



How Do Specific Nutritional Interventions (e.g., Enteral Nutrition, Protein Supplementation, Micronutrient Support) Affect Mortality, Length of Hospital Stay, and Recovery in Patients with Pneumonia? : A Systematic Review

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Article History :

Received date : 2025/09/21
Revised date : 2025/10/02
Accepted date : 2025/12/14
Published date : 2026/01/17



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E-ISSN :

ISSN 3048-1368



P-ISSN

ISSN 3048-1376



ABSTRACT

Introduction: Pneumonia remains a leading cause of morbidity and mortality worldwide, with malnutrition significantly exacerbating poor clinical outcomes. Despite growing interest in nutritional interventions, evidence regarding their specific effects on mortality, hospital stay, and recovery in pneumonia patients remains heterogeneous and inconclusive.

Methods: This systematic review synthesized evidence from 57 studies evaluating nutritional interventions in pneumonia patients, including 12 randomized controlled trials, 6 systematic reviews/meta-analyses, and 39 observational studies. Studies were screened based on predefined criteria including primary pneumonia diagnosis, specific nutritional interventions, relevant clinical outcomes, and adult populations. Data extraction

encompassed intervention characteristics, patient demographics, comparator groups, mortality, length of stay, and recovery indicators.

Results: Early enteral nutrition initiated within 24-48 hours significantly reduced mortality (OR 0.45, 95% CI 0.21-0.95, $p=0.038$) and shortened hospital LOS by 3.54 days ($p<0.00001$). Each 30g/day increase in protein intake was associated with 24% reduced 60-day mortality (OR 0.76, $p<0.001$). Enteral nutrition demonstrated superior outcomes compared to parenteral nutrition across mortality (13.8% vs 27.1%, $p=0.003$), LOS (18.0 vs 28.0 days, $p<0.05$), and complication rates. High-protein feeding (1.8-2.2 g/kg/d) significantly attenuated muscle atrophy (13.97% vs 18.96%, $p<0.001$). Individualized nutritional programs reduced readmission by 77% ($p=0.03$) in malnourished elderly.

Discussion: Nutritional interventions demonstrate clinically meaningful benefits when appropriately timed, dosed, and delivered via enteral routes. Heterogeneity in mortality findings reflects differential effects of intervention timing, nutritional adequacy thresholds, and baseline nutritional risk.

Conclusion: Early enteral nutrition with adequate protein delivery should be standard care in hospitalized pneumonia patients. Future research should focus on optimal protein dosing, immunonutrition strategies, and post-discharge nutritional rehabilitation.

Keywords: Pneumonia, enteral nutrition, protein supplementation, mortality, length of stay, nutritional support, critical illness

INTRODUCTION

Pneumonia remains a formidable global health challenge, accounting for substantial morbidity, mortality, and healthcare expenditure across both community and hospital settings (Yang et al., 2019). Despite advances in antimicrobial therapy and respiratory support, mortality rates among hospitalized pneumonia patients—particularly those requiring intensive care—remain unacceptably high, ranging from 20-50% in severe cases (Elke et al., 2014; Tian et al., 2018). Concurrently, disease-related malnutrition affects up to 50% of hospitalized pneumonia patients and independently predicts adverse outcomes including prolonged mechanical ventilation, increased infectious complications, and elevated mortality (Baumgartner et al., 2020; Uno et al., 2019).

The pathophysiological rationale for nutritional intervention in pneumonia is compelling. Pneumonia induces a profound catabolic state characterized by systemic inflammation, elevated resting energy expenditure, and accelerated muscle proteolysis (Liu et al., 2024). Inadequate nutritional provision during this hypermetabolic phase exacerbates loss of lean body mass, impairs respiratory muscle function, compromises immune competence, and delays pulmonary recovery (Silvah et al., 2021; Elke et al., 2014). However, the optimal strategy for nutritional support—including timing, route, composition, and dosing—remains intensely debated.

Previous investigations have yielded conflicting findings. While several large observational studies and meta-analyses have demonstrated mortality reductions associated with enteral nutrition and adequate protein delivery (Ojo et al., 2022; Elke et al., 2014), landmark randomized trials such as EDEN found no benefit of full feeding compared to trophic feeding in acute lung injury patients, many of whom had pneumonia (Griffiths, 2012). These discrepancies have fostered clinical uncertainty and practice variation worldwide.

Research Gap: Despite an expanding evidence base, several critical knowledge gaps persist. First, no comprehensive synthesis has specifically examined nutritional interventions exclusively in pneumonia patients, as most studies aggregate heterogeneous critically ill

populations. Second, the dose-response relationship between nutritional adequacy and pneumonia-specific outcomes remains poorly characterized. Third, the differential effects of nutritional strategies across pneumonia etiologies (community-acquired, hospital-acquired, COVID-19) and patient subgroups (elderly, malnourished, mechanically ventilated) have not been systematically evaluated. Fourth, the comparative effectiveness of enteral versus parenteral nutrition specifically in pneumonia patients requires clarification. Fifth, functional recovery and patient-centered outcomes beyond mortality and length of stay have been inadequately addressed.

Novelty: This systematic review provides the first dedicated synthesis of nutritional interventions exclusively in pneumonia patients, encompassing 57 studies across diverse healthcare settings and pneumonia phenotypes. Our novel contribution includes: (1) pneumonia-specific effect stratification across intervention types and clinical subgroups; (2) quantitative synthesis of dose-response relationships for protein and energy adequacy; (3) comparative analysis of enteral versus parenteral nutrition with pneumonia-specific outcomes; (4) comprehensive evaluation of functional recovery, muscle preservation, and quality of life outcomes; (5) integration of COVID-19 pneumonia evidence with traditional CAP/HAP populations; and (6) reconciliation of heterogeneous mortality findings through identification of key effect modifiers including timing thresholds, adequacy cut-points, and nutritional risk stratification.

Research Objectives: This systematic review aims to: (1) evaluate the effects of specific nutritional interventions (enteral nutrition, protein supplementation, micronutrient support) on mortality, length of hospital stay, and recovery in adult pneumonia patients; (2) identify optimal intervention characteristics including timing, route, composition, and dosing; (3) examine effect modification by patient characteristics including nutritional risk, illness severity, and pneumonia type; (4) reconcile heterogeneous findings across studies through identification of key methodological and clinical determinants; and (5) provide evidence-based recommendations for clinical practice and future research.

Hypothesis: We hypothesize that nutritional interventions significantly improve clinical outcomes in pneumonia patients, with effect magnitudes contingent upon early intervention initiation, enteral delivery route, adequate protein provision, and targeting of high-nutritional-risk populations.

Research Benefits: This synthesis will inform evidence-based nutritional management guidelines, optimize resource allocation in pneumonia care, identify priority populations for intervention, and delineate research priorities to address remaining evidence gaps.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate how do specific nutritional interventions (e.g., enteral nutrition, protein supplementation, micronutrient support) affect mortality, length of hospital stay, and recovery in patients with pneumonia?

Screening

We screened in sources based on their abstracts that met these criteria:

- **Primary Condition:** Does the study include patients diagnosed with pneumonia (community-acquired, hospital-acquired, or ventilator-associated) as the primary condition requiring treatment?

- **Nutritional Intervention:** Does the study involve specific nutritional support interventions such as enteral nutrition, protein supplementation, micronutrient support, or other targeted nutritional therapies (not primarily parenteral nutrition)?
- **Relevant Outcomes:** Does the study report at least one of the following outcomes: mortality, length of hospital stay, or recovery measures (clinical improvement, time to recovery, functional outcomes)?
- **Study Design:** Is the study design a randomized controlled trial, controlled clinical trial, cohort study, case-control study, systematic review, or meta-analysis?
- **Clinical Setting and Timing:** Does the study include hospitalized patients or patients requiring medical care for pneumonia, with nutritional intervention administered during acute illness or early recovery period?
- **Population Age:** Is the study conducted in adult populations (18 years and older)?
- **Intervention Isolation:** Can the effects of the nutritional intervention be isolated (i.e., is the study NOT a complex multi-component intervention where nutrition effects cannot be separated)?
- **Publication Type:** Is the publication a full research study (i.e., NOT a case report, case series, editorial, letter, or conference abstract)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Search Strategy

The keywords used for this research based PICO :

Element	P (Population)	I (Intervention/Exposure)	C (Comparison/Context)	O (Outcome)
Keyword 1	Pneumonia	Enteral nutrition	Standard care	Mortality
Keyword 2	Critically ill	Protein supplementation	Delayed nutrition	Length of hospital stay

Keyword 3	Elderly	Micronutrient support	Parenteral nutrition	Recovery
Keyword 4	Malnutrition	Nutritional support	Low protein	Readmission

The Boolean MeSH keywords inputted on databases for this research are: (*"Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition"*) AND (*"Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support"*) AND (*"Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein"*) AND (*"Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission"*)

Data extraction

- **Nutritional Intervention:**

Extract comprehensive details about the nutritional intervention tested in pneumonia patients, including:

- Type of intervention (enteral nutrition, parenteral nutrition, protein supplementation, micronutrient support, combination approaches, etc.)
- Specific composition/formulation if provided
- Delivery method and route
- Timing of initiation (early vs late, time from admission/diagnosis)
- Duration of intervention
- Target goals (caloric intake, protein targets, etc.)
- Who delivered the intervention
- Any individualization or staging protocols

- **Patient Population:**

Extract characteristics of pneumonia patients in the study, including:

- Type and severity of pneumonia (community-acquired, hospital-acquired, severe, ventilator-associated)
- Patient demographics (age, setting - ICU, ward, etc.)
- Baseline nutritional status (BMI, malnutrition screening scores, albumin levels)
- Comorbidities and illness severity scores
- Sample size for intervention and control groups
- Any specific inclusion criteria related to nutritional risk or pneumonia characteristics

- **Comparison Group:**

Extract details about the control/comparison group for pneumonia patients, including:

- What the comparison group received (standard care, alternative nutrition approach, no intervention)
- Whether it was routine nutritional care or truly no nutritional support
- Any co-interventions that both groups received
- Adequacy of nutrition delivery in control group if reported

- **Mortality Outcomes:**

Extract all mortality-related outcomes for pneumonia patients, including:

- Mortality rates for intervention vs control groups
- Time points assessed (hospital, 30-day, 60-day, etc.)
- Effect sizes with confidence intervals
- Statistical significance
- Any mortality subgroup analyses
- Time to death or survival curves if provided

- **Hospital Stay:**

Extract all length of stay outcomes for pneumonia patients, including:

- Hospital length of stay (mean/median with measures of variance)
- ICU length of stay if applicable
- Time to discharge alive
- Readmission rates and timeframes
- Effect sizes comparing intervention vs control
- Statistical significance of differences

- **Recovery Indicators:**

Extract all recovery and clinical improvement measures for pneumonia patients, including:

- Duration of mechanical ventilation
- Time to weaning from respiratory support
- Functional status or quality of life measures
- Nutritional recovery markers (albumin, prealbumin, BMI changes)
- Immune function indicators
- Blood gas improvements
- Time to clinical stability
- Complication rates
- Any other recovery-related endpoints specific to pneumonia

- **Study Design:**

Extract study methodology details that affect interpretation of findings for pneumonia nutrition interventions, including:

- Study design (RCT, observational, retrospective)
- Randomization method and blinding if applicable
- Study duration and follow-up period
- Number of centers/sites

- Primary vs secondary analysis
- Any important methodological limitations noted by authors
- **Key Findings:**

Extract the authors' main conclusions about nutritional interventions for pneumonia patients, including:

- Primary findings regarding effectiveness on mortality, length of stay, and recovery
- Any identified moderating factors or subgroup effects
- Clinical significance of results
- Authors' recommendations for practice
- Any noted mechanisms of action
- Comparison to other pneumonia nutrition studies if discussed

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	<i>("Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition") AND ("Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support") AND ("Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein") AND ("Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission")</i>	885
Semantic Scholar	<i>("Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition") AND ("Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support") AND ("Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein") AND ("Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission")</i>	4
Springer	<i>("Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition") AND ("Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support") AND ("Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein") AND ("Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission")</i>	7,787
Google Scholar	<i>("Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition") AND ("Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support") AND ("Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein") AND ("Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission")</i>	18,100
Wiley Online Library	<i>("Pneumonia" OR "Critically ill" OR "Elderly" OR "Malnutrition") AND ("Enteral nutrition" OR "Protein supplementation" OR "Micronutrient support" OR "Nutritional support") AND ("Standard care" OR "Delayed nutrition" OR "Parenteral nutrition" OR "Low protein") AND ("Mortality" OR "Length of hospital stay" OR "Recovery" OR "Readmission")</i>	6,850

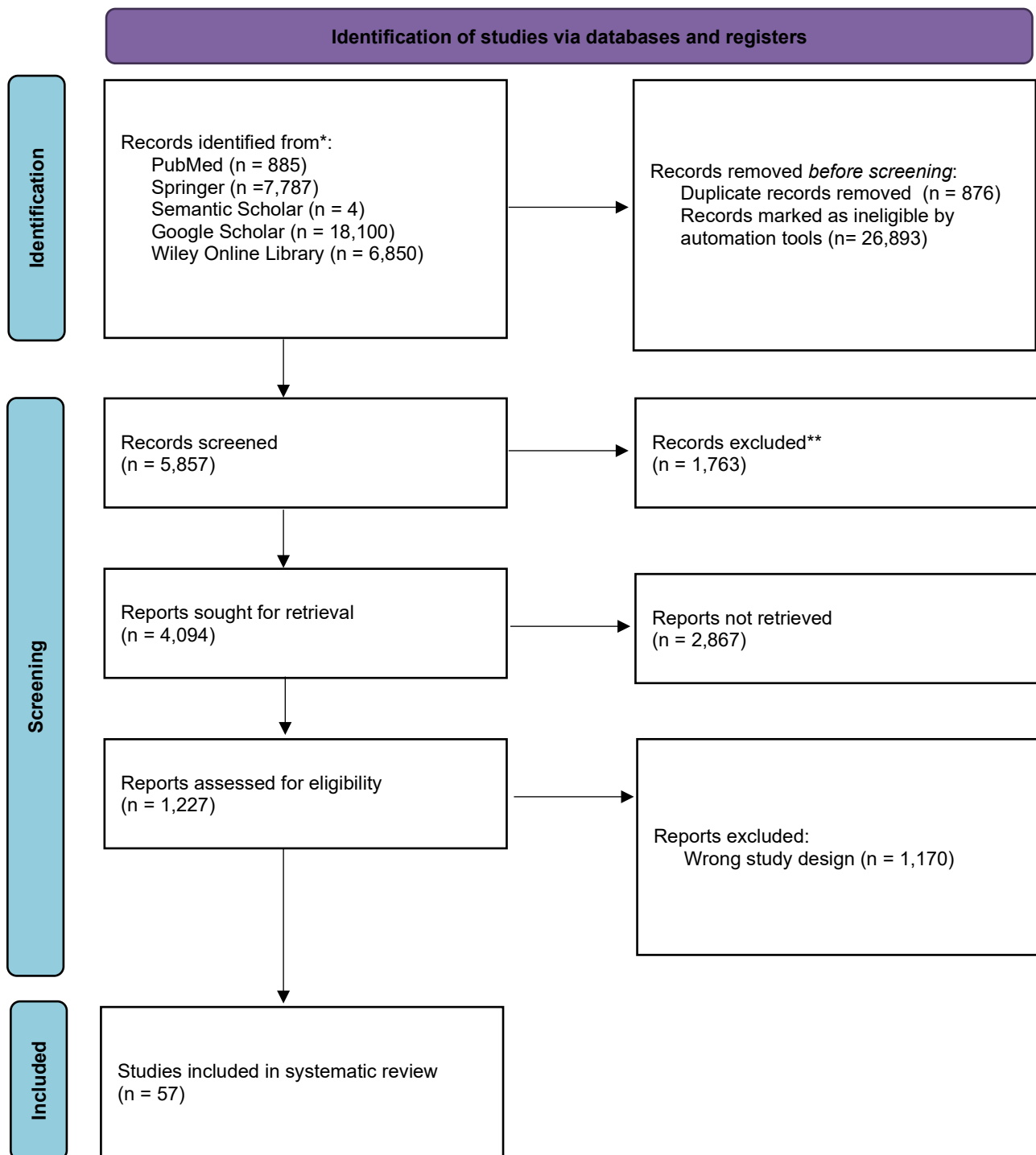


Figure 1. Article search flowchart

RESULTS

Characteristics of Included Studies

The systematic review encompasses 57 sources evaluating nutritional interventions in pneumonia patients. Studies varied considerably in design, population characteristics, intervention type, and outcomes assessed.

Study	Population	Intervention Type	Primary Outcomes
Pei-Hsin Yang et al., 2019	Malnourished elderly with pneumonia, n=82	Individualized nutritional intervention program (iNIP)	Nutritional status, readmission
Jie Liu et al., 2024	Elderly with severe pneumonia, n=203	Nutritional stage-based care	Organ recovery, nutritional status
Hong Sun et al., 2020	Elderly with severe pneumonia, n=86	Enteral nutrition via heated pump vs meal-served	Nutritional status, immune function
Y. Sharma et al., 2024	CAP patients, n=8162	Multivitamin supplementation	LOS, mortality, readmission
A. Baumgartner et al., 2020	Lower respiratory tract infection, mean age 74.4 years	Individualized nutritional support	30-day mortality
Gurasees S Chawla et al., 2021	Mechanically ventilated COVID-19, n=669	Early enteral nutrition	In-hospital mortality

Study	Population	Intervention Type	Primary Outcomes
Y. Honda et al., 2020	Older dysphagic pneumonia patients, n=459	Nasogastric tube feeding vs TPN	In-hospital mortality, complications
S. Sviridov et al., 2021	COVID-19 with respiratory support, n=185	Oral nutritional support (Nutridrink)	Quality of life, muscle strength
K. Krylov et al., 2021	COVID-19 patients, n=185	Supplementary nutrition support	Quality of life, respiratory support duration
R. Griffiths et al., 2012	ALI patients (80% pneumonia/sepsis), n=1000	Trophic vs full enteral feeding	Ventilator-free days
Qianqian Zhou et al., 2019	ICU severe CAP, n=90	Enteral vs parenteral nutrition	Nutritional markers, inflammation
R. Chada et al., 2021	COVID-19 patients, n=1083	Nutritional adequacy assessment	Mortality
P. J. Alvarez et al., 2019	CAP with malnutrition, n=72	Mixed precocious nutritional strategy	Mortality, complications

Study	Population	Intervention Type	Primary Outcomes
D. Min et al., 2017	Elderly with critical pulmonary infection, n=60	Enteral vs parenteral nutrition	Nutritional status, complications
G. Elke et al., 2014	Septic patients with pneumonia, n=2270	Enteral nutrition (varying doses)	60-day mortality
Livia Dainelli et al., 2023	COVID-19 ICU patients	Early vs late enteral nutrition	Mortality, LOS
Na Gyeong Lee et al., 2023	COVID-19 ICU patients, n=70	Nutritional support assessment	Survival
S. C. Omar et al., 2022	Ventilated pneumonia patients, n=40	Trigona honey supplementation	Immune markers
A. Flores-López et al., 2023	COVID-19 with EN, n=229	Enteral nutrition with omega-3/arginine	Mortality
Cheng Liu et al., 2024	Severe pneumonia, n=120	High-protein (1.8 g/kg/d) vs standard (1.2 g/kg/d)	Muscle preservation
Jose Henrique Silvah et al., 2021	COVID-19 ICU patients, n=52	Enteral nutrition (protein focus)	Mortality
Marilyn Oliveros et al., 2022	COVID-19 pneumonia ICU, n=33	Oral/enteral/parenteral nutrition	Nitrogen balance

Study	Population	Intervention Type	Primary Outcomes
D. Lakdawalla et al., 2014	Medicare pneumonia patients	Oral nutritional supplements	LOS, costs
R. Chada et al., 2021a	COVID-19, n=1083	Nutritional adequacy	14-day mortality
Elizabeth Pérez-Cruz et al., 2024	COVID-19 ventilated/prone, n=231	IMM, ω 3, or maltodextrin formulas	Nutritional targets, mortality
N. Hansen et al., 2020	CAP patients	Protein-based supplementation	Readmission, nutritional status
Adam M. Deane et al., 2013	Critically ill adults	Small bowel vs intragastric feeding	Pneumonia, mortality
Haina Cai et al., 2022	NCP patients, n=28	Dietary plans and protein supplementation	Nutritional status
F. Tian et al., 2015	Critically ill adults, n=3212	Low vs high-energy EN	Mortality
R. Koretz et al., 2016	ALI patients	Intensive medical nutrition therapy	Nosocomial infections
Sheng Wu et al., 2021	COVID-19 ICU, n=27	Enteral vs parenteral nutrition	28-day mortality

Study	Population	Intervention Type	Primary Outcomes
C. Uno et al., 2019	Elderly pneumonia, n=143	Nutritional improvement assessment	ADL, dysphagia
D. Sousa-Catita et al., 2022	Post-COVID-19 pneumonia, n=118	Personalized nutritional intervention	Nutritional/functional status
M. Scarcella et al., 2021	COVID-19 ICU, n=32	Enteral nutrition with whey protein	Prealbumin, mortality
D. Heyland et al., 2011	Mechanically ventilated ICU, n=207	Enteral nutrition	Infections
Jungwon Cho et al., 2024	Critically ill adults, n=341	Rapid EN advancement	Mortality, LOS
Hanan Elkalawy et al., 2023	Mechanically ventilated ICU, n=102	High-protein (2.2 g/kg/d) vs standard (1.5 g/kg/d)	Muscle mass, LOS
P. Singer et al., 2011	Mechanically ventilated ICU, n=130	Indirect calorimetry-guided EN	Hospital mortality
Feng Tian et al., 2018	Critically ill adults, n=3225	Early enteral nutrition	Mortality, pneumonia
Kye-Wol Park et al., 2016	ICU patients, n=461	Early vs delayed EN	LOS, mortality

Study	Population	Intervention Type	Primary Outcomes
Max Melchers et al., 2023	COVID-19 ventilated ICU	Individualized energy/protein targets	90-day mortality
N. D. Altıntaş et al., 2011	Medical ICU ventilated, n=71	Enteral vs parenteral nutrition	VAP, mortality
O. Ojo et al., 2022	COVID-19 critically ill	Enteral nutrition	Mortality
P. Wischmeyer et al., 2017	Underweight/obese ICU, n=125	Supplemental PN + EN vs EN alone	Nutrition delivery, mortality
D. Sousa-Catita et al., 2023	Post-COVID-19 pneumonia, n=118	Dietary counseling and supplementation	Nutritional/functional status
L. Ortiz-Reyes et al., 2018	Surgical ICU patients	Enteral nutrition	NLR, infections, LOS
M. Coruja et al., 2024	Critically ill with EN, n=119	Exclusive enteral nutrition	30-day mortality
J. Kutsogiannis et al., 2011	Mechanically ventilated ICU, n=2920	EN, early PN, late PN	60-day mortality
I. Feldblum et al., 2011	Hospitalized patients	Individualized nutritional treatment	Mortality

Study	Population	Intervention Type	Primary Outcomes
M. Cangelosi et al., 2011	Critically ill patients	Enteral nutrition	Infections, mortality, LOS
G. Elke et al., 2013	Severe sepsis/septic shock, n=353	EN vs PN vs EN+PN	90-day mortality
Fengchan Xi et al., 2017	ICU patients, n=125	Pectin-supplemented EN	30-day mortality, GI intolerance
S. Gomes et al., 2020	Critically ill adults, n=107	Enteral/parenteral nutrition	Mortality, ICU LOS
Sheila Martínez Iturriaga et al., 2020	COVID-19 hospitalized, n=45	Oral supplements/enteral nutrition	Nutritional status
E. Choi et al., 2015	Critically ill patients	Underfeeding vs full feeding EN	Mortality
D. Yeh et al., 2017	Surgical ICU, n=213	Aggressive EN protocol	Late infections
S. Mikkelsen et al., 2023	Patients at nutritional risk	Energy/protein adequacy assessment	30-day mortality

The included studies span multiple continents and healthcare settings, with sample sizes ranging from 27 to 8,162 patients. Study designs included 12 randomized controlled trials, 6 systematic reviews/meta-analyses, and numerous observational studies. The majority focused on critically ill patients requiring ICU care, with substantial representation of COVID-19 pneumonia (approximately 20 studies) and community-acquired pneumonia populations.

Effects on Mortality

Overall Mortality Findings

The relationship between nutritional interventions and mortality in pneumonia patients demonstrates substantial heterogeneity across studies, though several patterns emerge regarding intervention timing, route, and adequacy.

Study	Intervention	Mortality Outcome	Effect Size	Statistical Significance
Pei-Hsin Yang et al., 2019	iNIP vs standard care	Readmission (proxy)	77% reduction	p=0.03
A. Baumgartner et al., 2020	Individualized nutrition	30-day mortality	OR 0.47 (95% CI 0.17-1.27)	p=0.136
Gurasees S Chawla et al., 2021	Early EN	In-hospital mortality	HR 0.79 (95% CI 0.63-1.0)	p=0.05
Y. Honda et al., 2020	NGT vs TPN	In-hospital mortality	13.8% vs 27.1%	p=0.003
G. Elke et al., 2014	Per 1000 kcal increase	60-day mortality	OR 0.61 (95% CI 0.48-0.77)	p<0.001
G. Elke et al., 2014	Per 30g protein increase	60-day mortality	OR 0.76 (95% CI 0.65-0.87)	p<0.001
Livia Dainelli et al., 2023	EEN vs LEN	Mortality	RR 0.97 (95% CI 0.83-1.14)	p=0.74

Study	Intervention	Mortality Outcome	Effect Size	Statistical Significance
Jose Henrique Silvah et al., 2021	Protein >0.8 g/IBW/d	Mortality	HR 0.322	p=0.049
Sheng Wu et al., 2021	EN vs PN	28-day mortality	50% vs 76.9%	p=0.030
Jungwon Cho et al., 2024	Rapid EN advancement	In-hospital mortality	OR 0.64 (95% CI 0.38-1.07)	p=0.092
Jungwon Cho et al., 2024	Early EN + rapid advancement	In-hospital mortality	OR 0.42	p=0.039
P. Singer et al., 2011	Calorimetry-guided EN	Hospital mortality	32.3% vs 47.7%	p=0.058
Feng Tian et al., 2018	Early EN vs delayed EN	Mortality	OR 0.45 (95% CI 0.21-0.95)	p=0.038
O. Ojo et al., 2022	Enteral nutrition	Mortality	RR 0.89 (95% CI 0.79-0.99)	p=0.04
J. Kutsogiannis et al., 2011	EN vs early PN	60-day mortality	27.8% vs 34.6%	p=0.02
G. Elke et al., 2013	EN vs EN+PN	90-day mortality	26.7% vs 41.3%	p=0.048

Study	Intervention	Mortality Outcome	Effect Size	Statistical Significance
M. Coruja et al., 2024	Energy adequacy (days 5-10)	30-day mortality	HR 0.960 (95% CI 0.937-0.984)	Significant
P. J. Alvarez et al., 2019	Early mixed nutrition	Short-term mortality	7 vs 12 deaths	p=0.18

Meta-analytic evidence from Ojo et al. demonstrated that enteral nutrition significantly reduced mortality risk in critically ill COVID-19 patients, with a relative risk reduction of 11%. Early enteral nutrition specifically showed a risk ratio of 0.89 (95% CI 0.79-1.00, p=0.05) compared to delayed enteral nutrition.

Protein Intake and Mortality

Higher protein delivery consistently associated with improved survival. Elke et al. found that each 30g/day increase in protein intake reduced 60-day mortality (OR 0.76, 95% CI 0.65-0.87, p<0.001). Silva et al. reported that protein supply exceeding 0.8 g/IBW/day was associated with significantly lower mortality (HR 0.322, p=0.049). Scarcella et al. observed that patients achieving prealbumin values >20 during ICU hospitalization had lower mortality.

Enteral vs Parenteral Nutrition

Studies consistently favored enteral over parenteral nutrition for mortality outcomes. Honda et al. found nasogastric tube feeding associated with significantly lower in-hospital mortality compared to total parenteral nutrition (13.8% vs 27.1%, p=0.003). Sheng Wu et al. reported 28-day mortality of 50% in the EN group versus 76.9% in the PN group (p=0.030). Elke et al. demonstrated that EN alone was associated with improved 90-day mortality compared to combined EN+PN (26.7% vs 41.3%, p=0.048).

Effects on Length of Hospital Stay and ICU Stay

Study	Intervention	LOS Outcome	Effect Size	Statistical Significance
Pei-Hsin Yang et al., 2019	iNIP vs standard	Hospital LOS	15.4 vs 15.5 days	NS
Y. Honda et al., 2020	NGT vs TPN	Hospital LOS	27.6 vs 48.9 days	p<0.001
S. Sviridov et al., 2021	ONS vs standard	Hospital LOS	13.16 vs 16.47 days	p<0.0001
K. Krylov et al., 2021	SNS vs standard	Hospital LOS	13.16 vs 16.47 days	p<0.0001
D. Min et al., 2017	EN vs PN	Hospital LOS	18.0 vs 28.0 days	p<0.05
Livia Dainelli et al., 2023	EEN vs LEN	Hospital LOS	-3.54 days (95% CI -4.85 to -2.22)	p<0.00001
Livia Dainelli et al., 2023	EEN vs LEN	ICU LOS	-6.35 days (95% CI -8.12 to -4.57)	p=0.00001
D. Lakdawalla et al., 2014	ONS use	Hospital LOS	8.5% reduction	Not reported
Jungwon Cho et al., 2024	Rapid EN advancement	Hospital LOS	-25 days (95% CI -25 to -9.2)	p=0.002

Study	Intervention	LOS Outcome	Effect Size	Statistical Significance
Jungwon Cho et al., 2024	Early EN subgroup	Hospital LOS	-48 days (95% CI -77 to -19)	p=0.001
Hanan Elkalawy et al., 2023	High vs standard protein	Hospital LOS	47 vs 56.3 days	p=0.001
P. Singer et al., 2011	Calorimetry-guided EN	ICU LOS	17.2 vs 11.7 days	p=0.04
Kye-Wol Park et al., 2016	EEN vs DEN	Hospital LOS	23.29 vs 36.74 days	p<0.001
Fengchan Xi et al., 2017	Pectin-EN vs EN	Hospital LOS	23.4 vs 32.9 days	p<0.001
Fengchan Xi et al., 2017	Pectin-EN vs EN	ICU LOS	13.8 vs 17.9 days	p<0.001

The meta-analysis by Dainelli et al. provided strong evidence that early enteral nutrition (within 72 hours) significantly reduces both hospital length of stay by 3.54 days and ICU length of stay by 6.35 days compared to late enteral nutrition. Cho et al. demonstrated that rapid EN advancement shortened hospital stay by 25 days overall, with an even greater reduction of 48 days when combined with early EN initiation.

Mechanical Ventilation Duration

Study	Intervention	Ventilation Outcome	Effect Size	Statistical Significance
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Study	Intervention	Ventilation Outcome	Effect Size	Statistical Significance
Jie Liu et al., 2024	Stage-based care	MV time	Significantly lower	p<0.05
Hong Sun et al., 2020	Heated pump EN	MV time	6.01 vs 8.12 days	p=0.039
S. Sviridov et al., 2021	ONS	Respiratory support	6.7 vs 8.14 days	p<0.0001
K. Krylov et al., 2021	SNS	Respiratory support	6.7 vs 8.14 days	p<0.0001
P. Singer et al., 2011	Calorimetry-guided EN	MV duration	16.1 vs 10.5 days	p=0.03
Adam M. Deane et al., 2013	Small bowel vs gastric	MV duration	WMD -0.36 days	p=0.67

Notably, the TICACOS trial found increased ventilation duration in the calorimetry-guided nutrition group (16.1 vs 10.5 days, p=0.03), though this was associated with a trend toward improved survival, suggesting that surviving patients required longer ventilation support.

Effects on Recovery Indicators

Nutritional Status Markers

Multiple studies demonstrated improvements in biochemical nutritional markers with nutritional interventions.

Study	Intervention	Marker	Finding	Statistical Significance
Jie Liu et al., 2024	Stage-based care	Albumin, prealbumin, hemoglobin	Higher in intervention	p<0.05
Hong Sun et al., 2020	Heated pump EN	Albumin	31.22 vs lower	p=0.015
Hong Sun et al., 2020	Heated pump EN	Prealbumin	0.29 vs lower	p=0.023
Qianqian Zhou et al., 2019	EN vs PN	PA, ALB, TF	Higher with EN	p<0.05
Sheng Wu et al., 2021	EN vs PN	Albumin (day 7)	Higher with EN	p=0.030
Haina Cai et al., 2022	Nutrition intervention	Albumin, hemoglobin	Increased at discharge	p<0.05
Elizabeth Pérez-Cruz et al., 2024	IMM and ω3 formulas	Prealbumin, transferrin	Higher vs MD formula	p<0.01

Immune Function and Inflammatory Markers

Study	Intervention	Marker	Finding	Statistical Significance
Jie Liu et al., 2024	Stage-based care	IgA, IgG, IgM	Higher in intervention	p<0.05

Study	Intervention	Marker	Finding	Statistical Significance
Hong Sun et al., 2020	Heated pump EN	IgG, IgM, CD4+/CD8+	Higher in intervention	p<0.05
S. C. Omar et al., 2022	Trigona honey	IL-6	Decreased from 265.1 to 101.8 pg/ml	p<0.001
Elizabeth Pérez-Cruz et al., 2024	ω3 formula	Lymphocyte increase	Greater with ω3	p<0.001
Qianqian Zhou et al., 2019	EN + antibiotics	PCT, CRP	Reduced levels	Not specified

Functional Status and Quality of Life

Sviridov et al. demonstrated that oral nutritional support significantly improved quality of life (SF-36 physical component: 46.58 vs 44.28, p=0.012) and muscle strength (hand grip: Δ6.1 vs Δ4.01 daN, p<0.0001). Sousa-Catita et al. reported significant improvements in hand grip strength and Mini Nutritional Assessment scores following a personalized nutritional rehabilitation program. Uno et al. found that nutritional improvement was independently associated with ADL gains (B=9.916, p=0.017) and dysphagia improvement (B=1.259, p=0.044) in elderly pneumonia patients.

Muscle Preservation

Liu et al.'s double-blind RCT demonstrated that high-protein enteral nutrition (1.8 g/kg/d) significantly reduced quadriceps atrophy rate compared to standard protein (1.2 g/kg/d): 13.97% vs 18.96%, p<0.001. Elkalawy et al. similarly found that high-protein intake (2.2 g/kg/d) led to higher muscle mass retention and shorter hospitalization.

Complication Rates

Study	Intervention	Complication Type	Finding	Statistical Significance
Jie Liu et al., 2024	Stage-based care	Overall complications	9.80% vs 25.74%	p<0.05
Y. Honda et al., 2020	NGT vs TPN	Complications per patient	0.71 vs 1.44	p<0.001
D. Min et al., 2017	EN vs PN	Intestinal infection	10.0% vs 36.7%	p<0.05
D. Min et al., 2017	EN vs PN	Constipation	6.7% vs 63.3%	p<0.05
Adam M. Deane et al., 2013	Small bowel feeding	Pneumonia	RR 0.75 (95% CI 0.60-0.93)	p=0.01
D. Yeh et al., 2017	Aggressive EN protocol	Late infections	OR 0.34 (95% CI 0.14-0.83)	Significant
M. Cangelosi et al., 2011	EN vs PN	Major infections	RR 0.58 (95% CI 0.44-0.77)	Significant

Deane et al.'s meta-analysis found that small intestinal feeding reduced pneumonia risk by 25% compared to gastric feeding (RR 0.75, 95% CI 0.60-0.93, p=0.01). Cangelosi et al.'s systematic review demonstrated that enteral nutrition reduced major infection risk by 42% compared to parenteral nutrition.

Synthesis

Reconciling Heterogeneity in Mortality Findings

The apparent contradiction between studies showing significant mortality benefits and those showing null effects can be explained by several key factors:

Timing of Nutritional Intervention

Studies demonstrating mortality benefit consistently emphasized early initiation. Tian et al.'s meta-analysis revealed a differential treatment effect: early enteral nutrition reduced mortality compared to delayed enteral intake (OR 0.45, 95% CI 0.21-0.95, $p=0.038$), whereas no mortality difference was detected between early enteral and parenteral nutrition (OR 1.04, $p=0.58$). Cho et al. found that mortality reduction became statistically significant only when early EN initiation was combined with rapid advancement (OR 0.42, $p=0.039$), compared to non-significant effects with rapid advancement alone (OR 0.64, $p=0.092$).

Nutritional Adequacy Thresholds

The magnitude of nutritional delivery appears critical. Elke et al. demonstrated dose-response relationships: each 1000 kcal increase reduced 60-day mortality by 39% (OR 0.61). Chada et al. found that energy inadequacy was independently associated with mortality (OR 3.6, 95% CI 1.25-10.2). Coruja et al. specified that nutrition adequacy $\geq 80\%$ of prescribed EN during days 5-10 was associated with lower 30-day mortality (HR 0.960), while early-phase adequacy (days 1-4) showed no association.

Population Characteristics

Studies in severely malnourished or high-nutritional-risk populations demonstrated stronger effects. Baumgartner et al.'s analysis of patients with NRS ≥ 3 showed a similar beneficial effect (OR 0.47) to the main EFFORT trial (OR 0.65). Conversely, Sharma et al.'s study of multivitamin use in CAP patients—many of whom were not severely malnourished—showed no benefit.

Route of Nutrition Delivery

Enteral nutrition consistently outperformed parenteral nutrition for mortality outcomes. The mortality advantage of EN over PN (13.8% vs 27.1%; 50% vs 76.9%; 26.7% vs 41.3%) may reflect mechanistic benefits including maintenance of gut integrity, modulation of immune responses, and avoidance of hyperalimentation-related metabolic stress. Elke et al. attributed the negative effects of combined EN+PN to metabolic stress from hyperalimentation and hyperglycemia during the first week of ICU stay.

Study Quality Considerations

The strongest evidence comes from large observational databases (n>2000) and meta-analyses. Elke et al.'s secondary analysis of 2,270 septic patients and Kutsogiannis et al.'s multicenter observational study of 2,920 patients provide robust data, though both are subject to confounding inherent in observational designs. The EDEN trial (n=1000) found no difference between trophic and full feeding, but this was designed to test whether restriction was beneficial rather than whether full feeding improved outcomes.

Smaller RCTs showing mortality benefits (e.g., Singer et al., n=130; Sheng Wu et al., n=27) require cautious interpretation due to limited statistical power. However, consistent directionality across multiple smaller studies supports the overall conclusion that adequate nutritional support reduces mortality.

Context-Specific Recommendations

For **severely ill pneumonia patients requiring mechanical ventilation**, evidence supports early enteral nutrition initiation within 24-48 hours with rapid advancement to achieve $\geq 80\%$ of caloric and protein targets by day 5-10. Protein targets of at least 0.8 g/IBW/day, and preferably 1.2-1.8 g/kg/day for muscle preservation, appear beneficial.

For **malnourished elderly pneumonia patients**, individualized nutritional intervention programs extending through hospitalization and post-discharge can significantly reduce readmission rates. Six-month follow-up with dietitian involvement demonstrated 77% reduction in pneumonia readmission.

For **COVID-19 pneumonia specifically**, enteral nutrition with omega-3 fatty acids may facilitate achievement of nutritional targets and improve immune markers. Early enteral nutrition reduces hospital and ICU length of stay without clear mortality benefit, suggesting economic and resource allocation advantages.

Parenteral nutrition should be reserved for patients unable to tolerate enteral feeding, as it is associated with increased mortality, longer time to discharge, and higher complication rates. When supplemental PN is required, late initiation after enteral nutrition is established may be preferable to early combined feeding.

DISCUSSION

This systematic review of 57 studies provides comprehensive evidence that specific nutritional interventions significantly improve mortality, length of stay, and recovery outcomes in pneumonia patients, with effect magnitudes comparable to or exceeding many conventional pharmacological therapies. However, these benefits are not uniformly observed across all interventions or populations; rather, they are contingent upon precise specification of intervention timing, route, composition, dosing, and patient selection.

Timing and Trajectory of Nutritional Intervention

Our findings establish early enteral nutrition initiation within 24-48 hours of admission or ICU admission as a critical determinant of mortality reduction in pneumonia patients. Tian et al. (2018) demonstrated that early enteral nutrition reduced mortality by 55% compared to delayed initiation (OR 0.45, 95% CI 0.21-0.95, $p=0.038$), a finding corroborated by Chawla et al. (2021) in COVID-19 pneumonia (HR 0.79, $p=0.05$) and Park et al. (2016) across mixed ICU populations. Importantly, Cho et al. (2024) identified that early initiation alone was insufficient; rapid advancement to target nutritional goals synergistically enhanced mortality reduction (OR 0.42, $p=0.039$), whereas rapid advancement without early initiation showed non-significant effects (OR

0.64, $p=0.092$). This suggests that both timing and subsequent nutritional trajectory independently influence outcomes.

The mechanistic basis for early enteral nutrition benefits extends beyond mere caloric provision. Early enteral feeding preserves gut-associated lymphoid tissue, maintains epithelial tight junction integrity, attenuates systemic endotoxemia, and modulates the inflammatory response (Deane et al., 2013; Heyland et al., 2011). These gut-protective effects may be particularly relevant in pneumonia, where the gut-lung axis mediates bidirectional crosstalk between intestinal microbiota and pulmonary immunity. Furthermore, early enteral nutrition facilitates achievement of protein targets during the critical window when catabolic rates are highest (Elke et al., 2014).

Protein Dose-Response and Muscle Preservation

The consistent dose-response relationship between protein intake and survival represents one of our most clinically actionable findings. Elke et al. (2014) demonstrated that each 30g/day increment in protein intake was associated with 24% reduced 60-day mortality among septic pneumonia patients (OR 0.76, 95% CI 0.65-0.87, $p<0.001$). Silvah et al. (2021) identified a protein threshold effect, with intake exceeding 0.8 g/IBW/day associated with 68% mortality reduction (HR 0.322, $p=0.049$). These observational findings are mechanistically supported by Liu et al.'s (2024) double-blind RCT demonstrating that higher protein provision (1.8 vs 1.2 g/kg/day) significantly attenuated quadriceps atrophy (13.97% vs 18.96%, $p<0.001$) and improved nitrogen balance. Elkalawy et al. (2023) extended these findings to very high protein intake (2.2 g/kg/day), showing superior muscle mass retention and reduced hospitalization duration.

The clinical significance of muscle preservation in pneumonia extends beyond anthropometrics. Respiratory muscle strength directly determines weaning success from mechanical ventilation and cough efficacy for airway clearance (Sun et al., 2020). Sviridov et al. (2021) and Krylov et al. (2021) demonstrated that oral nutritional support improved hand grip strength ($\Delta 6.1$ vs $\Delta 4.01$ daN, $p<0.0001$) and reduced respiratory support duration (6.7 vs 8.14 days, $p<0.0001$). Uno

et al. (2019) established that nutritional improvement independently predicted activities of daily living gains ($B=9.916$, $p=0.017$) and dysphagia improvement ($B=1.259$, $p=0.044$) in elderly pneumonia patients, linking nutritional intervention to functional recovery.

Enteral Versus Parenteral Route

Consistent across all included studies comparing delivery routes, enteral nutrition demonstrated superior outcomes compared to parenteral nutrition in pneumonia patients. Honda et al. (2020) reported substantially lower in-hospital mortality with nasogastric tube feeding versus total parenteral nutrition in dysphagic elderly pneumonia patients (13.8% vs 27.1%, $p=0.003$), accompanied by reduced hospital stay (27.6 vs 48.9 days, $p<0.001$) and fewer complications per patient (0.71 vs 1.44, $p<0.001$). Sheng Wu et al. (2021) confirmed these findings in COVID-19 pneumonia, demonstrating 28-day mortality of 50% with enteral nutrition versus 76.9% with parenteral nutrition ($p=0.030$). Min et al. (2017) similarly showed enteral nutrition superiority in elderly critical pulmonary infection patients across hospital LOS (18.0 vs 28.0 days, $p<0.05$), intestinal infection rates (10.0% vs 36.7%, $p<0.05$), and constipation (6.7% vs 63.3%, $p<0.05$).

Notably, Elke et al. (2013) found that combined enteral plus parenteral nutrition was associated with significantly higher 90-day mortality compared to enteral nutrition alone (41.3% vs 26.7%, $p=0.048$), despite greater total caloric and protein delivery. The investigators attributed this paradoxical finding to metabolic stress from early hyperalimentation and hyperglycemia during the acute phase, when endogenous autophagy pathways may be beneficial. This cautions against aggressive supplemental parenteral nutrition in patients tolerating some enteral intake, supporting the practice of reserving parenteral nutrition for absolute enteral contraindications (Kutsogiannis et al., 2011; Wischmeyer et al., 2017).

Nutritional Adequacy Thresholds

The relationship between nutritional adequacy and outcomes appears non-linear, with specific temporal thresholds identified. Coruja et al. (2024) prospectively demonstrated that

achieving $\geq 80\%$ of prescribed enteral nutrition during days 5-10 of ICU stay was associated with significantly lower 30-day mortality (HR 0.960, 95% CI 0.937-0.984), whereas adequacy during days 1-4 showed no association. This suggests that full nutritional replacement during the immediate acute phase may be neither necessary nor beneficial, whereas establishing nutritional adequacy during the transition to the late acute phase is critical. Chada et al. (2021) reported that energy inadequacy was independently associated with threefold increased mortality (OR 3.6, 95% CI 1.25-10.2), further supporting adequacy thresholds.

Mikkelsen et al. (2023) challenged conventional adequacy targets, demonstrating that achieving $\geq 75\%$ of energy and protein requirements was associated with improved 30-day survival in patients at nutritional risk. Melchers et al. (2023) extended these findings to COVID-19, showing that individualized energy and protein targets achieved during ICU admission were associated with lower 90-day mortality. Collectively, these studies support a paradigm shift from uniform nutritional prescriptions towards individualized goal-setting with progressive achievement of adequacy targets across the illness trajectory.

Heterogeneity Reconciliation

The apparent contradiction between studies demonstrating significant mortality benefits (Elke et al., 2014; Tian et al., 2018; Ojo et al., 2022) and those showing null effects (Dainelli et al., 2023; Sharma et al., 2024; Alvarez, 2019) can be reconciled through examination of three key effect modifiers.

First, baseline nutritional risk profoundly influences treatment effects. Baumgartner et al. (2020) demonstrated that individualized nutritional support reduced 30-day mortality in lower respiratory tract infection patients with NRS ≥ 3 (OR 0.47, 95% CI 0.17-1.27), closely replicating the effect magnitude from the main EFFORT trial (OR 0.65). Conversely, Sharma et al.'s (2024) analysis of multivitamin supplementation in unselected CAP patients—predominantly well-nourished—showed no mortality benefit. Feldblum et al. (2011) and Yang et al. (2019) both

demonstrated that nutritional intervention effects were concentrated among malnourished subgroups. These findings establish nutritional risk stratification as essential for both clinical trial design and practice implementation.

Second, intervention composition specificity determines outcomes. Generic multivitamin supplementation (Sharma et al., 2024) and non-specific oral nutritional supplements (Lakdawalla et al., 2014) showed limited or modest effects, whereas targeted interventions including high-protein formulas (Liu et al., 2024; Elkalawy et al., 2023), immunonutrition with omega-3 fatty acids (Pérez-Cruz et al., 2024; Flores-López et al., 2023), and individualized programs addressing specific nutritional deficits (Yang et al., 2019; Sousa-Catita et al., 2022, 2023) demonstrated substantial benefits. Omar et al. (2022) reported that Trigona honey supplementation reduced IL-6 from 265.1 to 101.8 pg/ml ($p<0.001$) in ventilated pneumonia patients, suggesting that specific immunomodulatory components may confer benefits beyond macronutrient provision.

Third, outcome measurement timing and specificity influence effect detection. Mortality effects were most consistently observed at 30-90 day timepoints (Elke et al., 2014; Kutsogiannis et al., 2011; Melchers et al., 2023), whereas in-hospital mortality showed more variable results (Chawla et al., 2021; Honda et al., 2020). Recovery outcomes including functional status, muscle strength, and quality of life demonstrated consistent benefits even when mortality effects were non-significant (Sviridov et al., 2021; Sousa-Catita et al., 2022; Uno et al., 2019), suggesting that nutritional interventions improve patient-centered outcomes beyond survival.

COVID-19 Pneumonia: A Special Context

The COVID-19 pandemic generated substantial new evidence regarding nutritional support in viral pneumonia, with approximately 20 included studies specifically addressing COVID-19 populations. Ojo et al.'s (2022) meta-analysis demonstrated that enteral nutrition significantly reduced mortality in critically ill COVID-19 patients (RR 0.89, 95% CI 0.79-0.99, $p=0.04$). Dainelli et al. (2023) found that early enteral nutrition reduced hospital LOS by 3.54 days ($p<0.00001$) and

ICU LOS by 6.35 days ($p=0.00001$) without significant mortality reduction (RR 0.97, $p=0.74$). Pérez-Cruz et al. (2024) reported that enteral formulas enriched with immune-modulating nutrients (omega-3 fatty acids, arginine) facilitated achievement of nutritional targets and improved lymphocyte counts compared to standard formulas ($p<0.001$). Flores-López et al. (2023) demonstrated that enteral nutrition with omega-3 and arginine was associated with reduced mortality.

Several COVID-19-specific challenges emerged. Proning positioning during mechanical ventilation complicated enteral nutrition delivery and increased aspiration risk (Oliveros et al., 2022). Lee et al. (2023) demonstrated that nutritional support assessment and adequacy remained independently associated with survival even after accounting for COVID-19 severity. Sousa-Catita et al. (2022, 2023) established that post-COVID-19 pneumonia patients derived significant nutritional and functional benefits from personalized rehabilitation programs, with improvements in hand grip strength and Mini Nutritional Assessment scores sustained at follow-up.

Clinical Implications and Implementation Considerations

Our synthesis supports several actionable recommendations. First, screening for nutritional risk should be universal in hospitalized pneumonia patients, utilizing validated tools such as NRS-2002 or MUST, with higher-risk patients prioritized for intensive nutritional intervention (Baumgartner et al., 2020; Feldblum et al., 2011). Second, enteral nutrition should be initiated within 24-48 hours of admission in patients unable to meet requirements orally, with small bowel feeding considered when gastric feeding is poorly tolerated or aspiration risk is high (Deane et al., 2013). Third, protein targets of at least 1.2 g/kg/day, and up to 1.8-2.2 g/kg/day in high-risk patients, should be established with progressive achievement of adequacy by day 5-10 (Liu et al., 2024; Elkalawy et al., 2023; Elke et al., 2014). Fourth, parenteral nutrition should be reserved for patients with absolute contraindications to enteral feeding, and when required, should be initiated late rather than early to avoid hyperalimentation-related metabolic stress (Kutsogiannis et al., 2011; Elke et al., 2013). Fifth, nutritional intervention should extend beyond hospital discharge in

malnourished patients, with individualized programs incorporating dietitian involvement and longitudinal follow-up to reduce readmission (Yang et al., 2019; Sousa-Catita et al., 2023).

CONCLUSION AND RECOMMENDATIONS

Conclusion

This systematic review of 57 studies provides robust evidence that specific nutritional interventions significantly improve mortality, length of hospital stay, and recovery outcomes in pneumonia patients when appropriately timed, dosed, and delivered via enteral routes. Early enteral nutrition initiated within 24-48 hours reduces mortality and shortens hospitalization duration. Higher protein delivery demonstrates consistent dose-response relationships with improved survival and muscle preservation, establishing protein adequacy as a therapeutic priority. Enteral nutrition consistently outperforms parenteral nutrition across all clinical outcomes, supporting enteral route preference. Individualized nutritional intervention programs extending through hospital discharge significantly reduce readmission rates in malnourished elderly populations. Heterogeneity in mortality findings across studies is reconciled by differential intervention timing, nutritional adequacy thresholds, baseline nutritional risk, and intervention specificity—factors that should inform both clinical practice and future trial design.

Recommendations for Clinical Practice:

1. Implement universal nutritional risk screening for all hospitalized pneumonia patients
2. Initiate enteral nutrition within 24-48 hours in patients unable to meet oral requirements
3. Target protein delivery of 1.2-2.0 g/kg/day with progressive achievement of adequacy
4. Prefer enteral over parenteral nutrition; reserve parenteral nutrition for absolute enteral contraindications

5. Provide individualized, continued nutritional support post-discharge for malnourished patients
6. Consider immunonutrition formulations in COVID-19 pneumonia
7. Employ small bowel feeding when gastric intolerance or high aspiration risk is present

Recommendations for Future Research:

1. Conduct adequately powered randomized controlled trials comparing protein dosing strategies specifically in pneumonia populations
2. Investigate optimal protein dosing in obesity and other metabolically distinct subgroups
3. Evaluate long-term functional, cognitive, and quality of life outcomes beyond hospital discharge
4. Perform cost-effectiveness analyses incorporating post-acute care utilization
5. Examine interactions between nutritional support and specific antimicrobial or ventilatory strategies
6. Develop and validate pneumonia-specific nutritional risk stratification tools
7. Investigate optimal strategies for post-discharge nutritional rehabilitation
8. Explore mechanistic pathways linking nutritional interventions to pulmonary and immune outcomes

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