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# Nutritional Status in Intensive Care Unit: A Meta-Analysis and Systematic Review

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#### Abstract

It is important to consider the nutritional status of patients in the intensive care unit (ICU) since it is a key element in the ability to overcome and survive critical illnesses and clinical outcomes. The aim of the present study was to provide a meta-analysis and systematic overview in determining the nutritional status of patients in ICU by examining other studies. All studies published during 2015-2019 on nutritional status in ICU were retrieved from Medline (via PubMed), Embase, Scopus, and Web of Science databases. Finally, 23 articles were included in the meta-analysis. Results obtained from these studies showed that the nutritional status of patients in ICU was inappropriate (the pooled proportion of malnutrition was 0.51 in the type of study stratified), in which many patients in this unit had different degrees of malnutrition (moderate-mild malnourished and severe malnutrition is 0.46 and 20%, respectively). According to the results of this study, the nutritional status of patients in ICU was unsatisfactory; hence, it is necessary to consider the nutritional status along with other therapeutic measures at the beginning of the patient's admission. **[GMJ.2020;9:e1678] DOI:10.31661/gmj.v9i0.1678** 

Keywords: Nutritional Status; Intensive Care Unit; Systematic Review; Meta-Analysis

## Introduction

The intensive care unit (ICU) is a specialized ward at the hospital, in which patients with severe problems are admitted and undergo constant care and close supervision [1]. Most patients in ICU are unable to maintain a healthy diet due to their life-threatening and sometimes unconscious conditions [2]; therefore, paying attention to the nutritional status of patients in these units is very import-

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ant and is considered as one of the main factors in these wards [3]. In ICU, the nutritional status is a key factor in the ability to overcome critical diseases and to improve clinical outcomes [4, 5]. Nutrition and disease are closely related [6]. The reduction of nutrient intake, along with the increase in body needs and/or the use of modified nutrients, brings about the need to maintain homeostasis in ICU patients. On the other hand, these patients tend to have metabolic stress following a critical condition,

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Nutritional Status in ICU Patients

in which they develop systemic inflammatory responses [7]. Consequently, metabolism increases, and if adequate calories and protein are not provided for a healthy metabolism, it increases catabolism, reduces fat storage, and decreases muscle mass [8]. These conditions lead to protein-energy malnutrition (PEM), which is a major problem of hypercatabolic patients with severe conditions in the ICU [6, 8]. Studies have shown that malnutrition in ICU patients is more compared to other patients [9, 10]. In a study by Verghese et al., it was shown that all the studied patients admitted to the ICU had different levels of malnutrition [11]. Singh et al. revealed that the calorie and protein intakes of ICU patients were lower than the recommended level, and this is associated with a high mortality rate [12]. Many of the problems associated with PEM of ICU patients include the increase in hospital infections due to reduced immune function, delayed wound healing due to decreased tissue repair, delay in mechanical ventilation device isolation of patients due to changes in vital functions of the body and, depression and mental disorders [13]. One of the many factors identified in the etiology of malnutrition is the decreased food intake during hospitalization. Adequate daily intake is an essential factor in the treatment of malnutrition [14]; therefore, nutritional status has an impact on the ability to overcome critical conditions and clinical outcomes, especially in ICU patients. Inadequate food intake in these patients, in addition to nutritional deficiencies, can cause deterioration of health conditions and accelerate the onset of many disorders. The present study was conducted to determine the nutritional status of patients admitted to ICU.

## **Materials and Methods**

The systematic review and meta-analysis were performed according to the meta-analysis of observational studies in epidemiology (MOOSE) guidelines [15].

#### Search Strategy

We used four databases: Medline (via PubMed), Embase, Web of Science, and Scopus in this study. The search was restricted to the years 2015 to 2019 because the nutritional

status and prevalence of malnutrition in recent years was the focus of the present study. Keywords related to nutritional status in combination with words related to ICUs were used for search.

## Inclusion and Exclusion Criteria

In the present study, we included studies that were published between 1<sup>st</sup> January 2014 to 16<sup>th</sup> August 2019, were cohort, case-control, or cross-sectional studies, involved ICU unit type, had patient's referral date after 31<sup>st</sup> December 2013, and involved nutrition/malnutrition status. Also, old literature, pediatric, in which the patient's referral date was before 31<sup>st</sup> December 2013 studies were excluded from the systematic review.

## Data Extraction

After applying the inclusion and exclusion criteria for eligible studies, items such as first author name, sample size, number of malnutrition cases, method of obtained nutrition status, and findings were independently extracted by two reviewers after carefully reviewing the articles.

#### Quality Assessment

The quality of studies included in the meta-analysis was assessed using the Newcastle-Ottawa Scale (NOS) [16]. According to the NOS, studies scoring seven or more were regarded as having a low risk of bias; 4–6 a modest risk of bias; and studies <3 were considered to be at substantial risk of bias [17].

## Statistical Analysis

The proportion of the number of malnutrition cases to the total number of patients was analyzed using the metafor package in R software version 3.6.1 (https://www.r-project.org/) [18]. To assess the homogeneity between the studies, the Cochran's heterogeneity (Q) and I2 statistics were used. Based on these statistics, the fixed effect and random-effect models were applied to obtain the pooled proportion of the number of malnutrition cases [19]. Also, to assess publication bias, Egger's regression test for asymmetry studies was used [20, 21]. We used two strata (severe and mild-moderate) in the present study since all studies did not indicate all malnutrition status (severe,

moderate, and mild). Therefore, the stratified analysis was used to identify the burden of overall malnutrition status. Also, subgroup analysis performed for the type of studies include cross-sectional, case-control, and cohort studies as well as developed and developing countries for the proportion of patients with malnutrition regardless of malnutrition status.

## Results

## Study Selection

After a search in databases, we detected 8024 records (PubMed: 1571, Embase: 3126, Web of Science: 460, Scopus: 2863, and other sources: 4). Of these studies, 3287 were duplicates, 2873 did not include nutritional status, malnutrition, as well as the type of ICU unit. Then, 1875 records were removed after apply-

ing the filters (published during 2014-2019, the patient's referral date after 31<sup>st</sup> December 2013, and cross-sectional/ cohort/ case-control studies). After the screening of titles, abstracts, and full-text screening, 23 records [22-44] were included for systematic review and meta-analysis (Figure-1).

## Characteristics of Studies

From a total of 30942 subjects included in the 23 studies, 6845 subjects had malnutrition. The mean age of the subjects was 59.63 years. In all included studies, five studies were cross-sectional, two studies were case-control, and 16 studies were cohorts. Also, from these studies, only 13 studies indicated malnutrition status (the three malnutrition status in severe, moderate, and mild). Further details are shown in Table-1.



Table 1. Char	acteristic	s of the Ir	papulat	Studies.						
Author	Country	Type of study	Sample size	Mean age	Male gender	Sampling method	Type of feeding	Malnutrition criteria	Type of malnutrition	Follow- up
Al-Kalaldeh <i>et</i> al. (2018)	Jordan	Cross- sectional	321	60.03	211	Convenience	Tube feeding enteral nutrition	MUST and Phase Angle	MUST (low risk : 125, medium risk:65 , high risk:38) Phase angle (severe:54, moderate:79, mild: 95)	NA
Auiwattanakul <i>et al.</i> (2016)	Thailand	Cohort	1503	65	860	Convenience	Oral: 1375 Tube feed: 53 IV: 17 Combined: 43 none: 15	NRS-2002 score	Severe:319 Moderate:130 Mild:145	28 days
Ceniccola <i>et al.</i> (2018)	Brazil	Cohort	375	Non- malnutrition: 49.8 Malnutrition: 57.61 Severe malnutrition: 59.85	Non- malnutrition: 151 Malnutrition: 60 Severe malnutrition: 31	Convenience	Enteral nutrition	AND-ASPEN criteria	Not malnutrition: 229 Severe: 45 Moderate: 53	Until discharge or death
Coltman <i>et al.</i> (2015)	NA	Cohort	294	59	Total: 146 Malnutrition: 50	Convenience	Oral	SGA and NUTRIC	Severe:39 Moderate-mild:100	3 month
Dos Santos <i>et al.</i> (2019)	Brazil	Cohort	188	48.5	134	Convenience	NA	BMI and AC	Severe	12 month
Fetterplace <i>et</i> <i>al.</i> (2018)	Australia	Case- control	09	56	44	Random	Parenteral nutrition Enteral nutrition Tube feeding	SGA	Severe	15 days
Hiura <i>et al.</i> (2019)	America	Cohort	5606	NA	3029	Convenience	Enteral nutrition		Severe	12 month
Hope <i>et al</i> . (2017)	America	Cohort	95	57.1	51	Convenience	NA	Weight loss	Severe	10 month
Kalaiselvan <i>et</i> <i>al.</i> (2017)	India	Cohort	678	55.7	458	Convenience	NA	mNUTRIC score $\ge 5$	Severe	24 month
Kanekiyo <i>et al.</i> (2019)	Japan	Case- control	40	63.5	32	Random	Enteral nutrition oral	SGA	Well-nourished: 30 Mild-moderate malnutrition: 10 Severe malnutrition - 0	3 day
Continue in the	next page									

Severe 4 month	ow malnutrition: 261 24 month iigh malnutrition: 60 24	Severe 00014 month	Severe 14 month		Severe 14 month	Severe 14 month Severe 15 month	Severe14 monthSevere15 monthSevere:1830 daysModerate-mild:6030 days	Severe 14 month Severe 15 month Severe:18 30 days Moderate-mild:60 30 days Severe:416 Moderate: 270 12 month Mild:1319	Severe 14 month Severe 15 month Severe:18 30 days Moderate-mild:60 30 days Severe:416 12 month Mild:1319 12 month Mild:1319 12 month Mild:261 NA	Severe 14 month Severe 15 month Severe:18 30 days Moderate-mild:60 30 days Severe:416 12 month Mild:1319 12 month Mild:1319 12 month Mild:212 NA Mild:261 17 month Mild:214 17 month	Severe: 14 month Severe: 18 15 month Severe: 18 30 days Moderate-mild:60 30 days Severe: 416 012 month Mild: 1319 12 month Mild: 261 17 month Mild: 214 Severe: 22 Moderate: 162 17 month Mild: 214 Severe: 94 NA Mild: 38 NA	Severe: 18 15 month Severe: 18 15 month Severe: 18 30 days Severe: 18 30 days Severe: 416 12 month Midderate: 270 12 month Mild: 1319 12 month Mild: 1319 12 month Mild: 1319 12 month Mild: 214 14 17 month Mild: 214 162 17 month Mild: 214 17 month Mild: 214 162 17 month Mild: 214 17 month Mild: 214 162 17 month Mild: 214
	MST Lov Hig	SGA and mNUTRIC	SGA	V US	VDC	MST	MST CONUT score	MST MST CONUT score MUST	MST MST CONUT score MUST SGA	MST MST MUST SGA BMI and SGA	MST MST CONUT score MUST SGA SGA BMI and SGA Nutritional risk index	MST MST MUST MUST SGA SGA SGA SGA SGA NULTITIONAL Tisk index Nutritional Tisk index
NA	NA	NA	NA	NA		Enteral nutrition oral	Enteral nutrition oral NA C	Enteral nutrition oral NA C Oral	Enteral nutrition oral NA C Oral Enteral nutrition arenteral nutrition	Enteral nutrition oral Oral Oral Enteral nutrition arenteral nutrition NA E	Enteral nutrition oral NA C Oral Oral Enteral nutrition arenteral nutrition NA B	Enteral nutrition oral NA C Oral Oral Enteral nutrition arenteral nutrition NA B NA B Oral
Convenience	Consecutive	Consecutive	Consecutive	Consecutive	1	NA	NA <sup>1</sup> Consecutive	NA <sup>1</sup> Consecutive NA	NA Consecutive NA Convenience Pa	NA Consecutive NA Convenience Pa Convenience	NA Consecutive NA Convenience Pa Pa Convenience	NA Consecutive NA Convenience Pa Convenience Convenience
52	192	259	257	259	43		54	54 6276	54 6276 602	54 6276 602 306	54 6276 602 306 182	54 6276 602 306 182 39
68.7	59	61.4	61.6	61.6	59.3		61.4	61.4 NA	61.4 NA 58.6	61.4 NA 58.6 60.9	61.4 NA 58.6 60.9 61.4	61.4 NA 58.6 60.9 61.4 64.1
83	330	439	439	439	75		86	86 11750	86 11750 1053	86 11750 1053 398	86 111750 398 328	86 11750 1053 398 328 66
sectional	Cohort	Cohort	Cohort	Cohort	Cohort		Cohort	Cohort Cohort	Cohort Cohort Cohort Cross- sectional	Cohort Cohort Cross- sectional Cohort	Cohort Cohort Cross- sectional Cohort Cohort Sectional	Cohort Cohort Cross- sectional Cohort Cross- sectional Cohort Cohort
Brazil	America	Singapore	Singapore	Singapore	Australia Canada		Romania	Romania New Zealand	Romania New Zealand Argentina Brazil Chile Colombia Ecuador Mexico Panama Peru	Romania New Zealand Argentina Brazil Chile Colombia Ecuador Mexico Panama Peru Iran	Romania New Zealand Argentina Brazil Colombia Ecuador Mexico Panama Peru Iran	Romania New Zealand Argentina Brazil Colombia Ecuador Mexico Panama Peru Iran Brazil Brazil
Karst <i>et al.</i>	Lazarow <i>et al.</i> (2019)	Lew <i>et al.</i> (2018)	Lew <i>et al.</i> (2018)	Lew <i>et al.</i> (2019)	Marshall <i>et al.</i> (2017)		Rus <i>et al</i> . (2019)	Rus <i>et al.</i> (2019) Sharma <i>et al.</i> (2018)	Rus <i>et al.</i> (2019) Sharma <i>et al.</i> (2018) (2017)	Rus <i>et al.</i> (2019) Sharma <i>et al.</i> (2018) (2017) (2017) Velayati <i>et al.</i> (2019)	Rus et al. (2019) Sharma et al. (2018) (2017) (2017) Velayati et al. (2019) Martins et al. (2017)	Rus <i>et al.</i> (2019) Sharma <i>et al.</i> (2018) (2017) Velayati <i>et al.</i> (2019) Martins <i>et al.</i> (2017) Fischer <i>et al.</i>

## **Overall Publication Bias**

Based on the funnel plot, Egger's, and rank regression test, there was a significant publication bias between studies. The P-value of Egger's regression test was 0.004. The funnel plot is presented in Figure-2.

## Stratified Malnutrition Status

The present meta-analysis consists of three stratified malnutrition status, including severe, moderate, and mild. Therefore, since all the studies did not include all three status, we combined the moderate and mild conditions and compared them with the severe condition. The results of this section show that the proportion of people who are mild-moderate malnourished and severe malnutrition is 0.46 (with a 95% confidence interval [CI] 0.28 -0.64) and 0.20 (with a 95% CI 0.14 - 0.27), respectively. Since heterogeneity was higher than =98% (P<0.01), a random effect model was used to construct the combined confidence interval. The Forest plot for stratified malnutrition status is presented in Figure-3.

# Subgroup Analysis

Subgroup analysis was performed for all included study types (cross-sectional, case-control, and cohort studies) and countries development (developed and developing). Therefore, the proportion of people who are malnourished in cross-sectional/case-control/ cohort studies and developed/developing countries are 0.82 (95% CI: 0.62 - 0.92) / 0.2 (95% CI: 0.13 - 0.30) / 0.43 (95% CI: 0.33 - 0.54) and 0.37 (95% CI: 0.28 - 0.46) / 0.64 (95% CI: 0.48 - 0.78), respectively. Finally, the pooled proportion in the two subgroups analysis was 0.51 (95% CI: 0.39 - 0.62). Forest plot for subgroup analysis is presented in Figures-4 and 5.

## **Evaluated Studies**

Based on the three categories of NOS, the total score for one study is 8; for two studies is 7, for two studies is 6, for five studies is 5, for five studies is 4, for six studies is 3, and for two studies is 2. Assessments of studies are shown in Table-2.

# Discussion

These studies have shown that the nutritional status of patients in ICU is inappropriate with a high percentage of different degrees of malnutrition (the pooled proportion was 51%). Also, severe malnutrition in this unit is 20%, and for developing countries is 64%. Malnutrition is a serious problem among many ICU patients [8]. Studies have shown that not pay-



Figure 2. Funnel plot asymmetry for publication bias in 23 studies.

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Study	Evente	Total			Proportion	95%-01	(fixed)	(random)
Study	Events	Total			rioportion	5576-01	(lixed)	(random)
Type of malnutrition = Ma	oderate 8	Mild						
Al-Kalaldeh et al. (2018)	174	321		<b>—</b>	0.54	[0.49; 0.60]	1.7%	2.9%
Aujwattanakul et al. (2016)	275	1503			0.18	10.16: 0.201	4,9%	2.9%
Ceniccola et al. (2018)	282	375		-	0.75	0.71: 0.791	1.5%	2.9%
Coltman et al. (2015)	100	294			0.34	0.29; 0.40	1.4%	2.9%
Kanekiyo et al. (2019)	10	40	<u> </u>		0.25	[0.14: 0.41]	0.2%	2.7%
Lazarow et al. (2019)	221	330		-	0.67	0.62; 0.72	1.6%	2.9%
Rus et al. (2019)	68	86		_	0.79	[0.69; 0.86]	0.3%	2.8%
Sharma et al. (2018)	1589	11750			0.14	[0.13; 0.14]	29.7%	2.9%
Vallejo et al. (2017)	773	1053		+	0.73	[0.71; 0.76]	4.4%	2.9%
Velayati et al. (2019)	236	398		-	0.59	[0.54; 0.64]	2.1%	2.9%
Martins et al. (2017)	177	328		<b>—</b>	0.54	[0.49; 0.59]	1.8%	2.9%
Fischer et al. (2018)	10	66			0.15	[0.08; 0.26]	0.2%	2.7%
Hachemi et al. (2015)	77	185	· · ·	_	0.42	[0.35; 0.49]	1.0%	2.9%
Fixed effect model		16729	٠		0.25	[0.24; 0.26]	50.7%	
Random effects model					0.46	[0.28; 0.64]		37.3%
Heterogeneity: $l^2 = 100\%$ , $\tau^2$	= 1.9531,	p = 0						
Type of malnutrition = Se	vere							
Al-Kalaldeh et al. (2018)	54	321			0.17	[0.13; 0.21]	1.0%	2.9%
Auiwattanakul et al. (2016)	319	1503			0.21	[0.19; 0.23]	5.4%	2.9%
Ceniccola et al. (2018)	45	375	-		0.12	[0.09; 0.16]	0.9%	2.9%
Coltman et al. (2015)	39	294	-		0.13	[0.10; 0.18]	0.7%	2.9%
Dos Santos et al. (2019)	95	188			0.51	[0.43; 0.58]	1.0%	2.9%
Fetterplace et al. (2018)	10	60			0.17	[0.09; 0.28]	0.2%	2.7%
Hura et al. (2019)	/20	5606			0.13	[0.12; 0.14]	13.7%	2.9%
Hope et al. (2017)	19	90			0.20	[0.13; 0.29]	0.3%	2.6%
Kalaiservan et al. (2017)	228	0/0	-		0.34	[0.30; 0.37]	3.3%	2.9%
Karst et al. (2015)	60	330			0.71	[0.60; 0.60]	1.190	2.6%
Lazarow et al. (2019)	123	430	T_		0.18	[0.14, 0.23]	1.0%	2.5%
Lew et al. (2018)	123	439			0.28	10 24 0 321	1 9%	2.9%
Lew et al. (2019)	123	430	1		0.28	10 24 0 321	1 096	2.0%
Marshall et al. (2017)	18	75			0.24	10 16: 0 351	0.3%	2.8%
Rus et al. (2019)	18	86			0.21	10.14: 0.311	0.3%	2.8%
Sharma et al. (2018)	416	11750			0.04	10 03 0 041	8.7%	2.9%
Vallejo et al. (2017)	233	1053	+		0.22	0.20; 0.25	3.9%	2.9%
Velavati et al. (2019)	22	398	+		0.06	[0.04: 0.08]	0.4%	2.8%
Martins et al. (2017)	94	328			0.29	0.24: 0.341	1.5%	2.9%
Fischer et al. (2018)	3	66			0.05	0.01; 0.13	0.1%	2.3%
Hachemi et al. (2015)	23	185			0.12	[0.08; 0.18]	0.4%	2.8%
Fixed effect model		24791			0.15	[0.14; 0.16]	49.3%	
Random effects model			$\Leftrightarrow$		0.20	[0.14; 0.27]		62.7%
Heterogeneity: $I^2 = 99\%$ , $\tau^2 =$	0.8990, p	0 = 0						
Eived effect model		41620			0.20	10 10- 0 201	100.08/	
Random effects model		41020	-		0.20	10.21-0.361	100.0%	100.0%
Heteropeneity: $l^2 = 90\% r^2 =$	1 2774	= 0	$\sim$		0.20	[0.21, 0.30]		100.070
Residual beter consister t <sup>2</sup> = 1	00% o = 0		02 04	06 09				
reasonal neterogeneity. T = :	<i>io m</i> , p = 0		0.2 0.4	0.0 0.0				

Figure 3. Forest plot for stratified malnutrition status.

ing attention to the nutritional needs of ICU patients can lead to deterioration of the disease, increased length of the disease, ventilator dependence, and high cost [34, 35, 45, 46]. Studies also indicate that disruption in the provision of nutritional needs of ICU patients leads to a higher calorie deficit during critical periods of the disease. Some factors which can cause inadequate nutrition in patients include nutritional disruption for diagnostic procedures, nutrition discontinuation in managing the remaining gastric ulcer, lack of nutritional requirements, and delayed nutritional support [2, 9]. In modern medicine, the concept of "nutrition therapy" is a substitute for supportive nutrition, which plays a vital role in the nursing care of ICU patients [3]. Relatively, specific measures that have to be taken include periodic visits by a nutritionist and implementation of nutritional guidelines for ICU patients. Studies have shown that nutritional counseling, along with diverse strategies of a nutritional support team at the hospital, especially ICU, has led to a reduction in the

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	_	_			_		weight	weight
Study	Events	Total			Proportion	95%-CI	(fixed)	(random)
Type of study = cross-se	ctional		:	1				
Al-Kalaldeh et al. (2018)	277	321		+	0.86	[0.82: 0.90]	1.1%	4.4%
Karst et al. (2015)	59	83			0.71	10.60: 0.801	0.5%	4.3%
Valleio et al. (2017)	1003	1053			0.95	0.94: 0.961	1.3%	4.4%
Martins et al. (2017)	271	328		-	0.83	0.78: 0.86	1.3%	4.4%
Hachemi et al. (2015)	100	185			0.54	[0.47; 0.61]	1.3%	4.4%
Fixed effect model		1970		۵	0.83	[0.81: 0.85]	5.4%	
Random effects model				$\sim$	0.82	[0.62; 0.92]		22.0%
Heterogeneity: $I^2 = 98\%$ , $\tau^2 =$	1.2712, p	< 0.01						
Type of study = cohort								
Auiwattanakul et al. (2016)	594	1503	-		0.40	[0.37; 0.42]	10.0%	4.5%
Ceniccola et al. (2018)	327	375		+	0.87	[0.83; 0.90]	1.2%	4.4%
Coltman et al. (2015)	139	294		+	0.47	[0.42; 0.53]	2.0%	4.4%
Dos Santos et al. (2019)	95	188		←	0.51	[0.43; 0.58]	1.3%	4.4%
Hiura et al. (2019)	726	5606			0.13	[0.12; 0.14]	17.6%	4.5%
Hope et al. (2017)	19	95	-+		0.20	[0.13; 0.29]	0.4%	4.3%
Kalaiselvan et al. (2017)	228	678	+		0.34	[0.30; 0.37]	4.2%	4.5%
Lazarow et al. (2019)	322	330			+ 0.98	[0.95; 0.99]	0.2%	4.1%
Lew et al. (2018)	123	439	<del>!</del>		0.28	[0.24; 0.32]	2.5%	4.5%
Lew et al. (2018)	123	439	÷		0.28	[0.24; 0.32]	2.5%	4.5%
Lew et al. (2019)	123	439	֥		0.28	[0.24; 0.32]	2.5%	4.5%
Marshall et al. (2017)	18	75	$\rightarrow$		0.24	[0.16; 0.35]	0.4%	4.3%
Rus et al. (2019)	78	86	_ 1		0.91	[0.82; 0.95]	0.2%	4.1%
Sharma et al. (2018)	2005	11750			0.17	[0.16; 0.18]	46.2%	4.5%
Velayati et al. (2019)	184	398	÷ -+		0.46	[0.41; 0.51]	2.7%	4.5%
Fischer et al. (2018)	13	66	<del></del>		0.20	[0.12; 0.31]	0.3%	4.2%
Fixed effect model		22761	•		0.22	[0.21; 0.23]	94.1%	
Random effects model			$\sim$	*	0.43	[0.33; 0.54]		69.9%
Heterogeneity: $I^2 = 99\%$ , $\tau^2 =$	0.7305, p	= 0						
Type of study = case-cor	ntrol							
Fetterplace et al. (2018)	10	60	<del>+</del>		0.17	[0.09; 0.28]	0.2%	4.1%
Kanekiyo et al. (2019)	10	40	<u> </u>		0.25	[0.14; 0.41]	0.2%	4.1%
Fixed effect model		100	$\Leftrightarrow$		0.20	[0.13; 0.29]	0.4%	
Random effects model			<u></u>		0.20	[0.13; 0.30]		8.2%
Heterogeneity: $I^2 = 3\%$ , $\tau^2 = 0$	0.0038, p I	0.31						
Fixed effect model		24831			0.25	[0.24; 0.25]	100.0%	
Random effects model				>	0.51	[0.39; 0.62]		100.0%
Heterogeneity: I2 = 99%, t2 =	1.2923, p	= 0						
Residual heterogeneity: 12 = 9	99%, p = 0		0.2 0.4	0.6 0.8				

Figure 4. Forest plot for cross-sectional, case-control, and cohort studies subgroup analysis.

prevalence of malnutrition [47, 48]. The presence of experts and nutritional support team can significantly improve the performance of ICU staff by providing adequate nutritional support [49]. In a study performed by Park et al., the presence of a nutritional support team had a positive and significant effect on the nutritional and clinical outcomes of ICU patients [48]. Evidence suggests that using these guidelines and nutritional protocols can help increase nutritional adequacy and prevent complications arising from inappropriate nutrition in ICU patients [50-52]. ICU patients are a heterogeneous group, and in order to meet their nutritional needs, a single approach cannot be used for each patient. The medical

diagnosis of the different stages of the disease (early, post-recovery, stabilized, longterm residence) and any other complications should be taken into account simultaneously [2]. Nevertheless, the protocols provided by the European Society for Clinical Nutrition and Metabolism (ESPEN) present a set of nutrient recommendations in most clinical cases of the ICU [53]. Some of the advantages of using ESPEN protocols include timely and correct identification of high-risk patients, nutritional evaluation of ICU patients, determination of energy needs for each patient, and selecting appropriate methods to provide nutritional support based on the patients' clinical conditions [2].

Study         Events         Total         Proportion         95%-Cl         (fixed) (random)           Country = Developing         Al-Kalaideh et al. (2018)         273         321         +         0.85         [0.81; 0.89]         1.1%         4.4%           Ali-Kalaideh et al. (2018)         327         375         +         0.47         [0.42; 0.53]         2.0%         4.4%           Coltman et al. (2015)         139         294         -         0.47         [0.43; 0.58]         1.3%         4.4%           Coltman et al. (2017)         228         678         -         0.34         [0.30; 0.37]         4.2%         4.5%           Karist et al. (2017)         1003         1053         +         0.95         [0.94; 0.96]         1.3%         4.4%           Velayati et al. (2017)         1003         1053         +         0.46         [0.41; 0.51]         2.7%         4.5%           Valeigo et al. (2017)         171         328         +         0.46         [0.41; 0.51]         2.7%         4.5%           Fixed effect model         5287         0.32         [0.51; 0.54]         26.0%         -         -         0.64         [0.48; 0.78]         -         48.4%           Heterog										Weight	Weight
Country = Developing       Al-Kalaldeh et al. (2018)       273       321       +       0.85       [0.81; 0.89]       1.1%       4.4%         Auiwattanakul et al. (2016)       594       1503       +       0.40       [0.37; 0.42]       10.0%       4.5%         Ceniccola et al. (2015)       139       294       0.47       [0.42; 0.53]       2.0%       4.4%         Coltman et al. (2017)       228       678       -       0.47       [0.42; 0.53]       2.0%       4.4%         Kalaiselvan et al. (2017)       1003       1053       +       0.95       [0.94; 0.96]       1.3%       4.4%         Vallejoe et al. (2017)       1003       1053       +       0.95       [0.94; 0.96]       1.3%       4.4%         Velayati et al. (2018)       13       66       -       0.95       [0.94; 0.96]       1.3%       4.4%         Fischer et al. (2018)       13       66       -       0.20       [0.12; 0.51]       0.3%       4.2%         Heterogeneity: $t^2 = 99\%$ , $t^2 = 1.3080$ , $p < 0.01$ -       -       0.52       [0.51; 0.54]       26.0%       -         Country = Developed       -       -       0.17       [0.09; 0.28]       0.2%       4.1% <t< th=""><th>Study</th><th>Events</th><th>Total</th><th></th><th></th><th></th><th></th><th>Proportion</th><th>95%-CI</th><th>(fixed)</th><th>(random)</th></t<>	Study	Events	Total					Proportion	95%-CI	(fixed)	(random)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Country = Developing					1					
Auiwattanakul et al. (2016)       594       1503       +       0.40 $[0.37; 0.42]$ $10.0\%$ 4.5%         Ceniccola et al. (2018)       327       375       +       0.87 $[0.83; 0.90]$ $1.2\%$ $4.4\%$ Dos Santos et al. (2017)       139       294       +       0.47 $[0.43; 0.58]$ $1.3\%$ $4.4\%$ Karst et al. (2017)       228       678       -       0.41 $[0.51]$ $0.43; 0.58]$ $1.3\%$ $4.4\%$ Vallejo et al. (2017)       1003       1053       +       0.95 $[0.94; 0.96]$ $1.3\%$ $4.4\%$ Velayati et al. (2017)       1003       1053       +       0.83 $[0.78; 0.86]$ $1.3\%$ $4.4\%$ Velayati et al. (2017)       13       271       328       +       0.83 $[0.78; 0.86]$ $1.3\%$ $4.4\%$ Fixed effect model       5287       0.20 $[0.12; 0.31]$ $0.3\%$ $4.2\%$ Heterogeneity: $t^2 = 99\%$ , $t^2 = 1.3080$ , $p < 0.01$ 0.01 $0.25$ $0.14!$ $0.214!$ $17.6\%$ $4.5\%$ Lazarow et al. (2018)       123       439       + $0.28$ $0.24!$	Al-Kalaldeh et al. (2018)	273	321				-	0.85	[0.81; 0.89]	1.1%	4.4%
$\begin{array}{c} \text{Ceniccola et al. (2018)} & 327 & 375 \\ \text{Coltman et al. (2015)} & 139 & 294 \\ \text{Coltman et al. (2015)} & 139 & 294 \\ \text{Coltman et al. (2017)} & 228 & 678 \\ \text{Kalaiselvan et al. (2017)} & 228 & 678 \\ \text{Kalaiselvan et al. (2017)} & 1003 & 1053 \\ \text{Vallejo et al. (2017)} & 1003 & 1053 \\ \text{Velayati et al. (2017)} & 1003 & 1053 \\ \text{Fischer et al. (2018)} & 13 & 66 \\ \text{Fischer et al. (2018)} & 13 & 66 \\ \text{Fischer et al. (2018)} & 13 & 66 \\ \text{Heterogeneity: } l^2 = 99\%, \tau^2 = 1.3080, p < 0.01 \\ \text{Country = Developed} \\ \text{Fetterplace et al. (2018)} & 10 & 60 \\ \text{Heterogeneity: } l^2 = 99\%, \tau^2 = 1.3080, p < 0.01 \\ \text{Country = al. (2017)} & 19 & 95 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2018)} & 123 & 439 \\ \text{Lew et al. (2017)} & 18 & 75 \\ \text{Ruschan et al. (2015)} & 100 & 185 \\ \text{Fixed effect model} & 19544 \\ \text{Heterogeneity: } l^2 = 98\%, \tau^2 = 0.4269, p < 0.01 \\ \end{array}$	Auiwattanakul et al. (2016)	594	1503		+			0.40	[0.37; 0.42]	10.0%	4.5%
Coltman et al. (2015)       139       294        0.47 $[0.42; 0.53]$ 2.0%       4.4%         Dos Santos et al. (2017)       228       678       0.51 $[0.43; 0.58]$ 1.3%       4.4%         Karst et al. (2015)       59       83        0.47 $[0.43; 0.53]$ 2.0%       4.4%         Vallejo et al. (2017)       1003       1053        0.47 $[0.43; 0.53]$ 2.0%       4.4%         Velayati et al. (2017)       1003       1053        0.46 $[0.41; 0.51]$ 2.7%       4.5%         Martins et al. (2017)       271       328        0.46 $[0.41; 0.51]$ 2.7%       4.5%         Martins et al. (2018)       13       66        0.83 $[0.78; 0.86]$ 1.3%       4.4%         Heterogeneity: $l^2$ = 99%, $r^2$ = 1.3080, $p < 0.01$ 0.64 $[0.48; 0.78]$ 48.4%         Kanekiyo et al. (2018)       10       60        0.64 $[0.48; 0.78]$ 48.4%         Leavarow et al. (2018)       10       40        0.64 $[0.48; 0.73]$ 48.4%         Leavarow	Ceniccola et al. (2018)	327	375				-	0.87	[0.83; 0.90]	1.2%	4.4%
Dos Santos et al. (2019) 95 188 Kalaiselvan et al. (2017) 228 678 Karst et al. (2017) 228 678 Karst et al. (2017) 228 678 Vallejo et al. (2017) 1003 1053 Vallejo et al. (2017) 1003 1053 Velayati et al. (2017) 271 328 Fischer et al. (2018) 13 66 Fischer et al. (2018) 13 66 Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ Country = Developed Fetterplace et al. (2019) 726 5606 $\Box$ Kanekiyo et al. (2019) 726 5606 $\Box$ Fitzed effect model (2019) 726 5606 $\Box$ Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ Country = Developed Fetterplace et al. (2018) 10 60 Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ Country = Developed Fetterplace et al. (2019) 726 5606 $\Box$ Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ Country = Developed Fetterplace et al. (2019) 10 40 Lew et al. (2019) 322 330 Lew et al. (2019) 123 439 Kus et al. (2019) 123 439 Harshall et al. (2017) 18 75 Kus et al. (2018) 2005 11750 Hachemi et al. (2018) 2005 11750 Fixed effect model 19544 Heterogeneity: $l^2 = 98\%$ , $\tau^2 = 0.4269$ , $\rho < 0.01$	Coltman et al. (2015)	139	294		-+	-		0.47	[0.42; 0.53]	2.0%	4.4%
Kalaiselvan et al. (2017)       228 $678$ +       0.34       [0.30; 0.37] $4.2\%$ $4.5\%$ Karst et al. (2015)       59       83       +       0.95       [0.94; 0.96] $1.3\%$ $4.4\%$ Velayati et al. (2017)       1003       1053       +       0.95       [0.94; 0.96] $1.3\%$ $4.4\%$ Velayati et al. (2017)       271       328       +       0.83       [0.78; 0.86] $1.3\%$ $4.4\%$ Fischer et al. (2018)       13       66       +       0.20       [0.12; 0.31] $0.3\%$ $4.2\%$ Fixed effect model       5287       -       0.64       [0.48; 0.78]       -       48.4%         Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ -       0.64       [0.48; 0.78]       -       48.4%         Low et al. (2019)       10       60       +       0.17       [0.09; 0.28]       0.2%       4.1%         Lew et al. (2018)       123       439       +       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       +       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2018)       123	Dos Santos et al. (2019)	95	188		_	<u> </u>		0.51	[0.43; 0.58]	1.3%	4.4%
Karst et al. (2015) 59 83 Vallejo et al. (2017) 1003 1053 Velayati et al. (2017) 1003 1053 Martins et al. (2019) 184 3986 Fixed effect model 5287 Random effects model 5287 Fetterplace et al. (2018) 10 60 Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ Country = Developed Fetterplace et al. (2019) 10 40 Heure et al. (2017) 19 95 Law et al. (2019) 10 40 Law et al. (2018) 123 439 Lew et al. (2019) 123 439 Marshall et al. (2017) 18 75 Kus et al. (2019) 123 439 Heure et al. (2019) 123 439 Harshall et al. (2017) 18 75 Kus et al. (2018) 2005 11750 Karachemi et al. (2018) 2005 11750 Harshall et al. (2015) 100 185 Harshall et al. (2015) 100 185 Heure et al. (2018) 2005 11750 Harshall et al. (2015) 100 185 Harshall et al. (2016) 1.3, 44.4% Harshall et al. (2017) 18 75 Harshall et al. (2018) 75 Harshall et al. (2017) 75 Harshal	Kalaiselvan et al. (2017)	228	678		-			0.34	[0.30; 0.37]	4.2%	4.5%
Vallejo et al. (2017)       1003       1053       +       0.95       (0.94; 0.96)       1.3%       4.4%         Velayati et al. (2019)       184       398       +       0.46       [0.41; 0.51]       2.7%       4.5%         Martins et al. (2017)       271       328       +       0.83       [0.78; 0.86]       1.3%       4.4%         Fixed effect model       5287       •       0.20       [0.12; 0.31]       0.3%       4.2%         Random effects model       5287       •       0.52       [0.51; 0.54]       26.0%          Random effects model       5287       •       0.52       [0.51; 0.54]       26.0%          Random effects model       5287       •       0.64       [0.48; 0.78]        48.4%         Heterogeneity: $l^2$ = 99%, $\tau^2$ = 1.3080, $p < 0.01$ •       0.17       [0.09; 0.28]       0.2%       4.1%         Kanekiyo et al. (2017)       19       95        0.20       [0.13; 0.29]       0.4%       4.3%         Lew et al. (2018)       123       439        0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2018)       123       439        0.28 <t< td=""><td>Karst et al. (2015)</td><td>59</td><td>83</td><td></td><td></td><td></td><td></td><td>0.71</td><td>[0.60; 0.80]</td><td>0.5%</td><td>4.3%</td></t<>	Karst et al. (2015)	59	83					0.71	[0.60; 0.80]	0.5%	4.3%
Velayati et al. (2019)184398 $$ 0.46(0.41; 0.51]2.7%4.5%Martins et al. (2017)271328 $$ 0.83(0.78; 0.86]1.3%4.4%Fischer et al. (2018)1366 $$ 0.52(0.51; 0.54]26.0% $$ Random effects model5287 $$ 0.64(0.41; 0.51]2.7%4.5%Heterogeneity: $l^2$ = 99%, $\tau^2$ = 1.3080, $p < 0.01$ $$ 0.64(0.41; 0.51]2.7%4.5%Country = Developed $$ 0.64(0.48; 0.78] $$ 48.4%Hiura et al. (2019)7265606 $$ 0.17[0.09; 0.28]0.2%4.1%Kanekiyo et al. (2019)1040 $$ 0.25[0.14; 0.41]0.2%4.1%Lew et al. (2018)123439 $$ 0.98[0.95; 0.99]0.2%4.1%Lew et al. (2018)123439 $$ 0.28[0.24; 0.32]2.5%4.5%Marshall et al. (2017)1875 $$ 0.28[0.24; 0.32]2.5%4.5%Marshall et al. (2019)7886 $$ 0.28[0.24; 0.32]2.5%4.5%Marshall et al. (2018)200511750 $$ 0.18(0.47; 0.61]1.3%4.4%Hachemi et al. (2015)100185 $$ 0.37(0.28; 0.46] $$ 51.6%Hachemi et al. (2015)100185 $$ 0.37(0.28; 0.46] $$ 51.6%Heterogeneity: $l^2$ =	Vallejo et al. (2017)	1003	1053				+	0.95	[0.94; 0.96]	1.3%	4.4%
Martins et al. (2017)       271       328	Velayati et al. (2019)	184	398		-+-	-		0.46	[0.41; 0.51]	2.7%	4.5%
Fixed effect model       13       66       0.20       0.12; 0.31]       0.3%       4.2%         Fixed effect model       5287       0.52       0.52       0.52       0.51; 0.54]       26.0%          Random effects model       5287       0.64       0.48; 0.78]        48.4%         Heterogeneity: $l^2$ = 99%, $\tau^2$ = 1.3080, $p < 0.01$ 0.17       0.09; 0.28]       0.2%       4.1%         Country = Developed       0.17       0.09; 0.28]       0.2%       4.1%         Hope et al. (2019)       10       40       0.20       0.13; 0.29       0.4%       4.3%         Lew et al. (2018)       123       439       +       0.28       0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       +       0.28       0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75       0.24       0.28       0.24; 0.32]       2.5%       4.5%         Marshall et al. (2019)       78       86        0.28       0.24; 0.32]       2.5%       4.5%         Marshall et al. (2018)       2005       11750        0.28       0.24; 0.32]       2.5%       4.5%	Martins et al. (2017)	271	328				-	0.83	[0.78; 0.86]	1.3%	4.4%
Fixed effect model       5287 $\diamond$ 0.52 [0.51; 0.54]       26.0%          Random effects model       Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $p < 0.01$ 0.64 [0.48; 0.78]        48.4%         Country = Developed       0.17 [0.09; 0.28]       0.2%       4.1%         Hiura et al. (2019)       726 5606       0       0.13 [0.12; 0.14]       17.6%       4.5%         Hope et al. (2019)       10 40       0.20 [0.13; 0.29]       0.4%       4.3%         Lew et al. (2018)       123 439        0.28 [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123 439        0.28 [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18 75        0.28 [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2019)       78 86        0.28 [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2018)       2005 11750         0.28 [0.24; 0.32]       2.5%       4.5%         Hachemi et al. (2015)       100 185         0.37 [0.28; 0.46]        0.37 [0.28; 0.46]        51.6%	Fischer et al. (2018)	13	66	-++	-			0.20	[0.12; 0.31]	0.3%	4.2%
Random effects model       0.64 [0.48; 0.78]        48.4%         Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $p < 0.01$ 0       0        48.4%         Country = Developed       0.17 [0.09; 0.28]       0.2%       4.1%         Hiura et al. (2019)       726 5606       0       0.13 [0.12; 0.14]       17.6%       4.5%         Hope et al. (2017)       19       95        48.4%       4.3%         Kanekiyo et al. (2019)       10       40       0.25 [0.14; 0.41]       0.2%       4.1%         Lew et al. (2018)       123       439        0.98 [0.95; 0.99]       0.2%       4.5%         Lew et al. (2018)       123       439        0.28 [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75        0.24 [0.16; 0.35]       0.4%       4.3%         Sharma et al. (2018)       2005 11750         0.27%       4.1%       0.17 [0.16; 0.18]       46.2%       4.5%         Hachemi et al. (2015)       100       185        0.37 [0.28; 0.46]        0.37 [0.28; 0.46]        51.6%	Fixed effect model		5287			•		0.52	[0.51; 0.54]	26.0%	
Heterogeneity: $l^2 = 99\%$ , $\tau^2 = 1.3080$ , $\rho < 0.01$ <b>Country = Developed</b> Fetterplace et al. (2018) 10 60 Hiura et al. (2019) 726 5606 Hope et al. (2017) 19 95 Lazarow et al. (2019) 10 40 Lazarow et al. (2019) 322 330 Lew et al. (2018) 123 439 Lew et al. (2018) 123 439 Lew et al. (2019) 123 439 Hashall et al. (2017) 18 75 Rus et al. (2018) 2005 11750 Sharma et al. (2018) 2005 11750 Fixed effect model 19544 Heterogeneity: $l^2 = 98\%$ , $\tau^2 = 0.4269$ , $\rho < 0.01$	Random effects model				-			0.64	[0.48; 0.78]		48.4%
Country = Developed         Fetterplace et al. (2018)       10       60         Hiura et al. (2019)       726       5606       0         Hiura et al. (2017)       19       95       0.17       [0.09; 0.28]       0.2%       4.1%         Manual (2017)       19       95       0.20       [0.13; 0.29]       0.4%       4.3%         Kanekiyo et al. (2019)       10       40       0.25       [0.14; 0.41]       0.2%       4.1%         Lew et al. (2018)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75       -       0.24       [0.16; 0.35]       0.4%       4.3%         Sharma et al. (2018)       2005       11750       Image: colspan="2">-       -       0.17       [0.16; 0.18]       46.2%       4.5%         Hachemi et al. (2015)       100       185       -       0.37       [0.28; 0.46]	Heterogeneity: $I^2 = 99\%$ , $\tau^2 =$	1.3080, p	> < 0.01								
Fetterplace et al. (2018)10600.17(0.09; 0.28)0.2%4.1%Hiura et al. (2019)726560600.13(0.12; 0.14)17.6%4.5%Hope et al. (2017)19950.200.13; 0.290.4%4.3%Kanekiyo et al. (2019)10400.250.14; 0.41]0.2%4.1%Lazarow et al. (2018)1234390.280.24; 0.32]2.5%4.5%Lew et al. (2018)1234390.280.24; 0.32]2.5%4.5%Lew et al. (2019)18750.280.24; 0.32]2.5%4.5%Marshall et al. (2017)18750.240.16; 0.35]0.4%4.3%Sharma et al. (2018)20051175004.1%0.170.16; 0.18]46.2%4.5%Hachemi et al. (2015)1001850.540.47; 0.61]1.3%4.4%Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $\rho$ < 0.01	Country = Developed										
Hiura et al. (2019)       726       5606       0       0.13 $0.12$ ; $0.14$ ] $17.6\%$ $4.5\%$ Hope et al. (2017)       19       95       0.20 $0.13$ ; $0.29$ ] $0.4\%$ $4.3\%$ Kanekiyo et al. (2019)       10       40       0.25 $0.14$ ; $0.41$ ] $0.2\%$ $4.1\%$ Lazarow et al. (2019)       322       330       -       0.98 $0.95$ ; $0.99$ ] $0.2\%$ $4.1\%$ Lew et al. (2018)       123       439       -       0.28 $0.24$ ; $0.32$ ] $2.5\%$ $4.5\%$ Lew et al. (2019)       123       439       -       0.28 $0.24$ ; $0.32$ ] $2.5\%$ $4.5\%$ Lew et al. (2019)       123       439       -       0.28 $0.24$ ; $0.32$ ] $2.5\%$ $4.5\%$ Marshall et al. (2017)       18       75       -       0.28 $0.24$ ; $0.32$ ] $2.5\%$ $4.5\%$ Sharma et al. (2018)       2005       11750       -       0.17 $0.18$ $46.2\%$ $4.5\%$ Hachemi et al. (2015)       100       185       -       0.37 $0.28$ ; $0.46$ ]       - $51.6\%$ Heterogeneity: $l$	Fetterplace et al. (2018)	10	60					0.17	[0.09; 0.28]	0.2%	4.1%
Hope et al. (2017)19950.200.13; 0.290.4%4.3%Kanekiyo et al. (2019)10400.250.14; 0.41]0.2%4.1%Lazarow et al. (2019)322330+0.980.95; 0.990.2%4.1%Lew et al. (2018)123439+0.280.24; 0.32]2.5%4.5%Lew et al. (2019)123439+0.280.24; 0.32]2.5%4.5%Lew et al. (2019)123439+0.280.24; 0.32]2.5%4.5%Rus et al. (2019)7886-0.91[0.82; 0.95]0.2%4.1%Sharma et al. (2018)200511750-0.54(0.16; 0.18]46.2%4.5%Hachemi et al. (2015)100185-0.54(0.47; 0.61]1.3%44.9%Hachemi et al. (2015)100185-0.37[0.28; 0.46]-51.6%Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $p < 0.01$ 51.6%	Hiura et al. (2019)	726	5606					0.13	[0.12; 0.14]	17.6%	4.5%
Kanekiyo et al. (2019)       10       40       0.25 $(0.14; 0.41]$ $0.2\%$ 4.1%         Lazarow et al. (2019)       322       330       -       0.98 $(0.95; 0.99]$ $0.2\%$ 4.1%         Lew et al. (2018)       123       439       -       0.28 $(0.24; 0.32]$ 2.5%       4.5%         Lew et al. (2019)       123       439       -       0.28 $(0.24; 0.32]$ 2.5%       4.5%         Marshall et al. (2017)       18       75       -       0.24 $(0.16; 0.35]$ 0.4%       4.3%         Rus et al. (2018)       2005       11750       -       0.17 $(0.16; 0.18]$ 46.2%       4.5%         Hachemi et al. (2015)       100       185       -       0.17 $(0.16; 0.18]$ 46.2%       4.5%         Hachemi et al. (2015)       100       185       -       0.37 $(0.28; 0.46]$ -       51.6%         Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $\rho$ < 0.01	Hope et al. (2017)	19	95	-++	-			0.20	[0.13; 0.29]	0.4%	4.3%
Lazarow et al. (2019)       322       330       -       0.98       [0.95; 0.99]       0.2%       4.1%         Lew et al. (2018)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       -       0.28       [0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75       -       0.24       [0.32]       0.5%       4.5%         Sharma et al. (2018)       2005       11750       -       0.91       [0.82; 0.95]       0.2%       4.1%         Hachemi et al. (2015)       100       185       -       0.54       [0.47; 0.61]       1.3%       4.4%         Fixed effect model       19544       I       -       0.37       [0.28; 0.46]       -       51.6%         Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $\rho$ < 0.01	Kanekiyo et al. (2019)	10	40	$\rightarrow$				0.25	[0.14; 0.41]	0.2%	4.1%
Lew et al. (2018)       123       439       0.28       0.24       0.32]       2.5%       4.5%         Lew et al. (2018)       123       439       0.28       0.24       0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       0.28       0.24       0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75       0.28       0.24       0.32]       2.5%       4.5%         Marshall et al. (2019)       78       86        0.24       0.025       0.2%       4.1%         Sharma et al. (2018)       2005       11750	Lazarow et al. (2019)	322	330				+	0.98	[0.95; 0.99]	0.2%	4.1%
Lew et al. (2018)       123       439       0.28       0.24       0.32]       2.5%       4.5%         Lew et al. (2019)       123       439       0.28       0.24       0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75       0.28       0.24       0.32]       2.5%       4.5%         Rus et al. (2019)       78       86        0.24       0.16       0.35]       0.4%       4.3%         Sharma et al. (2018)       2005       11750        0.17       0.16       0.18       4.5%         Hachemi et al. (2015)       100       185        0.54       0.17       0.18       44.9%         Fixed effect model       19544       +        0.37       0.28; 0.46]        51.6%         Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $p$ < 0.01	Lew et al. (2018)	123	439	÷.	-			0.28	[0.24; 0.32]	2.5%	4.5%
Lew et al. (2019)       123       439 $\leftarrow$ 0.28       0.24; 0.32]       2.5%       4.5%         Marshall et al. (2017)       18       75 $\circ$ 0.24       (0.16; 0.35]       0.4%       4.3%         Rus et al. (2019)       78       86 $\circ$ 0.24       (0.16; 0.35]       0.24%       4.1%         Sharma et al. (2018)       2005       11750 $\circ$ $\circ$ 0.17       (0.16; 0.18]       46.2%       4.5%         Hachemi et al. (2015)       100       185 $\circ$ $\circ$ 0.54       (0.47; 0.61]       1.3%       4.4%         Fixed effect model       19544 $\circ$ $\circ$ 0.37       [0.28; 0.46] $- $ 51.6%         Heterogeneity: $l^2$ = 98%, $\tau^2$ = 0.4269, $\rho$ < 0.01	Lew et al. (2018)	123	439	+	-			0.28	[0.24; 0.32]	2.5%	4.5%
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Lew et al. (2019)	123	439	÷	-			0.28	[0.24; 0.32]	2.5%	4.5%
Rus et al. (2019)       78       86        0.91       [0.82; 0.95]       0.2%       4.1%         Sharma et al. (2018)       2005       11750       Image: Constraint of the state of the st	Marshall et al. (2017)	18	75		_			0.24	[0.16; 0.35]	0.4%	4.3%
Sharma et al. (2018)       2005 11750       Image: Constraint of the system of	Rus et al. (2019)	78	86	- 1				0.91	[0.82; 0.95]	0.2%	4.1%
Hachemi et al. (2015)       100       185       0.54       0.47 (0.61)       1.3%       4.4%         Fixed effect model       19544       0.18 [0.17; 0.18]       74.0%          Random effects model       0.37 [0.28; 0.46]        51.6%         Heterogeneity: $l^2 = 98\%$ , $\tau^2 = 0.4269$ , $p < 0.01$ 51.6%	Sharma et al. (2018)	2005	11750					0.17	[0.16; 0.18]	46.2%	4.5%
Fixed effect model       19544       0.18 [0.17; 0.18]       74.0%          Random effects model       0.37 [0.28; 0.46]        51.6%         Heterogeneity: $l^2 = 98\%$ , $\tau^2 = 0.4269$ , $p < 0.01$ 51.6%	Hachemi et al. (2015)	100	185		-	-		0.54	[0.47; 0.61]	1.3%	4.4%
Random effects model $0.37 [0.28; 0.46] 51.6\%$ Heterogeneity: $l^2 = 98\%$ , $\tau^2 = 0.4269$ , $p < 0.01$	Fixed effect model		19544	• •				0.18	[0.17; 0.18]	74.0%	==
Heterogeneity: $T = 98\%$ , $\tau = 0.4269$ , $p < 0.01$	Random effects model	0.4000			$\sim$			0.37	[0.28; 0.46]		51.6%
	Heterogeneity: $I^- = 98\%$ , $\tau^+ =$	0.4269, p	> < 0.01								
Fixed effect model 24831 0.25 [0.24; 0.25] 100.0%	Fixed effect model		24831	÷				0.25	[0.24; 0.25]	100.0%	
Random effects model 0.51 [0.39; 0.62] 100.0%	Random effects model	1 2000	- 0		$\sim$	_	_	0.51	[0.39; 0.62]		100.0%
neutrogeneity: $r = 39\%, \tau = 1.2303, p = 0$ Residual heterogeneity: $r^2 = 99\%, a = 0$ 0.2 0.4 0.6 0.8	Residual beterogeneity: $I = 99\%$ , $\tau =$	1.2909, p	) – U	0.2	0.4	0.6	0.8				

Figure 5. Forest plot for developed and developing countries subgroup analysis.

# Table 2. Assessment of Study Quality Using the NOS

Authors	Selection	Comparability	Exposure	Total
Al-Kalaldeh et al. (2018)	3	1	2	6
Auiwattanakul et al. (2016)	3	1	1	5
Ceniccola et al. (2018)	4	1	1	6
Coltman <i>et al.</i> (2015)	4	1	3	8
Dos Santos et al. (2019)	1	0	2	3
Fetterplace et al. (2018)	2	1	2	5
Hiura et al. (2019)	3	0	1	4
Hope et al. (2017)	3	0	1	4
Kalaiselvan et al. (2017)	1	0	1	2
Kanekiyo et al. (2019)	2	1	1	4
Karst et al. (2015)	2	1	2	5
Lazarow et al. (2019)	2	0	1	3
Lew et al. (2018)	2	0	1	3
Lew et al. (2018)	2	0	1	3
Lew et al. (2019)	2	0	1	3
Marshall et al. (2017)	1	0	1	2
Rus et al. (2019)	3	0	1	4
Sharma et al. (2018)	3	2	2	7
Vallejo et al. (2017)	3	2	2	7
Velayati et al. (2019)	1	1	1	3
Martins et al. (2017)	2	2	1	5
Fischer et al. (2018)	3	0	2	5
Hachemi et al. (2015)	1	2	1	4

# Conclusion

The results of this study revealed that the nutritional status of patients in the ICU is inappropriate, and most ICU patients are facing varying degrees of malnutrition. Malnutrition was associated with unfavorable clinical outcomes, such as increased length of stay in ICU, the duration of mechanical ventilation, and mortality rate. Therefore, it is necessary

## References

1. Huynh TN, Kleerup EC, Raj PP, Wenger NS. The opportunity cost of futile treatment in the intensive care unit. Crit Care Med. 2014;42(9):1977.

2. Singer P, Blaser AR, Berger MM, Alhazzani W, Calder PC, Casaer MP, et al. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr. 2019;38(1):48-79.

3. Shabanpur M, Nachvak SM, Moradi S, Hedayati S, Hosseinikia M, Pasdar Y, et al. Nutritional Care in Iranian Intensive Care Units. Clin Nutr Res. 2018;7(2):136-45.

4. Weijs P, Mogensen K, Rawn J, Christopher K. Protein intake, nutritional status and outcomes in icu survivors: A single center cohort study. J Clin Med. 2019;8(1):43.

5. Fuhrmann K, Panamonta N, Roaten S. Malnutrition in the ICU: Current recommendations for the assessment of nutritional status and a review of the use of albumin as an indicator of malnutrition. The Southwest Respiratory and Critical Care Chronicles. 2013;1(4):8-14.

6. Webb A. Oxford textbook of critical care: Oxford University Press; 2016.

7. Berger MM, Pichard C. Best timing for energy provision during critical illness. Crit Care. 2012;16(2):215.

 Shayesteh F, Poudineh S, Pouryazdanpanah-Kermani M, Sadat Ayoudi S, Norouzy A. Assessment of nutritional intake in intensive care unit patients of Ghaem hospital. Iran J Basic Med Sci. 2015;58(4):217-24.

9. Osooli F, Abbas S, Farsaei S, Adibi P. Identifying critically ill patients at risk of malnutrition and underfeeding: a prospective study at an academic hospital. Adv Pharm Bull. 2019; 9(2): 314–320. to accurately analyze the nutritional status of patients at the beginning and during their admission and to implement nutritional guidelines developed for the ICU by a professional nutritional support team, including nutritionists, physicians, and nurses.

# **Conflict of Interest**

The authors declare no conflict of interest.

10. Powers J, Samaan K. Malnutrition in the ICU patient population. Crit Care Nurs Clin North Am. 2014;26(2):227-42.

11. Verghese PP, Mathai AS, Abraham V, Kaur P. Assessment of malnutrition and enteral feeding practices in the critically ill: A single-centre observational study. Indian J Anaesth. 2018;62(1):29.

12. Singh N, Gupta D, Aggarwal AN, Agarwal R, Jindal SK. An assessment of nutritional support to critically ill patients and its correlation with outcomes in a respiratory intensive care unit. Respir Care. 2009;54(12):1688-96.

13. Ramprasad R, Kapoor MC. Nutrition in intensive care. J Anaesthesiol Clin Pharmacol. 2012;28(1):1.

14. Agarwal E, Ferguson M, Banks M, Bauer J, Capra S, Isenring E. Nutritional status and dietary intake of acute care patients: results from the Nutrition Care Day Survey 2010. Clin Nutr. 2012;31(1):41-7. 15. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. Jama. 2000;283(15):2008-12.

16. The Newcastle-Ottawa Scale
(NOS) for assessing the quality of nonrandomizedstudies in meta-analyses. http://www.medicine.mcgill.ca/rtamblyn/
Readings5CThe20Newcastle20-20Scale20for
20assessing20the20quality20of20nonrandom
ised20studies20in%20meta-analyses.pdf [
17. Sabbagh HJ, Hassan MH, Innes
NP, Elkodary HM, Little J, Mossey PA.
Passive smoking in the etiology of nonsyndromic orofacial clefts: a systematic review and meta-analysis. PloS one. 2015;10(3):e0116963.

 Viechtbauer W. Conducting metaanalyses in R with the metafor package.
 Journal of Statistical Software. 2010;36(3):1-48.

19. Michael Borenstein LH, Hannah Rothstein. Meta-Analysis Fixed effect vs. random effects. 2007.

20. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629.

21. Begg CB, Mazumdar M. Operating Characteristics of a Rank Correlation Test for Publication Bias. Biometrics. 1994;50(4):1088-101.

22. Al-Kalaldeh M, Alghabeesh S, Suleiman K, Abu-Sharour L. Assessment of Nutritional Status of Critically Ill Patients Using the Malnutrition Universal Screening Tool and Phase Angle. Topics in Clin Nutr. 2018;33(2):134-43.

23. Auiwattanakul S, Chittawatanarat K, Chaiwat O, Morakul S, Kongsayreepong S, Ungpinitpong W, et al. Effects of nutrition factors on mortality and sepsis occurrence in a multicenter university-based surgical intensive care unit in Thailand (THAI-SICU study). Nutrition. 2019;58:94-9.

24. Ceniccola G, Holanda T, Pequeno R, Mendonça V, Oliveira A, Carvalho L, et al. Relevance of AND-ASPEN criteria of malnutrition to predict hospital mortality in critically ill patients: A prospective study. J Crit Care. 2018;44:398-403.

25. Coltman A, Peterson S, Roehl K, Roosevelt H, Sowa D. Use of 3 tools to assess nutrition risk in the intensive care unit. JPEN J Parenter Enteral Nutr. 2015;39(1):28-33.

26. Santos HVDd, Araújo ISd. Impact of protein intake and nutritional status on the clinical outcome of critically ill patients. Rev Bras Ter Intensiva. 2019;31(2):210-6. 27. Fetterplace K, Deane AM, Tierney A, Beach LJ, Knight LD, Presneill J, et al. Targeted full energy and protein delivery in critically ill patients: a pilot randomized controlled trial (FEED trial). JPEN J Parenter Enteral Nutr. 2018;42(8):1252-62. 28. Hiura G, Lebwohl B, Seres DS. Malnutrition Diagnosis in Critically Ill Patients Using 2012 Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition Standardized Diagnostic Characteristics Is Associated With

Longer Hospital and Intensive Care Unit Length of Stay and Increased In-Hospital Mortality. JPEN J Parenter Enteral Nutr. 2020;44(2):256-264.

29. Hope AA, Hsieh S, Petti A, Hurtado-Sbordoni M, Verghese J, Gong MN. Assessing the usefulness and validity of frailty markers in critically ill adults. Ann Am Thorac Soc. 2017;14(6):952-9.

30. Kalaiselvan M, Renuka M, Arunkumar A. Use of nutrition risk in critically ill (nutric) score to assess nutritional risk in mechanically ventilated patients: A prospective observational study. Indian J Crit Care Med. 2017;21(5):253.

31. Kanekiyo S, Takeda S, Iida M, Nishiyama M, Kitahara M, Shindo Y, et al. Efficacy of perioperative immunonutrition in esophageal cancer patients undergoing esophagectomy. Nutrition. 2019;59:96-102. 32. Karst FP, Vieira RM, Barbiero S. Relationship between adductor pollicis muscle thickness and subjective global assessment in a cardiac intensive care unit. Rev Bras Ter Intensiva. 2015;27(4):369-75. 33. Lazarow H, Nicolo M, Compher C, Kucharczuk CR, Stadtmauer EA, Landsburg DJ. Nutrition-Related Outcomes for Autologous Stem Cell Transplantation Patients. Clin Lymphoma Myeloma Leuk. 2019.

34. Lew CCH, Cheung KP, Chong MFF, Chua AP, Fraser RJ, Miller M. Combining 2 commonly adopted nutrition instruments in the critical care setting is superior to administering either one alone. JPEN J Parenter Enteral Nutr. 2018;42(5):872-6. 35. Lew C, Wong G, Cheung K, Chua A, Chong M, Miller M. Association between malnutrition and 28-day mortality and intensive care length-of-stay in the critically ill: a prospective cohort study. Nutrients. 2018;10(1):10.

36. Lew CCH, Wong GJY, Cheung KP, Fraser RJ, Chua AP, Chong MFF, et al. The association between nutritional adequacy and 28-day mortality in the critically ill is not modified by their baseline nutritional status and disease severity. Crit Care. 2019;23(1):222.

37. Marshall AP, Lemieux M, Dhaliwal R, Seyler H, MacEachern KN, Heyland DK. Novel, Family-Centered Intervention to Improve Nutrition in Patients Recovering From Critical Illness: A Feasibility Study. Nutr Clin Pract. 2017;32(3):392-9. 38. Rus VA, Chitu M, Cernea S, Benedek I, Hodas R, Zavate R, et al. Altered nutritional status, inflammation and systemic vulnerability in patients with acute myocardial infarction undergoing percutaneous coronary revascularisation: A prospective study in a level 3 cardiac critical care unit. Rus VA, Chitu M, Cernea S, Benedek I, Hodas R, Zavate R, et al. Altered nutritional status, inflammation and systemic vulnerability in patients with acute myocardial infarction undergoing percutaneous coronary revascularisation: A prospective study in a level 3 cardiac critical care unit. Nutrition & Dietetics. 2019. 39. Sharma Y, Miller M, Kaambwa B, Shahi R, Hakendorf P, Horwood C, et al. Factors influencing early and late readmissions in Australian hospitalised patients and investigating role of admission nutrition status as a predictor of hospital readmissions: a cohort study. BMJ open. 2018;8(6):e022246.

40. Vallejo KP, Martínez CM, Adames AAM, Fuchs-Tarlovsky V, Nogales GCC, Paz RER, et al. Current clinical nutrition practices in critically ill patients in Latin America: a multinational observational study. Crit Care. 2017;21(1):227.

41. Velayati A, Shariatpanahi MV, Shahbazi E, Shariatpanahi ZV. The association between preoperative nutritional status and postoperative delirium in individuals with coronary artery bypass graft surgery: A Prospective Cohort Study. Nutrition. 2019. 42. Velayati A, Vahdat Shariatpanahi M, Shahbazi E, Vahdat Shariatpanahi Z. Association between preoperative nutritional status and postoperative delirium

in individuals with coronary artery bypass graft surgery: A prospective cohort study. Nutrition. 2019;66:227-32.

43. Martins RCFdC, Vital WC, Amaral JFd, Volp ACP. Perfil nutricional de pacientes internados em unidade de terapia intensiva. 2017.

44. de Queiroz Fischer M, Poll FA. Relação entre o estado nutricional, nutrição precoce, hiperglicemia e desfecho clínico de pacientes internados em uma unidade de terapia intensiva. Revista de Epidemiologia e Controle de Infecção. 2019;9(1).

45. Lucas MCS, Fayh APT. Nutritional status, hyperglycemia, early nutrition, and mortality of patients hospitalized in an intensive care unit. Rev Bras Ter Intensiva. 2012;24(2):157-61.

46. Costa CA, Tonial CT, Garcia PCR. Association between nutritional status and outcomes in critically-ill pediatric patients-a systematic review. Jornal de pediatria. 2016;92(3):223-9.

47. Mo YH, Rhee J, Lee E-K. Effects of nutrition support team services on outcomes in ICU patients. Yakugaku Zasshi. 2011;131(12):1827-33.

48. Park YE, Park SJ, Park Y, Cheon JH, Kim TI, Kim WH. Impact and outcomes of nutritional support team intervention in patients with gastrointestinal disease in the intensive care unit. Medicine. 2017;96(49). 49. Terblanche E. The role of dietitians in critical care. J Intensive Care Soc. 2018:1751143718774715.

50. Sioson MS, Martindale R, Abayadeera A, Abouchaleh N, Aditianingsih D, Bhurayanontachai R, et al. Nutrition therapy for critically ill patients across the Asia-Pacific and Middle East regions: A consensus statement. Clin Nutr ESPEN. 2018;24:156-64.

51. Doig GS, Simpson F, Finfer S, Delaney A, Davies AR, Mitchell I, et al. Effect of evidence-based feeding guidelines on mortality of critically ill adults: a cluster randomized controlled trial. Jama. 2008;300(23):2731-41.

52. Barr J, Hecht M, Flavin KE, Khorana A, Gould MK. Outcomes in critically ill patients before and after the implementation of an evidence-based nutritional management protocol. Chest. 2004;125(4):1446-57. 53. Cederholm T, Barazzoni R, Austin P, Ballmer P, Biolo G, Bischoff SC, et

al. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin Nutr. 2017;36(1):49-64.

54.