doi: 10.1128/CMR.00028-20
8. Abate SM, Chekole YA, Estifanos MB, Abate KH, Kabthymer RH. Prevalence and outcomes of malnutrition among hospitalized COVID-19 patients: a systematic review and meta-analysis. Clin Nutr ESPEN. 2021;43: 174–183. doi: 10.1016/j.clnesp.2021.03.002
9. Mancin S, Bertone A, Cattani D, al. Malnutrition risk as a negative prognostic factor in COVID-19 patients. Clin Nutr ESPEN. 2021;45: 369–373. doi: 10.1016/j.clnesp.2021.07.016
10. Di Filippo L, De Lorenzo R, D'Amico M, et al. COVID-19 is associated with clinically significant weight loss and risk of malnutrition, independent of hospitalisation: a post-hoc analysis of a prospective cohort study. Clin Nutr. 2021;40(4): 2420–2426. doi: 10.1016/j.clnu.2020.10.043
11. Arab-Zozani M, Hashemi F, Safari H, Yousefi M, Ameri H. Health-related quality of life and its associated factors in COVID-19 patients. Osong Public Health Res Perspect. 2020;11(5): 296–302. doi: 10.24171/j.phrp.2020.11.5.05
12. Wierdsma NJ, Kruizenga HM, Konings LAML, et al. Poor nutritional status, risk of sarcopenia and nutrition related complaints are prevalent in COVID-19 patients during and after hospital admission. Clin Nutr ESPEN. 2021;43: 369–376. doi: 10.1016/j.clnesp.2021.03.021
13. Katona P, Katona-Apte J. The interaction between nutrition and infection. Clin Infect Dis. 2008;46(10): 1582–1588. doi: 10.1086/587658
14. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395(10229):1054–1062.doi:10.1016/S0140-6736(20)30566-3
15. James PT, Ali Z, Armitage AE, et al. The role of nutrition in COVID-19 susceptibility and severity of disease: a systematic review. J Nutr. 2021;151(7): 1854–1878. doi: 10.1093/jn/nxab059
16. Yeo HJ, Byun KS, Han J, et al. Prognostic significance of malnutrition for long-term mortality in community-acquired pneumonia: a propensity score matched analysis. Korean J Intern Med. 2019;34(4): 841–849. doi: 10.3904/kjim.2018.037
17. Bedock D, Bel Lassen P, Mathian A, et al. Prevalence and severity of malnutrition in hospitalized COVID-19 patients. Clin Nutr ESPEN. 2020;40: 214–219. doi: 10.1016/j.clnesp.2020.09.018
18. Venter C, Eyerich S, Sarin T, Klatt KC. Nutrition and the immune system: a complicated tango. Nutrients. 2020;12(3): 818. doi: 10.3390/nu12030818
19. Zabetakis I, Lordan R, Norton C, Tsoupras A. COVID-19: the inflammation link and the role of nutrition in potential mitigation. Nutrients. 2020;12(5): 1466. doi: 10.3390/nu12051466
20. Yu Y, Ye J, Chen M, et al. Malnutrition prolongs the hospitalization of patients with COVID-19 infection: a clinical epidemiological analysis. J Nutr Health Aging. 2021;25(3): 369–373. doi: 10.1007/s12603-020-1541-y
21. Spolidoro GCI, Azzolino D, Shamir R, Cesari M, Agostoni C. Joint effort towards preventing nutritional deficiencies at the extremes of life during COVID-19. Nutrients. 2021;13(5): 1616. doi: 10.3390/nu13051616
22. Kurtz A, Grant K, Marano R, et al. Long-term effects of malnutrition on severity of COVID-19. Sci Rep. 2021;11(1): 14974. doi: 10.1038/s41598-021-94138-z
23. Li T, Zhang Y, Gong C, et al. Prevalence of malnutrition and analysis of related factors in elderly patients with COVID-19 in Wuhan, China. Eur J Clin Nutr. 2020;74(6): 871–875. doi: 10.1038/s41430-020-0642-3
24. Diagnosis and treatment protocol for COVID-19 patients (Trial Version 9). Health Care Sci. 2022;1(1): 14–28. doi: 10.1002/hcs2.1
25. Agarwal A, Hunt BJ, Stegemann M, et al. A living WHO guideline on drugs for COVID-19. BMJ. 2020; m3379. doi: 10.1136/bmj.m3379
26. Skipper A, Coltman A, Tomesko J, et al. Adult malnutrition (undernutrition) screening: an Evidence Analysis Center systematic review. J Acad Nutr Diet. 2020;120(4): 669–708. doi: 10.1016/j.jand.2019.09.010
27. Espiritu AI, Reyes NGD, Leochico CFD, et al. Body mass index and its association with COVID-19 clinical outcomes: findings from the Philippine CORONA study. Clin Nutr ESPEN. 2022;49: 402–410. doi: 10.1016/j.clnesp.2022.03.013
28. Sattar N, Ho FK, Gill JMR, et al. BMI and future risk for COVID-19 infection and death across sex, age and ethnicity: preliminary findings from UK Biobank. Diabetes Metab Syndr Clin Res Rev. 2020;14(5): 1149–1151. doi: 10.1016/j.dsx.2020.06.060
29. Mohammadi P, Varpaei HA, Khafaee pour khamseh A, Mohammadi M, Rahimi M, Orandi A. Evaluation of the relationship between nutritional status of COVID-19 patients admitted to the ICU and patients' prognosis: a cohort study. J Nutr Metab. 2022;2022: 1–8. doi: 10.1155/2022/5016649
30. Cederholm T, Barazzoni R, Austin P, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin Nutr. 2017;36(1): 49–64. doi: 10.1016/j.clnu.2016.09.004
31. Gao M, Piernas C, Astbury NM, et al. Associations between body-mass index and COVID-19 severity in 6.9 million people in England: a prospective, community-based, cohort study. Lancet Diabetes Endocrinol. 2021;9(6): 350–359. doi: 10.1016/S2213-8587(21)00089-9
32. Feng X, Liu Z, He X, et al. Risk of malnutrition in hospitalized COVID-19 patients: a systematic review and meta-analysis. Nutrients. 2022;14(24): 5267. doi: 10.3390/nu14245267
33. Green SB. How many subjects does it take to do a regression analysis. Multivar Behav Res. 1991;26(3): 499–510. doi: 10.1207/s15327906mbr2603_7
34. Soeroto AY, Soetedjo NN, Purwiga A, et al. Effect of increased BMI and obesity on the outcome of COVID-19

adult patients: a systematic review and meta-analysis. Diabetes Metab Syndr Clin Res Rev. 2020;14(6): 1897–1904. doi: 10.1016/j.dsx.2020.09.029
35. Liu S, Zhang L, Weng H, et al. Association between average plasma potassium levels and 30-day mortality during hospitalization in patients with COVID-19 in Wuhan, China. Int J Med Sci. 2021;18(3): 736–743. doi: 10.7150/ijms.50965
36. Aziz PY, Hadi JM, Sha AM, et al. The strategy for controlling COVID-19 in Kurdistan Regional Government (KRG)/Iraq: identification, epidemiology, transmission, treatment, and recovery. Int J Surg Open. 2020;25: 41–46. doi: 10.1016/j.ijso.2020.06.006
37. Ahmad S. A review of COVID-19 (Coronavirus Disease-2019) diagnosis, treatments and prevention. Eurasian J Med Oncol. 2020; doi: 10.14744/ejmo.2020.90853
38. Noori M, Nejadghaderi SA, Sullman MJM, Carson-Chahhoud K, Kolahi A, Safiri S. Epidemiology, prognosis and management of potassium disorders in Covid-19. Rev Med Virol. 2022;32(1). doi: 10.1002/rmv.2262
39. Bozkurt FT, Tercan M, Patmano G, Bingol Tanrıverdi T, Demir HA, Yurekli UF. Can ferritin levels predict the severity of illness in patients with COVID-19? Cureus. 2021; doi: 10.7759/cureus.12832
40. Shoenfeld Y. Corona (COVID-19) time musings: our involvement in COVID-19 pathogenesis, diagnosis, treatment and vaccine planning. Autoimmun Rev. 2020;19(6): 102538. doi: 10.1016/j.autrev.2020.102538
41. Moreira AC, Mesquita G, Gomes MS. Ferritin: an inflammatory player keeping iron at the core of pathogen-host interactions. Microorganisms. 2020;8(4): 589. doi: 10.3390/microorganisms8040589
42. Wu C, Chen X, Cai Y, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med. 2020;180(7): 934. doi: 10.1001/jamainternmed.2020.0994
43. Lechuga GC, Morel CM, De-Simone SG. Hematological alterations associated with long COVID-19. Front Physiol. 2023;14. doi: 10.3389/fphys.2023.1203472
44. Shang W, Dong J, Ren Y, et al. The value of clinical parameters in predicting the severity of COVID-19. J Med Virol. 2020;92(10): 2188–2192. doi: 10.1002/jmv.26031
45. Ali AM, Kunugi H. Hypoproteinemia predicts disease severity and mortality in COVID-19: a call for action. Diagn Pathol. 2021;16(1): 31. doi: 10.1186/s13000-021-01092-5
46. Alimohamadi Y, Mansouri Yekta E, Sepandi M, Sharafoddin M, Arshadi M, Hesari E. Hospital length of stay for COVID-19 patients: a systematic review and meta-analysis. Multidiscip Respir Med. 2022;17. doi: 10.4081/mrm.2022.856
47. Alwafi H, Naser AY, Qanash S, et al. Predictors of length of hospital stay, mortality, and outcomes among hospitalised COVID-19 patients in Saudi Arabia: a cross-sectional study. J Multidiscip Healthc. 2021;14: 839–852. doi: 10.2147/JMDH.S304788
48. Simón-Frapolli VJ, López-Montalbán Á, Vegas-Aguilar IM, et al. Relationship between vitamin D levels with in-hospital complications and morphofunctional recovery in a cohort of patients after severe COVID-19 across different obesity phenotypes. Nutrients. 2024;17(1): 110. doi: 10.3390/nu17010110
49. van Raaij BFM, Noordam R, Smits RAL, et al. Preparing for future pandemics: frailty associates with mortality in hospitalised older people during the entire COVID-19 pandemic, a Dutch multicentre cohort study. Eur Geriatr Med. 2024;15(4): 951–959. doi: 10.1007/s41999-024-01001-1
50. Santos-Ribeiro C, Rodríguez-Blázquez C, Ayala A, Romay-Barja M, Falcón M, Forjaz MJ. Evolution of Spanish population well-being during the COVID-19 pandemic: results from the COSMO-Spain study. Heliyon. 2025;11(3): e42409. doi: 10.1016/j.heliyon.2025.e42409

Correspondence:
Received: 28 May 2025
Accepted: 24 July 2025
Albandari Bin Ammar, Associate Professor
Department of Clinical Nutrition, College of Applied Medical Sciences, University of Ha'il, Hail, KSA, Hail, 2440 KSA
E-mail: ab.benammar@uoh.edu.sa
ORCID: 0000-0002-7116-9263