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Association Between Nutritional Status, Energy-Protein-Micronutrient Intake, and Mortality in Critically Ill Patients Receiving Enteral Nutrition

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Abstract

Aim: Malnutrition is a common issue in the intensive care units (ICUs) and can lead to poor clinical outcomes if not managed with adequate nutritional support. This study aimed to examine the association between energy, protein, and micronutrient intake and mortality among malnourished and well-nourished critically ill patients.

Study Design: This retrospective cohort study was conducted in a tertiary medical ICU. Patients were enrolled within the first 48 hours of ICU admission and categorized as either well-nourished (modified Nutrition Risk in the Critically Ill [mNUTRIC] score: 0-4) or malnourished (mNUTRIC score: 5-9). Daily energy, protein, and micronutrient intake of adult critically ill patients receiving enteral tube feeding was meticulously monitored during the first seven days in the ICU.

Results: A total of 226 patients were included, with 137 classified as malnourished and 89 as well-nourished. The median age of the study population was 65.0 years (range: 47.8-74.0). Patients with malnutrition had lower energy adequacy (%) compared to well-nourished patients (median: 52.3 vs. 68.3, p=0.001). Malnourished patients also received significantly lower amounts of chromium, copper, iodine, iron, manganese, molybdenum, selenium, biotin, vitamin A, vitamin C, and vitamin D compared to well-nourished patients ($p<0.05$ for all). Multivariate Cox regression analysis revealed that the mNUTRIC score was a significant predictor of ICU mortality (Hazard Ratio (95% Confidence Interval): 1.235 (1.112-1.371), $p<0.001$). Kaplan-Meier analysis demonstrated that malnourished patients had a significantly lower probability of survival compared to well-nourished patients (median (95% CI): 29.0 (16.2-41.8) vs. 17.0 (15.0-19.0) days, p=0.001).

Conclusions: Critically ill adult patients with malnutrition had significantly lower energy and selected micronutrient intake via the enteral route, along with a reduced probability of survival.

Keywords: Enteral nutrition; Intensive care unit; Malnutrition; Micronutrient.

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Introduction

Malnutrition is a prevalent clinical issue in intensive care units (ICUs), with reported prevalence rates ranging from 38% to 78%.[1] It is associated with adverse clinical outcomes, including delayed wound healing, prolonged hospitalization, and increased mortality.[2] The nutritional status of patients plays a crucial role in their ability to withstand critical illness and improve clinical outcomes.[3]

In situations where patients are at risk of malnutrition and/or are unable to receive adequate nutrition orally and have a functional gastrointestinal (GI) tract, enteral nutrition (EN) should be considered the primary nutritional support option.[4] The main goal of EN in the ICU is to prevent malnutrition and to halt further nutritional decline in patients who are already malnourished.[5] However, EN may be interrupted, leading to insufficient energy, protein, and micronutrient intake. While some studies have shown a link between inadequate energy and protein intake and increased mortality in malnourished ICU patients,[6,7] other studies have reported no significant association between nutritional adequacy and clinical outcomes.[8,9]

Until recently, there were limited specific recommendations for daily micronutrient intake in critically ill patients. The European Society for Clinical Nutrition and Metabolism (ESPEN) has since published a micronutrient guideline, providing daily intake recommendations based on a 1500 kcal diet for critically ill patients.[10] However, the association between micronutrient intake and clinical outcomes in this population, as defined by the guideline, has not yet been clarified.

The objective of this study was to evaluate the energy, protein, and micronutrient intake from enteral tube feeding during the first seven days in the ICU, as well as the mortality outcomes of malnourished and well-nourished critically ill patients.

Materials and Methods

Study Design and Population

This cohort study was conducted in a tertiary medical ICU. Approval for the study was granted by the Erciyes University Health Sciences Research Ethics Committee (Approval Number: 2024/205, Date: 09.10.2024), and the study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all study participants.

The inclusion criteria were as follows: patients had to be over 18 years of age, expected to remain in the ICU for at least seven days, have initiated enteral nutrition within the first 48 hours of ICU admission, and have received enteral tube feeding for a minimum of 72 hours. Patients were excluded if they were pregnant, receiving standard diets and/or parenteral nutrition, or had routinely received high-dose multivitamin supplementation prior to ICU admission.

Data Collection

The demographic details of the study participants, including age, gender, and body mass index (BMI), were meticulously recorded. The underlying reasons for ICU admission, along with APACHE II (Acute Physiology and Chronic Health Evaluation II) and SOFA (Sequential Organ Failure Assessment) scores, were documented. The Charlson Comorbidity Index and Glasgow Coma Scale scores were also recorded.

Nutritional status was assessed using the Modified Nutrition Risk in the Critically Ill (mNUTRIC) and the Nutritional Risk Screening 2002 (NRS-2002) scores. According to the mNUTRIC score, a score of 0-4 was classified as well-nourished, while a score of 5-9 indicated malnutrition.[11]

In our clinical setting, patients receive 25-30 kcal/kg and 1.3 g/kg/day of protein, in line with ESPEN recommendations.[4] Energy and protein intake from EN, initiated within the first 72 hours of ICU admission, was monitored over a seven-day period following the start of feeding. Additionally, participants' daily micronutrient intake was assessed, including chromium, copper, iodine, iron, manganese, molybdenum, selenium, zinc, thiamine, riboflavin, niacin, pantothenic acid, folic acid, biotin, vitamin A, vitamin C, and vitamin D.

The initial 48 hours of EN in the ICU were excluded from the calculation of mean energy, protein, and micronutrient intake to allow time for patients to reach the target feeding rate.[12] The adequacy of energy or protein intake was calculated as the sum of the percentage of energy or protein received relative to the amount prescribed, divided by the total number of evaluable nutrition days. Daily energy, protein, and micronutrient intake was assessed in accordance with ESPEN recommendations.[4,10]

ICU length of stay, requirement for mechanical ventilation (MV), and patient mortality were also recorded.

Statistical Analysis

Data analysis was conducted using the R program (version 4.0.2, R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were presented as median (25th–75th percentile, interquartile range [IQR]), while categorical variables were expressed as number (%). Differences between malnourished and well-nourished patients were assessed using the Mann-Whitney U test for continuous variables and the chi-squared test for categorical variables. The difference between each micronutrient intake and the corresponding reference value was assessed using the Sign Test. Cox regression analysis was employed to predict ICU mortality. Kaplan-Meier analysis was used to estimate the survival probability of malnourished and well-nourished study participants.

Results

This study included a total of 226 patients, divided into two groups: 137 malnourished and 89 well-nourished patients (Fig. 1).

The median age of the study population was 65.0 years (range: 47.8-74.0), with malnourished patients being older than well-nourished patients (median: 67.0 vs. 53.0, p<0.001). The most common reason for ICU admission among participants was respiratory failure (37.6%). Malnourished patients had significantly higher APACHE II scores, SOFA scores, mNUTRIC scores, and NRS-2002 scores compared to well-nourished patients (p<0.001 for all). The mortality rate among malnourished patients was 65.1%, significantly higher than that of well-nourished patients (34.9%) (Table 1).

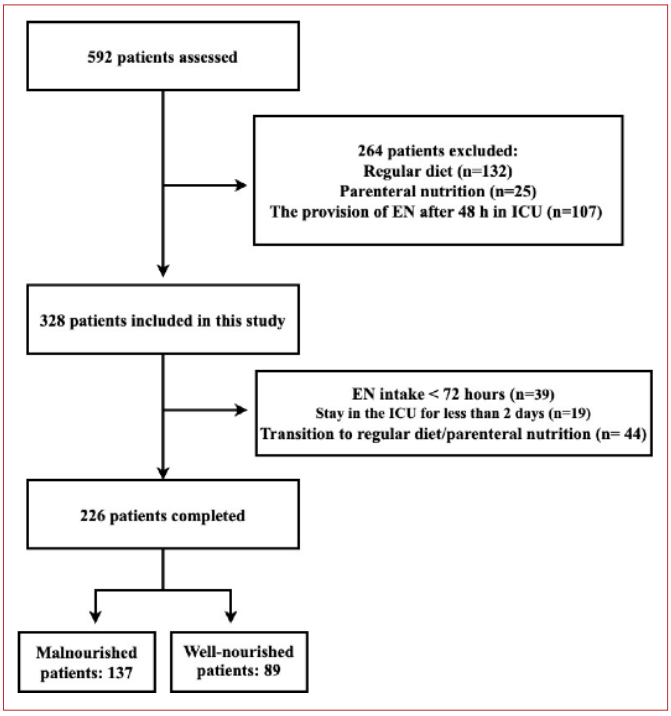

Figure 1. Study flowchart.

The majority of patients in both groups received duodenal enteral tube feeding (71.5% vs. 58.4%), with a median duration of 6 days (range: 4-7). While 79.8% of well-nourished patients received a standard EN product, 55.5% and 35.0% of malnourished patients received standard and renal EN products, respectively. Mean energy adequacy was significantly lower in malnourished patients (52.3 [42.6-72.0]) compared to well-nourished patients (68.3 [48.5-89.2], p=0.001). Furthermore, malnourished patients experienced a significantly higher frequency of enteral nutrition interruptions (ENI) compared to well-nourished patients (median: 2.9 vs. 2.4 hours/day, respectively, p=0.035) (Table 2).

Malnourished patients received significantly lower levels of iodine (median: 138.3 mcg; reference range: 150 mcg, p=0.042), iron (median: 16.0 mg; reference range: 18-30 mg, p=0.012), vitamin A (median: 813 mg; reference range: 900-1500 mg, p=0.016), and vitamin D (median: 11.0 mcg; reference range: 25 mcg, p<0.001). Additionally, well-nourished patients also received significantly lower levels of vitamin D (median: 14.2 mcg; reference range: 25 mcg, p<0.001). Other micronutrients were provided in accordance with ESPEN recommendations. Compared to well-nourished patients, malnourished patients achieved significantly lower intake levels of chromium, copper, iodine, iron, manganese, molybdenum, selenium, biotin, vitamin A, vitamin C, and vitamin D (p<0.05 for all) (Table 3).

Daily micronutrient intake for both malnourished and well-nourished patients over the seven-day study period is detailed in Table 1.

During the study period, the most common micronutrient inadequacies were observed for vitamin D (98.7% of patients; malnourished: 59.3%, well-nourished: 39.4%), folic acid (76.1%; malnourished: 46.5%, well-nourished: 29.6%), vitamin B3 (73.5%; malnourished: 43.4%, well-nourished: 30.1%), iodine (71.6%; malnourished: 45.1%, well-nourished: 26.5%), and iron (70.4%; malnourished: 44.7%, well-nourished: 25.7%) (Fig. 2).

Table 1. Characteristics of the study population

	Total (n=226)	Malnourished (n=137)	Well-nourished (n=89)	p
Age	65.0 (47.8-74.0)	67.0 (54.0-76.0)	53.0 (32.5-69.0)	**<0.001**
Gender				
Male	131 (58.0)	75 (54.7)	56 (62.9)	0.252
Female	95 (42.0)	61 (45.3)	34 (38.1)	
BMI	26.6 (24.7-29.3)	27.3 (25.0-30.9)	26.2 (24.2-28.6)	**0.047**
Reason for ICU admission				
Respiratory failure	85 (37.6)	56 (40.9)	29 (32.6)	0.061
Neurological disorders	44 (19.5)	23 (16.8)	21 (23.6)	
Sepsis/septic shock	39 (17.3)	24 (17.5)	15 (16.9)	
Metabolic disorders	21 (9.3)	17 (12.4)	4 (4.5)	
Trauma	21 (9.3)	7 (5.1)	14 (15.7)	
Cardiovascular disorders	12 (5.3)	7 (5.1)	5 (5.6)	
Postoperative	4 (1.7)	3 (2.2)	1 (1.1)	
APACHE II score	21.0 (16.0-26.0)	24.0 (20.0-28.0)	16.0 (13.8-19.3)	**<0.001**
SOFA score	8.0 (6.0-10.0)	9.0 (7.0-11.5)	6.0 (4.0-8.0)	**<0.001**
Charlson Comorbidity Index	3.0 (2.0-4.0)	3.0 (2.0-4.0)	2.0 (1.0-4.0)	**<0.001**
GCS score	6.0 (3.0-11.0)	6.0 (3.0-11.0)	6.0 (3.0-11.0)	0.944
mNUTRIC score	5.0 (3.0-6.0)	6.0 (5.0-7.0)	3.0 (2.0-4.0)	**<0.001**
NRS-2002 score	5.0 (4.0-6.0)	5.0 (4.0-6.0)	4.0 (3.0-5.0)	**<0.001**
Need for MV support	189 (83.6)	117 (61.9)	72 (38.1)	0.793
Duration of MV support	12.0 (4.3-18.0)	11.5 (5.0-18.0)	12.0 (4.0-22.8)	0.651
Length of ICU stay	15.0 (10.0-23.0)	14.0 (10.0-21.0)	15.0 (11.0-28.0)	0.136
Serum CRP	128.0 (24.7-219.0)	146.5 (51.8-231.0)	112.5 (9.0-140.3)	0.219
ICU mortality	149 (65.9)	97 (65.1)	52 (34.9)	**0.036**

*Continuous variables are presented as median (interquartile range [IQR]); categorical variables are presented as number (%).

Despite patients receiving a caloric intake exceeding 1,500 calories, 49.1% of the sample had inadequate levels of vitamin D, 22.6% had insufficient vitamin B3 intake, and 16.8% demonstrated a deficiency of biotin. The distribution of well-nourished and malnourished patients with inadequate micronutrient intake during the study period is presented in detail in Table 2.

Table 4 displays the results of the Cox regression analysis used to identify predictors of ICU mortality among all participants. In the univariate analysis, the mNUTRIC score (Hazard Ratio [HR] (95% Confidence Interval [Cl]): 1.231 [1.104-1.372], p<0.001), the percentage of target chromium intake achieved (HR (95% Cl): 1.066 [1.011-1.137], p=0.048), and the percentage of target vitamin C intake achieved (HR (95% Cl): 0.901 [0.819-0.992], p=0.034) were all significantly associated with ICU mortality. In the multivariate analysis, only the mNUTRIC score remained a significant predictor of ICU mortality (HR (95% Cl): 1.235 [1.112-1.371], p<0.001).

Kaplan-Meier analysis demonstrated that well-nourished patients had a significantly higher probability of survival compared to malnourished patients (median (95% CI): 29.0 [16.2-41.8] vs. 17.0 [15.0-19.0] days; log-rank chi-square: 10.965, p=0.001) (Fig. 3).

Discussion

This study demonstrated that malnourished patients had significantly lower intake of energy and several micronutrients (chromium, copper, iodine, iron, manganese, molybdenum, selenium, biotin, vitamin A, vitamin C, and vitamin D) compared to well-nourished patients. The most prevalent micronutrient inadequacies were observed for vitamins D, B3, and folic acid. Despite receiving a caloric intake exceeding 1,500 kcal, some patients still exhibited insufficient levels of vitamin D, vitamin B3, and biotin. The mNUTRIC score was a significant predictor of ICU mortality, and an mNUTRIC score >4 (indicating malnutrition) was significantly associated with a lower likelihood of survival.

Table 2. Nutritional data of the study participants

	Total (n=226)	Malnourished (n=137)	Well-nourished (n=89)	p
Route of enteral tube feeding				
Gastric	76 (33.6)	39 (28.5)	37 (41.6)	0.227
Duodenal	150 (66.4)	98 (71.5)	52 (58.4)	
Duration of enteral tube feeding (days)	6 (4-7)	6 (4-7)	6 (4-7)	0.872
Type of EN product, n (%)				
Standard (1.2 kcal/mL)	147 (65.0)	76 (55.5)	71 (79.8)	**0.001**
Renal (1.8 kcal/mL)	58 (25.7)	48 (35.0)	10 (11.3)	
Peptide-based (1.0 kcal/mL)	10 (4.4)	5 (3.6)	5 (5.6)	
Diabetes-specific (1.0 kcal/mL)	6 (2.7)	5 (3.6)	1 (1.1)	
Immune-modulating (1.0 kcal/mL)	3 (1.3)	2 (1.5)	1 (1.1)	
Pulmonary-specific (1.5 kcal/mL)	2 (0.9)	1 (0.8)	1 (1.1)	
Target energy intake, kcal/day	1583 (1491-1764)	1578 (1491-1750)	1592 (1428-1811)	0.936
Percentage of target energy achieved				
Day 1	37.3 (20.0-53.8)	34.1 (21.4-48.8)	41.7 (20.3-58.4)	0.301
Day 2	57.5 (29.1-83.6)	52.9 (26.5-73.9)	75.9 (50.7-94.4)	**<0.001**
Day 3	56.2 (31.3-81.0)	52.8 (27.0-70.5)	75.6 (46.0-92.6)	**0.001**
Day 4	58.6 (39.6-85.0)	56.1 (32.6-80.1)	71.5 (48.6-93.8)	**0.008**
Day 5	62.6 (47.2-85.4)	56.1 (32.5-79.2)	80.0 (59.2-97.2)	**<0.001**
Day 6	62.9 (46.0-86.2)	55.4 (38.2-8.4)	73.7 (52.9-94.8)	**0.008**
Day 7	63.2 (48.0-83.6)	56.0 (47.0-79.7)	74.5 (54.0-92.3)	0.056
Energy adequacy (%)	57.5 (44.2-77.9)	52.3 (42.6-72.0)	68.3 (48.5-89.2)	**0.001**
Target protein intake, g/day	82.8 (77.5-91.7)	82.0 (77.5-91.0)	83.2 (74.3-94.2)	0.936
Percentage of target energy achieved				
Day 1	48.3 (24.9-64.1)	48.4 (26.5-62.6)	49.9 (22.9-68.0)	0.667
Day 2	77.2 (35.6-100.0)	73.0 (33.3-89.6)	91.4 (49.0-109.0)	**0.002**
Day 3	76.7 (41.2-96.0)	70.9 (30.7-91.1)	84.1 (51.6-110.9)	**0.018**
Day 4	78.6 (50.9-97.5)	76.7 (47.5-95.4)	83.2 (58.1-103.9)	0.142
Day 5	83.3 (55.1-101.5)	77.9 (41.2-92.0)	92.1 (68.0-108.0)	**0.004**
Day 6	85.2 (56.2-102.9)	82.8 (52.9-96.8)	93.9 (59.0-111.4)	0.079
Day 7	86.2 (61.1-103.4)	82.8 (56.7-102.1)	92.0 (63.5-106.1)	0.618
Protein adequacy (%)	75.4 (54.7-92.0)	71.1 (53.9-89.8)	79.4 (56.0-97.9)	0.072
EN interruptions, hours/day	2.7 (1.1-5.6)	2.9 (0.9-6.6)	2.4 (1.2-5.5)	**0.035**

The findings also showed that malnutrition at the time of ICU admission was significantly associated with lower energy adequacy. This aligns with a study by Javid et al.[13] involving 1,321 critically ill patients, which found that higher mNUTRIC scores were associated with increased daily energy deficits. Another study similarly reported that patients with lower malnutrition risk scores achieved higher energy intake.[14] One plausible explanation for this trend is that malnourished patients may experience more frequent or prolonged interruptions in their enteral nutrition. Some studies reported that enteral nutrition interruptions can result in inadequate energy delivery in critically ill patients.[12,15] Malnourished individuals may face greater challenges in tolerating EN; therefore, it is important to incorporate this consideration into nutritional protocols for such patients to help improve clinical outcomes.

Malnourished patients received significantly lower levels of chromium, copper, iodine, iron, manganese, molybdenum, selenium, biotin, vitamin A, vitamin C, and vitamin D compared to well-nourished patients. This may be attributable to the reduced energy intake often observed in malnourished individuals. Nevertheless, the study findings revealed that patients received inadequate amounts of vitamin D, vitamin B3, and biotin

Table 3. Mean daily micronutrient intake of malnourished and well-nourished patients

	Total (n=226)	Malnourished (n=137)	Well-nourished (n=89)	p	Ref.
Chromium (mcg)	70.2 (41.4-102.8)	49.4 (33.5-92.0)	90.5 (54.6-113.4)	**<0.001**	**35**
Copper (mg)	1.0 (0.6-1.5)	0.9 (0.5-1.4)	1.2 (0.7-1.5)	**0.014**	**1-3**
Iodine (mcg)	155.7 (108.1-194.5)	138.3 (92.7-176.8)*	179.4 (129.3-215.5)	**<0.001**	**150**
Iron (mg)	18.1 (12.4-22.6)	16.0 (11.1-20.9)*	20.3 (13.3-25.0)	**0.005**	**18-30**
Manganese (mg)	3.3 (2.0-4.9)	2.4 (1.6-4.6)	4.4 (2.7-5.2)	**<0.001**	**2-3**
Molybdenum (mcg)	110.0 (9.1-158.9)	75.5 (7.0-146.8)	140.4 (87.2-168.7)	**<0.001**	**50-250**
Selenium (mcg)	73.6 (50.2-90.2)	60.6 (43.9-81.0)	82.0 (57.3-96.9)	**<0.001**	**50-150**
Zinc (mg)	15.1 (10.6-19.1)	14.4 (9.8-18.7)	16.0 (11.4-19.7)	0.052	10
Thiamine (mg)	2.2 (1.5-2.7)	2.2 (1.3-3.1)	2.2 (1.5-2.6)	0.545	1.5-3
Riboflavin (mg)	2.4 (1.6-3.2)	2.5 (1.4-3.6)	2.4 (1.7-2.9)	0.543	1.2
Niacin (mg)	17.1 (10.2-26.6)	16.5 (8.6-26.9)	14.6 (10.3-24.9)	0.910	18-40
Pantothenic acid (mg)	9.1 (6.2-12.2)	9.1 (5.2-12.4)	8.3 (6.5-11.3)	0.790	5
Vitamin B6 (mg)	2.7 (1.8-3.7)	2.8 (1.6-3.7)	2.7 (1.8-3.1)	0.634	1.5
Biotin (mcg)	42.8 (9.7-63.2)	29.8 (7.2-57.0)	57.7 (35.4-67.3)	**<0.001**	**30**
Folic acid (mcg)	362.4 (247.2-463.7)	351.8 (230.4-467.0)	376.2 (269.7-439.1)	0.701	330-400
Vitamin B_{12} (mcg)	3.6 (2.4-5.3)	3.7 (2.1-6.1)	3.6 (2.7-4.7)	0.747	2.5
Vitamin A (mg)	909 (651-1179)	813 (531-1026)*	1049 (784-1291)	**<0.001**	**900-1500**
Vitamin C (mg)	113.4 (78.3-149.8)	98.9 (63.5-138.2)	135.8 (96.4-164.4)	**<0.001**	**100**
Vitamin D (mcg)	11.8 (8.1-16.9)	11.0 (6.8-14.2)*	14.2 (10.6-19.6)*	**<0.001**	**25**
Vitamin E (mg)	22.1 (14.9-27.9)	21.0 (12.5-27.9)	21.6 (16.0-27.1)	0.669	15

despite consuming more than 1,500 kcal, which does not align with the recommendations outlined by ESPEN.[10] This issue likely relates to the composition of certain enteral nutrition products. These products can be enriched with micronutrients to help ensure adequate intake in critically ill patients.

It was also observed that malnourished patients received significantly lower amounts of iodine, iron, and vitamin A than recommended, while well-nourished patients received insufficient amounts of vitamin D. Given that the ESPEN micronutrient guideline has only recently been introduced, research on micronutrient intake in critically

Table 4. Cox Regression analysis of the mNUTRIC score, energy and micronutrient intake to predicting ICU mortality

	Univariate		Multivariate	
	HR (95% CI)	p	HR (95% CI)	p
mNUTRIC score	1.231 (1.104-1.372)	**<0.001**	1.235 (1.112-1.371)	**<0.001**
Energy intake (%)	1.006 (0.986-1.026)	0.575		
Chromium intake (%)	1.066 (1.011-1.137)	**0.048**	1.007 (0.992-1.023)	0.352
Copper intake (%)	1.000 (1.000-1.001)	0.051		
Iodine intake (%)	1.021 (0.980-1.063)	0.321		
Iron intake (%)	0.638 (0.360-1.130)	0.123		
Manganese intake (%)	2.550 (0.844-4.638)	0.061		
Molybdenum intake (%)	0.983 (0.929-1.041)	0.564		
Selenium intake (%)	1.052 (0.946-1.170)	0.353		
Biotin intake (%)	0.859 (0.717-1.029)	0.099		
Vitamin A intake (%)	0.999 (0.995-1.004)	0.771		
Vitamin C intake (%)	0.901 (0.819-0.992)	**0.034**	0.995 (0.984-1.006)	0.362
Vitamin D intake (%)	1.263 (0.922-1.729)	0.145		

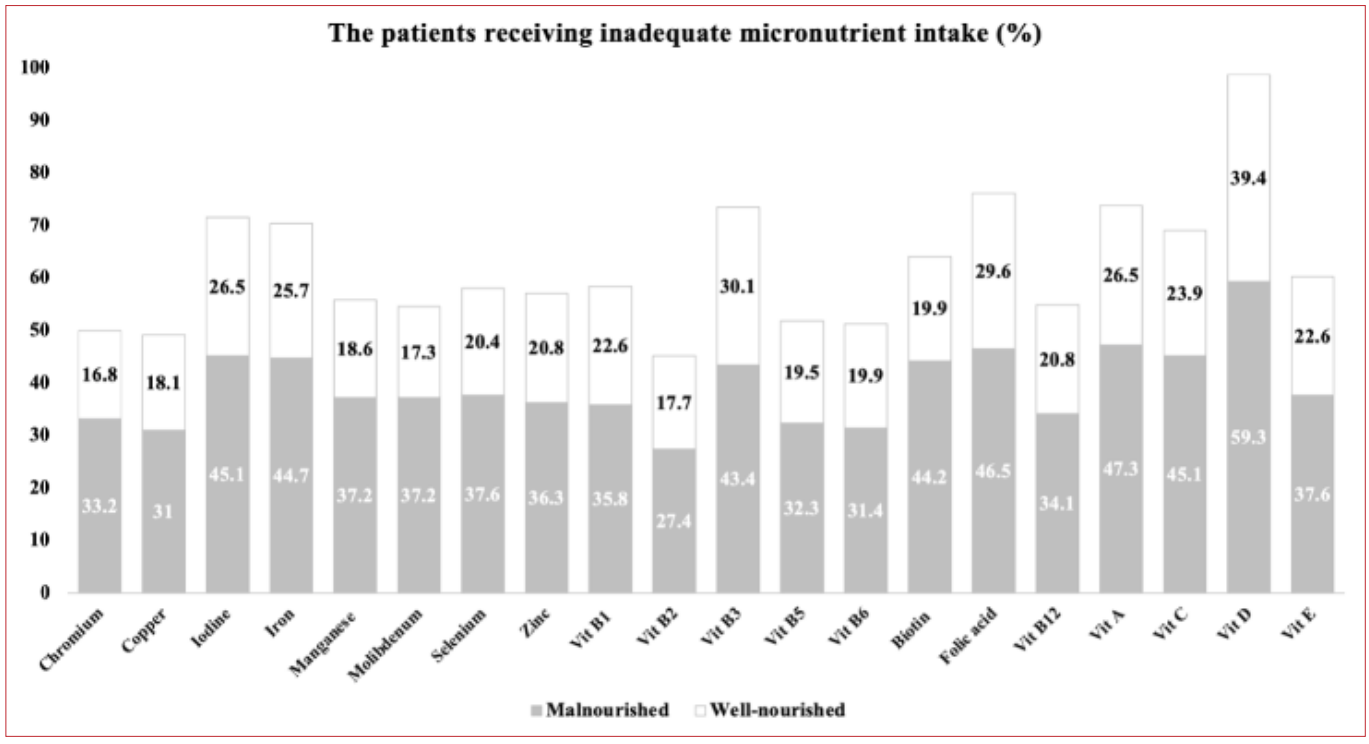

Figure 2. Proportion of patients with inadequate micronutrient intake.

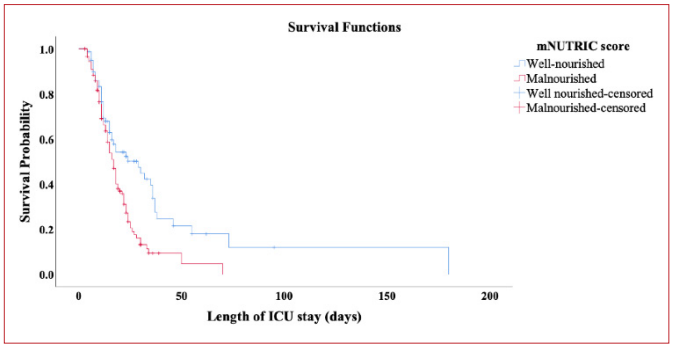

Figure 3. Survival analysis comparing malnourished and well-nourished patients.

ill patients remains limited. In this context, Kasti et al.[16] conducted a clinical study to examine the relationship between enteral nutrition interruptions and the intake of antioxidant micronutrients, including vitamins A, C, and D, as well as selenium, manganese, and zinc, in critically ill patients, in accordance with ESPEN recommendations. Patients received significantly lower intakes of all micronutrients, with the exception of manganese. The median duration of ENIs was 5.2 hours per day (range: 3.4-7.4), and most patients received less than 65% of their daily energy requirements. These findings may be explained by the fact that the sample in the referenced study experienced longer ENIs and lower energy intake compared to the sample in our study. On the other hand, a comprehensive review of 13 clinical trials examined micronutrient intake (including vitamin B12, vitamin D, vitamin C, vitamin A, thiamine, iron, zinc, and selenium) in critically ill patients receiving EN, based on the recommended dietary intakes of Australia and New Zealand. That review reported that patients received adequate levels of all micronutrients from EN, even when energy intake was suboptimal (<80% of adequacy).[17] The discrepancy between their findings and ours may be attributed to differences in the reference standards used.

The findings of this study indicated that the presence of malnutrition, as identified by the mNUTRIC score at the time of ICU admission, was a significant predictor of ICU mortality. Moreover, the survival probability of malnourished patients was significantly lower compared to well-nourished patients. Consistent with these findings, a significant association between the mNUTRIC score and 28-day mortality has been reported in medical ICU patients receiving enteral and/or parenteral nutrition.[7] Furthermore, Wang et al.[18] demonstrated that the mNUTRIC score was an independent risk factor for 28-day mortality in critically ill patients.

Multivariate Cox regression analysis also revealed that energy adequacy and the intake of certain micronutrients (chromium, copper, iodine, iron, manganese,

molybdenum, selenium, biotin, vitamins A, C, and D) were not significantly associated with ICU mortality. The relationship between energy adequacy and mortality in critically ill patients is inconsistent. One study conducted in an ICU population primarily receiving enteral nutrition found no association between energy adequacy and mortality. Similarly, a multicenter study involving 2,781 ICU patients reported no relationship between energy adequacy and 60-day mortality.[9] Conversely, some studies with smaller sample sizes have shown that increased energy intake is associated with reduced mortality in critically ill patients.[6,19] Several studies have also reported associations between dietary intake of copper,[20,21] iron,[22,23] manganese,[24] selenium,[25,26] and vitamins A,[21,26] and all-cause mortality in non-ICU populations. The findings concerning the effects of vitamin C[27] and vitamin D[28] supplementation on ICU mortality are inconclusive. However, the present data indicate that micronutrient intake is not associated with ICU mortality.

This study has certain limitations. First, the study population consisted exclusively of medical ICU patients, which may limit the generalizability of the findings to broader ICU populations. Second, the retrospective design of the study is a potential limitation, and the results should be confirmed by prospective clinical studies with larger sample sizes. Additionally, while medications can influence micronutrient and vitamin levels, this potential impact was not assessed. Despite these limitations, this study is among the first to comprehensively evaluate micronutrient deficiencies in relation to malnutrition at ICU admission, based on ESPEN recommendations.

In conclusion, the data demonstrated that patients with malnutrition at ICU admission exhibited significantly lower energy adequacy and intake of several micronutrients (specifically chromium, copper, iodine, iron, manganese, molybdenum, selenium, biotin, vitamin A, vitamin C, and vitamin D) compared to well-nourished patients. This discrepancy appeared to be associated with prolonged ENI in malnourished patients. Furthermore, some patients received insufficient amounts of vitamin D, vitamin B3, and biotin despite consuming more than 1,500 kcal. The mNUTRIC score was identified as an independent predictor of ICU mortality, whereas energy adequacy and micronutrient intake were not.

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Informed Consent: Informed consent was obtained from all study participants.

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