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Determinants of hypoalbuminemia in hemodialysis patients: A literature review

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ABSTRACT

Hypoalbuminemia was a frequent nutritional complication among patients undergoing hemodialysis and was associated with unfavorable clinical outcomes. This review aimed to identify factors associated with hypoalbuminemia in adult hemodialysis patients. A literature search was conducted in July 2026 in PubMed, selected for its indexed biomedical coverage, and Google Scholar, selected to capture regional and Indonesian-language publications. Observational studies published from 2021 to 2026 that examined serum albumin in adults receiving hemodialysis were screened by title, abstract, and full text. Six studies from Colombia, Jordan, Indonesia, the Republic of the Congo, and China were synthesized narratively: one retrospective multicenter cohort and five cross-sectional studies, including one machine-learning analysis. Inadequate protein intake and chronic inflammation were the most consistently reported correlates of low albumin. Evidence linking dialysis frequency and adequacy to albumin was limited to descriptive findings, and poor dietary adherence was associated with protein-energy wasting rather than independently with hypoalbuminemia. The contribution of this review is an integrated framework of nutritional, inflammatory, treatment-related, and behavioral determinants for Indonesian hemodialysis practice, where local studies have so far examined single determinants. Albumin monitoring should be combined with assessment of dietary intake and adherence, inflammation, and delivered dialysis. The small number of studies and heterogeneous outcome definitions limit the certainty of these conclusions.

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INTRODUCTION

Chronic kidney disease (CKD) is a major global health problem characterized by a progressive decline in kidney function that may lead to end-stage kidney disease (Kalantar-Zadeh et al., 2021). Its rising burden has increased the number of patients requiring renal replacement therapy, with

hemodialysis remaining the most widely used modality (Kovesdy, 2022). In Indonesia, the number of patients undergoing hemodialysis continues to increase (Indonesian Renal Registry, 2022). A nationwide analysis of 99,552 adult patients in the registry reported a five-year survival rate of 77% and found that twice-weekly hemodialysis was associated with higher mortality (HR 1.080; 95% CI 1.011–1.155) (Puspitasari et al., 2024). Nutritional disorders are common in this population and may manifest as protein-energy wasting (PEW), a multifactorial condition driven by inadequate intake, chronic inflammation, metabolic disturbances, and the catabolic effects of CKD and dialysis (Hanna et al., 2020; K. Zhang et al., 2025). When PEW progresses, it may lead to muscle wasting, sarcopenia, and cachexia, which further impair functional status and survival (Hanna et al., 2020).

The prevalence of PEW varies across populations according to diagnostic methods and patient characteristics (Carrero et al., 2018). Serum albumin is one of the most widely used markers of nutritional status, and hypoalbuminemia is a strong predictor of morbidity and mortality in hemodialysis patients (Alp Ikizler et al., 2020). International guidelines therefore recommend regular nutritional assessment, including serum albumin, in patients receiving dialysis (Alp Ikizler et al., 2020; Fiaccadori et al., 2021; Navaneethan et al., 2025). In Indonesia, malnutrition-inflammation has been documented among hemodialysis patients at Cipto Mangunkusumo National General Hospital (Adrianto & Utari, 2024), and protein intake and nutritional therapy have been linked to serum albumin (Dewi & Lestari, 2024; Selvianita et al., 2025).

However, hypoalbuminemia cannot be explained solely by insufficient protein or energy intake. Among 1,567 new hemodialysis patients in Taiwan, low albumin was associated with age, sex, hypertension, hemoglobin, iron, ferritin, electrolytes, creatinine, alkaline phosphatase, and triglycerides (Yang et al., 2023); with PEW, inflammation, and treatment characteristics (Castillo et al., 2025); with dialysis-related and inflammatory factors (Jiwintarum et al., 2026; Sinomono et al., 2026); with biochemical predictors and dialysis modality (K. Zhang et al., 2025); and with dietary adherence (Farrah et al., 2025). These determinants are usually examined separately, although they are likely to interact in determining nutritional status and prognosis. The specific gap is that these studies used different nutritional measures, albumin thresholds, and analytical approaches, which limits comparison of the contribution of each factor. Indonesian studies have mostly been single-center investigations of one determinant, such as protein intake (Selvianita et al., 2025), nutritional therapy (Dewi & Lestari, 2024), or dialysis frequency, as reported by Jiwintarum et al. (2026). Moreover, evidence on dietary adherence or composite hypoproteinemia is not equivalent to evidence on isolated hypoalbuminemia.

Accordingly, this review aimed to identify and analyze the factors associated with hypoalbuminemia among patients undergoing hemodialysis, based on the premise that hypoalbuminemia results from the interaction of nutritional intake, inflammation, dialysis frequency and adequacy, modality, and dietary adherence. The review addressed two questions: which nutritional, inflammatory, dialysis-related, and behavioral factors are associated with hypoalbuminemia in adults receiving hemodialysis, and how these factors can be assessed together in Indonesian practice. For Indonesian hemodialysis practice, its contribution is twofold: it places the limited single-center Indonesian evidence alongside international studies, and it translates the synthesis into an assessment sequence that links serial albumin measurement with dietary intake, inflammatory status, and delivered dialysis. Dietary compliance is considered alongside clinical and nutritional factors because it is the behavioral link between the prescribed renal diet and actual intake. Patients must achieve adequate protein and energy intake while restricting sodium, potassium, phosphorus, and fluid, so difficulty following these recommendations may cause either insufficient protein intake or unnecessary over-restriction (Kolak et al., 2022). Conversely, low albumin in an adherent patient may reflect inflammation or inadequate dialysis rather than dietary failure. Joint assessment therefore avoids attributing hypoalbuminemia solely to patient behavior and indicates whether dietary support, inflammatory evaluation, or dialysis review is needed (Farrah et al., 2025).

Background of the study/related work, adequate protein and energy intake is a key determinant of serum albumin in hemodialysis. A meta-analysis of randomized trials found that oral nutritional supplementation increased serum albumin in patients receiving maintenance dialysis (Liu et al., 2023); across 22 trials involving 1,185 patients, albumin increased by 1.26 g/L, with larger effects among hemodialysis patients and with non-intradialytic supplementation. Protein requirements are also higher because amino acids are lost during dialysis and end-stage kidney disease is catabolic (Fiaccadori et al., 2021). Jiwintarum et al. (2026) observed that serum albumin rose over six months of regular twice-weekly hemodialysis, suggesting that consistent treatment delivery may support albumin status, whereas inadequate dialysis may contribute to uremic toxin accumulation and inflammation (Sinomono et al., 2026). Dialysis modality appears less influential: albumin variation did not differ between expanded and high-flux hemodialysis (Castillo et al., 2025), although albumin losses during extracorporeal treatment, usually about 2 to 7 g per session through leakage into the dialysate and possibly more through membrane adsorption, have been proposed as a contributor (Karabelas, 2024).

Chronic inflammation combined with malnutrition contributes to the malnutrition-inflammation complex and PEW (J. Zhang et al., 2025). In 6,679 hemodialysis patients from 138 centers in Beijing, the prognostic nutritional index, which incorporates serum albumin and lymphocyte count, was the strongest of several inflammatory and nutritional indices for predicting survival (adjusted HR 0.78) (Chen et al., 2025). Malnutrition is also common in other dialysis populations; in Croatia, 47.3% of hemodialysis participants were malnourished according to the malnutrition-inflammation score, and dietary intake frequently fell short of recommendations (Kolak et al., 2022). Behavioral and treatment factors also matter: among 188 patients in Palestine, Hamdan et al. (2025) found malnutrition in 28.2%, with longer dialysis duration, unmet calorie intake, dependence in daily activities, and low albumin as independent predictors of the malnutrition-inflammation score. Limited nutrition knowledge, socioeconomic constraints, and uremic symptoms may further reduce adherence and appetite (Dewi & Lestari, 2024). Low albumin should therefore not be interpreted solely as evidence of inadequate dietary protein.

RESEARCH METHOD

This literature review synthesized observational evidence on factors associated with hypoalbuminemia in adults receiving routine hemodialysis and was reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework.
The electronic literature search was conducted in July 2026. PubMed and Google Scholar were the principal databases, and the identification stage also included Scopus and ScienceDirect (Figure 1). The search combined keywords, Medical Subject Headings terms, and Boolean operators: ("Hemodialysis" OR "Haemodialysis") AND ("Hypoalbuminemia" OR "Serum Albumin") AND ("Risk Factors" OR "Associated Factors" OR "Determinants"). Mendeley was used for reference management and duplicate removal. PubMed was selected because it indexes peer-reviewed nephrology and clinical nutrition journals and supports MeSH-based searching. Google Scholar was included because many Indonesian studies on hemodialysis and nutrition appear in national journals that are not consistently indexed in PubMed or Scopus, and this review aimed to interpret the evidence for the Indonesian context. Scopus and ScienceDirect added coverage of multidisciplinary and publisher-based journals.

Eligible studies involved adults (>18 years) with CKD undergoing routine hemodialysis, evaluated factors associated with hypoalbuminemia, used a cross-sectional, case-control, or cohort design, were published between 2021 and 2026, and were available in full text in Indonesian or English. Studies of pediatric patients, pregnant women, or peritoneal dialysis, as well as reviews, case reports, editorials, and abstract-only publications, were excluded. Hypoalbuminemia could be defined according to each study, and studies analyzing serum albumin as a continuous outcome or reporting composite outcomes that included albumin, such as PEW or hypoproteinemia, were also

eligible. Titles and abstracts were screened first, followed by full-text assessment against the same criteria. The 2021–2026 window was chosen because it captures studies published since the KDOQI 2020 (Alp Ikizler et al., 2020) and ESPEN 2021 (Fiaccadori et al., 2021) nutrition guidelines, reflects contemporary practice such as expanded hemodialysis and machine-learning risk prediction, and keeps the evidence relevant to Indonesian hemodialysis services, where patient numbers continue to rise. Coverage of 2026 ended at the July 2026 search date. Earlier guidelines and foundational studies were used only for background and discussion. Of 845 records identified, 225 duplicates were removed and 588 were excluded at title and abstract screening. Of the 32 full-text articles assessed, 26 were excluded because of inappropriate population (n=8), outcome not specific to albumin (n=7), inappropriate design (n=5), intervention studies or reviews (n=3), or incomplete full text (n=3), leaving six included studies (Figure 1).

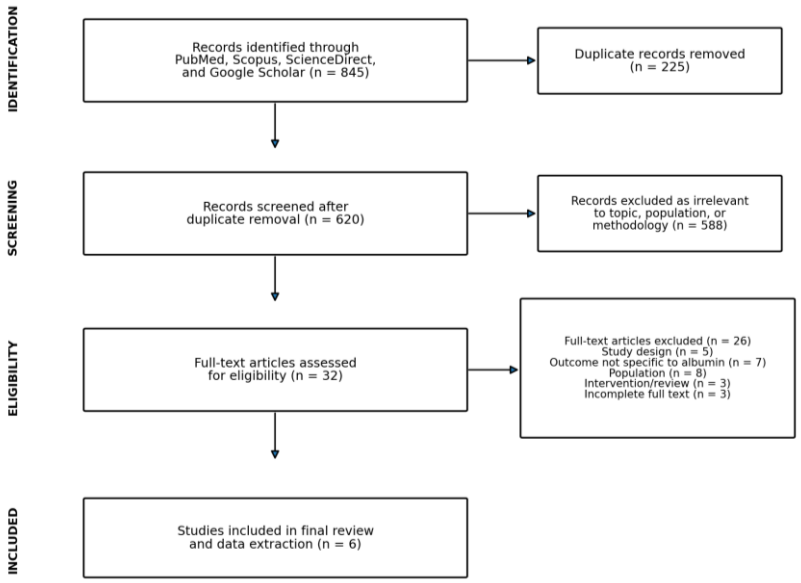


Figure 1. PRISMA flow diagram of the study selection process

Data from each included study were extracted into a structured matrix covering author, year, location, design, participants, instruments, analysis, and main findings (Table 1). The findings were then grouped into four domains that guided the synthesis: nutritional intake, inflammation and biochemical markers, dialysis-related factors (frequency, adequacy, and modality), and behavioral factors, particularly dietary adherence. Protocol registration, formal risk-of-bias assessment, and dual independent screening were not undertaken. Because the included studies differed in design, population, measurement, and analysis, the evidence was synthesized narratively.

RESULTS AND DISCUSSIONS

Six studies from Colombia, Jordan, Indonesia, the Republic of the Congo, and China were included: one retrospective multicenter cohort and five cross-sectional studies, one of which used machine learning (Table 1). All were published in 2025 or 2026. Reported sample sizes ranged from 32 to 1,092 patients, while one study did not report its sample size in the extracted data. Two studies were conducted in Indonesia. The outcomes also differed: three studies examined hypoalbuminemia or serum albumin directly, one examined albumin variation over time, one assessed PEW risk defined partly by albumin, and one used a composite hypoproteinemia endpoint.

Table 1. Characteristics and main findings of the included studies

Author	Location	Design	Participants	Instruments/Data	Analysis	Main findings
Castillo et al. (2025)	Colombia	Retrospective multicenter cohort	1,092 adults (HDx 559; HF-HD 533)	Medical records; serial albumin; PEW criteria	Repeated-measures ANOVA; linear panel regression	Mean albumin >3.8 g/dL over 48 months; no difference by modality (p=0.789); associated with PEW, CRP, platelet-lymphocyte ratio, age, vascular access, hospitalization.
Farrah et al. (2025)	Amman, Jordan	Cross-sectional	344 adults in four hospitals	ISRNM PEW criteria; renal dietary compliance questionnaire	Descriptive, bivariate	PEW (albumin <40 g/L) 59.6%; protein (p=0.003) and calorie intake (p=0.044) associated with albumin; low adherence to renal diet.
Jiwintarum et al. (2026)	Praya, Indonesia	Cross-sectional	32 patients on twice-weekly HD	Hb, urea, creatinine, albumin	Descriptive, comparative	Albumin rose over six months (3.7 to 4.4 g/dL; abstract: 3.4 to 4.0 g/dL); no comparison group or Kt/V/URR.
Selvianita et al. (2025)	Bantul, Indonesia	Cross-sectional	60 patients on routine HD	24-hour food recall; serum albumin	Chi-square test	Inadequate protein intake 93.3% (mean 31.5 g/day); hypoalbuminemia 81.7%; protein intake (p=0.017) and animal-to-plant ratio (p=0.039) associated with albumin.
Sinomono et al. (2026)	Brazzaville, Republic of the Congo	Cross-sectional	Chronic HD patients (n not reported)	CRP; nutritional indicators	Bivariate analysis	Inflammation and malnutrition associated with hypoalbuminemia.
K. Zhang et al. (2025)	Jining, China	Cross-sectional	288 maintenance HD patients	Globulin, Hb, β2-microglobulin, prealbumin, CRP; LR, RF, SVM, XGBoost	LASSO, cross-validation, ROC/AUC, SHAP	Hypoproteinemia 17.4%; SVM AUC=0.937; 13 key features, led by globulin, Hb, β2-microglobulin, prealbumin, modality.

Nutritional intake emerged as an important determinant of albumin status. Selvianita et al. (2025) reported inadequate protein intake in 93.3% of 60 hemodialysis patients and hypoalbuminemia in 81.7% (mean albumin 3.15 g/dL). Mean protein intake was only 31.5 g per day, or 48.8% of individual requirements, and 91.7% had an inadequate animal-to-plant protein proportion; protein intake (p=0.017) and the animal-to-plant protein ratio (p=0.039) were associated with albumin, indicating that both the amount and composition of dietary protein matter. Farrah et al. (2025) similarly found that mean protein and calorie intakes were associated with serum albumin (p=0.003 and p=0.044, respectively) among 344 patients in Jordan. Across the six studies, nutritional and inflammatory domains showed the most consistent pattern: intake-related findings were reported by Selvianita et al. (2025) and Farrah et al. (2025), and inflammatory associations by Castillo et al. (2025) and Sinomono et al. (2026), with supporting evidence from K. Zhang et al. (2025) using a composite hypoproteinemia endpoint. Because the synthesis was narrative, this convergence reflects consistency in direction rather than a pooled effect size.

These findings agree with KDOQI, ESPEN, and KDIGO-based recommendations on adequate protein and energy intake (Alp Ikizler et al., 2020; Fiaccadori et al., 2021; Navaneethan et al., 2025), supporting routine dietary assessment and individualized counseling for patients with

low albumin. Supplementation is supported by randomized evidence: oral nutritional supplements increased serum albumin by 1.26 g/L in a meta-analysis of 22 trials, although effects on C-reactive protein and on clinically relevant outcomes remained uncertain (Liu et al., 2023).

Evidence on whether dialysis frequency and adequacy influence albumin was more limited. The only direct evidence came from Jiwintarum et al. (2026), who followed 32 patients on twice-weekly hemodialysis: albumin increased from 3.7 g/dL after the first session to 4.4 g/dL at month six, although the study abstract reported lower values (3.4 to 4.0 g/dL). This suggests improvement during regular treatment, but the study had no comparison group and did not relate albumin to Kt/V or urea reduction ratio. Indirect support came from K. Zhang et al. (2025), in which dialysis modality was a strong predictor of hypoproteinemia, and from Sinomono et al. (2026), who linked inflammatory syndrome, a consequence of insufficient uremic toxin clearance, to hypoalbuminemia. In contrast, the Frequent Hemodialysis Network trial found that six sessions per week did not raise 12-month albumin compared with three (Kaysen et al., 2012). At the population level, twice-weekly hemodialysis was associated with higher five-year mortality among 99,552 Indonesian patients (Puspitasari et al., 2024), but albumin was not analyzed, so it is unknown whether nutritional status mediates this association. Whether moving from twice- to thrice-weekly treatment, the comparison most relevant to Indonesia, improves albumin therefore remains untested. Adequate and consistent dialysis delivery is supported as part of management, but a causal effect of higher frequency is not.

Inadequate dialysis can allow uremic toxin accumulation and inflammation that suppress hepatic albumin synthesis (Sinomono et al., 2026); low albumin should therefore prompt evaluation of both intake and dialysis delivery, because protein supplementation alone may be insufficient. Dialysis modality appeared less decisive. Castillo et al. (2025) followed 1,092 prevalent adult patients (mean age 61 years; 42% with diabetes) for up to 48 months. Mean albumin remained above 3.8 g/dL and did not differ between expanded and high-flux hemodialysis ($p=0.789$), and linear panel regression showed no association between dialyzer type and albumin over time ($p=0.208$). Instead, PEW, CRP, platelet-to-lymphocyte ratio, age, vascular access, and hospitalization were associated with albumin variation.

In Indonesia, expanded hemodialysis relies on medium cut-off dialyzers that may be costlier and less available outside referral hospitals, so optimizing dialysis adequacy together with nutritional management is the more immediately applicable strategy under National Health Insurance. In practice, when albumin declines on serial measurement, nurses and dietitians can assess actual protein and energy intake and adherence, check inflammatory markers such as CRP, and compare prescribed with delivered dialysis. Counseling can then emphasize affordable local animal-protein sources such as eggs and fish, consistent with the animal-to-plant protein ratio finding (Selvianita et al., 2025), while addressing appetite and understanding of dietary restrictions. This sequence is proposed from the synthesis and has not been validated as an intervention protocol.

Inflammatory status was repeatedly associated with low albumin or protein status. Sinomono et al. (2026) linked inflammatory syndrome and malnutrition to hypoalbuminemia in Brazzaville, although sample size and effect estimates were not available. K. Zhang et al. (2025) retrospectively analyzed 288 patients treated between January and December 2023 and found hypoproteinemia in 17.4%. Four machine-learning models (logistic regression, random forest, support vector machine, and XGBoost) were compared using LASSO feature selection and three-fold cross-validation; the support vector machine performed best (AUC 0.937), and SHAP analysis identified globulin, hemoglobin, β2-microglobulin, prealbumin, and dialysis modality as leading predictors among 13 key features. Such models may help identify high-risk patients early, but because they were developed in a single center and used a composite endpoint, external validation is required before clinical use.

These findings are consistent with the malnutrition-inflammation complex, in which inflammation reduces albumin synthesis and increases protein catabolism (J. Zhang et al., 2025). Albumin should therefore be interpreted with inflammatory markers to identify patients unlikely to respond to supplementation alone. The assay method also matters: in 103 hemodialysis patients, applying the general 3.5 g/dL cut-off to bromocresol purple results classified 33% of patients as hypoalbuminemic when immunonephelometry did not, and method-specific thresholds of 3.05 g/dL for bromocresol purple and 3.4 g/dL for immunoturbidimetry were proposed (Rami Arab et al., 2023). Volume status is a further consideration: in the Frequent Hemodialysis Network trial, part of an early difference in albumin was attributed to hemodilution related to the interdialytic interval (Kaysen et al., 2012). Albumin values should therefore be compared at consistent points in the dialysis cycle. Dialysis vintage may also contribute, as Hamdan et al. (2025) identified longer time on dialysis as an independent predictor of malnutrition.

Dietary adherence was an additional behavioral determinant. Farrah et al. (2025) found that poor adherence to renal-specific dietary recommendations was associated with higher PEW risk among 344 adults in Amman, although this does not establish an independent effect of non-adherence on hypoalbuminemia. PEW, indicated by albumin below 40 g/L, occurred in 59.6% of participants. Notably, 70% reported that a healthcare provider had rarely or never discussed a renal-specific diet with them, 24% had great difficulty following dietary recommendations, and approximately 15% were unable to follow any recommendations. These figures show that non-adherence often reflects gaps in nutritional care rather than patient unwillingness alone, which is why compliance should be assessed alongside clinical and nutritional status. Adherence is difficult because patients must balance adequate protein and energy intake against sodium, potassium, phosphorus, and fluid restrictions, and limited knowledge, socioeconomic constraints, and uremic symptoms may further reduce it (Dewi & Lestari, 2024). Education should therefore consider economic capacity, food availability, appetite, and treatment burden.

Placing the Indonesian evidence within this framework clarifies its contribution. At Cipto Mangunkusumo National General Hospital, malnutrition-inflammation was found in 55.8% of 120 hemodialysis patients; male sex, age of 40 years or older, and inadequate protein intake were associated with 4.1-fold, 3.1-fold, and 2.8-fold higher risks of malnutrition, respectively (Adrianto & Utari, 2024). Selvianita et al. (2025) linked low protein intake to hypoalbuminemia in Bantul, and Jiwintarum et al. (2026) described albumin improvement during regular twice-weekly treatment in Praya. These single-center findings are consistent with international evidence on intake and inflammation, but none measured dietary adherence, inflammatory markers, and dialysis adequacy together. The integrated assessment proposed in this review therefore addresses a practical gap in Indonesian hemodialysis care rather than duplicating existing local studies.

Table 2. Direction and strength of evidence by determinant domain

Determinant domain	Included studies	Direction of association	Strength of evidence and gaps
Nutritional intake	Selvianita et al. (2025); Farrah et al. (2025)	Lower protein and calorie intake and a lower animal-to-plant protein ratio associated with lower albumin	Consistent direction; cross-sectional and mostly unadjusted analyses
Inflammation and biochemical markers	Castillo et al. (2025); Sinomono et al. (2026); K. Zhang et al. (2025)	CRP, platelet-to-lymphocyte ratio, inflammatory syndrome, globulin, and β2-microglobulin associated with low albumin or hypoproteinemia	Consistent direction; heterogeneous markers and endpoints
Dialysis frequency and adequacy	Jiwintarum et al. (2026)	Albumin increased during regular twice-weekly treatment	Limited; descriptive single-center data without comparison group or Kt/V/URR
Dialysis modality	Castillo et al. (2025); K. Zhang et al. (2025)	No albumin difference between HDx and HF-HD; modality contributed to hypoproteinemia classification	Inconsistent; few studies with different endpoints
Dietary adherence	Farrah et al. (2025)	Low adherence associated with higher	Limited; outcome was PEW

Determinant domain	Included studies	Direction of association	Strength of evidence and gaps
		PEW risk; frequent lack of dietary counseling	rather than isolated hypoalbuminemia

Table 2 summarizes the direction and strength of the evidence for each domain. Overall, hypoalbuminemia reflects the combined influence of nutritional intake, dialysis delivery, inflammation, and adherence rather than a single pathway (Kalantar-Zadeh et al., 2021), so nutritional optimization, adequate dialysis, inflammation control, and adherence support are complementary components of long-term hemodialysis care (Kovesdy, 2022). Two patient profiles illustrate how this framework can guide care. Patients with persistently low albumin despite adequate reported intake should be evaluated for inflammation, infection, or inadequate dialysis rather than receiving repeated dietary instruction alone. Conversely, patients with low intake and reported difficulty following recommendations are most likely to benefit from individualized counseling that considers food costs, local food availability, appetite, and family support.

CONCLUSION

Hypoalbuminemia in hemodialysis patients is multifactorial and most consistently associated with inadequate protein intake and chronic inflammation. Evidence that dialysis frequency and adequacy affect albumin remains descriptive, and dietary adherence has been linked to PEW rather than independently to hypoalbuminemia. Low albumin should prompt integrated assessment of dietary intake and adherence, inflammation, and delivered dialysis rather than supplementation alone. For Indonesian practice, this review contributes a framework that connects dietary compliance with clinical and nutritional assessment, so that education can be tailored to each patient's intake, appetite, economic capacity, and available dialysis resources. Because the current evidence is mainly cross-sectional and single-center, these recommendations should be applied as part of clinical judgment and refined as stronger Indonesian evidence becomes available.

Limitations and future works, this review was limited by the small number of included studies, heterogeneity in design, population, measurement, and analysis, and the absence of protocol registration, formal risk-of-bias assessment, dual independent screening, and meta-analysis. Nevertheless, it combined international and Indonesian evidence across nutritional, inflammatory, dialysis-related, and behavioral domains, which single-determinant studies cannot provide. Studies indexed only in other databases or published in languages other than English and Indonesian may have been missed. Database-specific search strings and per-source yields were also not reported, which limits reproducibility. Future research should prioritize (1) prospective multicenter Indonesian cohorts with repeated measurement of albumin, dietary intake and adherence, CRP, and delivered Kt/V or urea reduction ratio, adjusted for diabetes, residual kidney function, hydration, and baseline nutritional status; (2) comparisons of twice- and thrice-weekly schedules with measured adequacy; (3) controlled trials of individualized nutritional and adherence support using functional outcomes, hospitalization, quality of life, and albumin; (4) external validation of risk-prediction models in Indonesian populations; and (5) future reviews with registered protocols, reproducible search strategies, and standardized risk-of-bias appraisal.

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