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SYSTEMATIC REVIEW

Nutrition Education on Health Outcomes in Hemodialysis Patients: A Systematic Review

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Abstract

Malnutrition is a prevalent issue among patients with End-Stage Renal Disease (ESRD) on hemodialysis, contributing to increased morbidity and mortality. Common challenges include poor dietary adherence, protein-energy wasting, and electrolyte imbalances. Nutritional education has been proposed as a key intervention to improve health outcomes in this population. This systematic review aimed to evaluate the effectiveness of nutritional education interventions on clinical outcomes, dietary adherence, and quality of life among ESRD patients undergoing hemodialysis. A total of 22 studies, including randomized controlled trials, quasi-experimental, and observational designs, were analyzed. The review followed PRISMA guidelines to ensure a comprehensive assessment of the literature. Data were extracted using an adapted Cochrane template, and study quality was assessed using the Cochrane Risk of Bias Tool. Interventions included telehealth counseling, in-person sessions, group education, and educational materials. Nutritional education interventions significantly improved key biochemical markers, such as potassium and phosphorus levels. Improvements were also observed in malnutrition rates, muscle mass, and adherence to dietary guidelines, with personalized approaches, including telehealth and one-on-one counseling, yielding the best outcomes. Quality of life and self-management behaviors showed positive trends, although results varied due to differences in study designs and intervention formats. Nutritional education is effective in improving clinical outcomes, dietary adherence, and quality of life for ESRD patients on hemodialysis. Despite the benefits, the variability in approaches and outcomes highlights the need for a more standardized and consistent delivery of nutrition education.

Key words: End-Stage-Renal-Disease, Hemodialysis, Nutrition Education, Nutrition Counseling

1 | INTRODUCTION

Malnutrition is prevalent among End-Stage Renal Disease (ESRD) patients and is associated with increased morbidity and mortality (Schünemann et al., 2020; Sahatheven et al., 2020; Rashid, et al., 2024). ESRD is a critical health condition where one has irreversible loss of kidney function, necessitating renal replacement therapies such as hemodialysis (National Kidney Foundation, 2023). Patients with ESRD, who are on hemodialysis, are at risk for malnutrition due to several factors such as poor appetite, dietary restrictions, inflammation, and protein-energy wasting (Sahathevan et al., 2020). Hemodialysis can exacerbate malnutrition by causing a loss of amino acids and proteins during the dialysis process, which contributes to protein-energy wasting (PEW) (Lodebo & Shah, 2018). Additionally, patients often experience poor appetite due to the uremic state and the buildup of toxins, which can lead to inadequate caloric and protein intake. Since the kidneys are no longer able to adequately remove excess minerals from the blood, toxic levels of phosphorus, potassium, and

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sodium can accumulate, requiring dietary restrictions (National Kidney Foundation, 2024). The kidneys are also no longer able to maintain proper fluid balance, requiring fluid limitations (Kaplan & Karadağ, 2022). Inflammation, commonly seen in ESRD patients, can increase metabolic demands and contribute to muscle breakdown (Cobo et al., 2018). Patients undergoing hemodialysis face numerous challenges, including managing their dietary regimen. Therefore, nutrition education is likely a key component in improving health outcomes for ESRD patients on hemodialysis.

Nutrition education empowers patients with the knowledge and skills to make informed dietary choices, which potentially can improve overall health outcomes (Silva et al., 2023). The nutrition education process involves providing patients with dietary recommendations that align with the specific needs of ESRD patients (Anderson & Nguyen, 2018). Additionally, nutrition education programs can be delivered through various methods, such as individual counseling sessions, group classes, written materials, and digital tools like apps or online resources (Skelton et al., 2015). The nutrition education programs are typically delivered by renal dietitians who can tailor advice to each patient's unique situation.

This systematic review seeks to examine the impact of nutrition education on various patient outcomes for ESRD patients on hemodialysis. By compiling current evidence, the review aims to provide a comprehensive understanding of how nutritional education and interventions influence clinical parameters, quality of life, and overall health in this patient population. The findings from this review could inform healthcare practices the importance of nutrition education to enhance the care and outcomes of ESRD patients on hemodialysis.

2 | METHODS

Protocol and Registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to assess the impact of nutrition education on patient outcomes in ESRD patients undergoing hemodialysis (Page et al., 2021). In accordance with PRISMA guidelines, the review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the ID CRD42024566398.

Search Strategy

In this systematic review, the search strategy utilized Boolean operators to combine the PICO (Population, Intervention, Comparison, Outcome) terms and ensure comprehensive coverage of the relevant literature. Boolean operators such as "AND" and "OR" were used to refine and expand the search. The operator "AND" was applied between each PICO component to ensure that all studies included addressed the specified population, intervention, and outcomes. As seen below in Table 1, different search terms for nutrition education were utilized and various outcome terms were included to capture a comprehensive view of health outcomes. Both 'dietitian' and 'dietician' were used interchangeably in the search terms to account for regional spelling variations. Similarly, "hemodialysis" and "haemodialysis," as well as "hospitalization" and "hospitalisation," were included to capture a wide range of relevant studies.

Eligibility Criteria

The criteria for study selection were established to ensure a targeted evaluation. Studies were included if they met specific criteria: Participants were adults aged 18 years and older receiving in-center hemodialysis or on maintenance hemodialysis for at least three months. Interventions of interest included nutrition education, counseling, or ongoing dietary monitoring, focusing on outcomes such as nutritional status, clinical parameters (e.g., hospitalization rates, mortality rates), adherence to dietary recommendations, biomarkers (e.g., serum potassium, serum phosphorus), and quality of life (QoL). Studies needed to obtain adequate sample sizes (at least ten participants per group). Studies focusing on home hemodialysis or peritoneal dialysis were excluded for consistency and unbiased outcomes. Additionally, reviews, opinion pieces, stud-

Table 1. Search Terms

Population	Intervention	Outcome
H(a)emodialysis OR in-center h(a)emodialysis OR end-stage renal disease OR ESRD patients OR dialysis patients	Dietitian (dietitician) education OR dietitian (dietitician) counseling OR dietary education OR dietary counseling OR nutrition education OR dietitian (dietitician) communication OR dietitian (dietitician) visits OR renal dietitian (dietitician) OR diet education OR dietitican (dietitician) involvement OR nutrition knowledge OR medical nutrition therapy	Dietary compliance OR mortality OR death OR hospitalization (hospitalisation) OR hospitalization (hospitalisation) rates OR nutrition status OR nutrition labs OR quality of life (QoL) OR long-term outcomes OR sustained outcomes OR potassium OR phosphorus OR albumin OR fluid management OR interdialytic weight gain (IDWG) OR hyperphosphatemia OR hyperkalemia OR hypoalbuminemia

ies with less than ten participants per study group, studies published more than ten years ago, and articles not available in English were excluded from the review. A search for peer-reviewed literature was performed using three primary databases and one register, PubMed, CINAHL, Embase, and International Clinical Trials Registry Platform (ICTRP).

Table 2. Inclusion and Exclusion Criteria

Critera	Inclusion	Exclusion
Age	Adult patients 19 years old +	18 years old or younger
Health Problem	ESRD patients on in-center hemodialysis; patients on maintenance hemodialysis for at least 3 months	Patients on home hemodialysis, patients on peritoneal dialysis
Intervention	Nutrition education, nutrition counseling, ongoing dietary monitoring	Interventions solely focused on medical management, non-dietary aspects
Outcomes	Nutritional status (serum albumin levels, dietary intake), clinical outcomes (hospitalization rates, mortality rates), adherence to dietary recommendations, dietary intake, biomarkers (serum potassium, serum phosphorus), fluid management, QoL	Studies not reporting on relevant patients' outcomes
Study Design Preferences	Clinical studies, Clinical trials, Randomized controlled trials, Observational Studies	Reviews, opinion pieces
Size of Study Groups	At least 10 participants in each study group	Less than 10 participants
Language	Limited to articles published in English	Studies published in languages other than English
Publication Year Range	Limited to the past 10 years	Studies published more than 10 years ago
Other	Full text available	

Data Extraction & Quality Assessment

The data extraction process followed an adapted Cochrane template to meet the specific requirements and scope of this review (Higgins et al., 2020). The extracted information included the title, author, year of publication, study design, age range, setting, study duration, aim of the study, participant characteristics, number of groups, description of the intervention, measures, outcome measures, and results/conclusions (Ryan et al., 2016). Quality assessment and risk of bias were evaluated using the Cochrane Risk of Bias Tool, which assesses domains such as selection bias, performance bias, detection bias, attrition bias, and reporting bias (Higgins et al., 2011).

This tool categorizes studies as having "low risk," "some concerns," or "high risk" of bias, based on factors like the validity of study design, transparency of reporting, and consistency of outcomes. The use of the Cochrane tool ensures a standardized and robust approach to evaluating the strengths and limitations of the evidence in this review.

3 | RESULTS

A total of 22 studies were included in this systematic review, involving 2,821 hemodialysis patients. The studies varied in design, including randomized controlled trials (RCTs), quasi-experimental studies, and observational studies, with intervention durations ranging from two months to two years. Interventions focused on nutrition education delivered in various forms, such as one-on-one nutrition counseling, group sessions, telehealth, educational videos, and educational booklets. Control groups received standard care or no specific nutritional intervention(s). The findings are categorized into key areas, including biochemical outcomes, nutritional status, dietary adherence, quality of life, and knowledge/self-management behaviors.

Biochemical Outcomes

A range of studies examined the impact of nutrition education on key biochemical markers in hemodialysis patients, specifically focusing on serum potassium, phosphorus, calcium, and albumin levels (Valente et al., 2022; Jarupala et al., 2023; Naseri-Salahshour et al., 2020; Çavdar & Şahin, 2021; Ribeiro et al., 2020; Beer et al., 2018; Steiber et al., 2015; Martins et al., 2017; Feng et al., 2022; Parveen et al., 2018) Many studies observed improvements in the aforementioned markers following nutritional interventions, though results varied across different nutrition education formats.

Potassium is an electrolyte which is commonly abnormal in patients with ESRD. Increased dietary potassium intake poses a risk for patients with ESRD as it can lead to life-threatening cardiac arrhythmias, including ventricular fibrillation, and increased mortality (Narasaki et al., 2021). Significant ($p < 0.001$) reductions in serum potassium levels were reported, with interventions showing decreases of 0.5 mEq/dL in serum potassium utilizing telehealth-delivered dietary counseling via phone calls (Valente et al., 2022). This study also demonstrated a significant ($p < 0.05$) decrease in prevalence of hyperkalemia. Jarupala et al. (2023) conducted a study which the intervention group received a comprehensive dietary education program, including personalized dietary plans and nutritional counselling, while the control group received standard care without any specific nutritional intervention. In the intervention group, serum potassium levels significantly decreased from 5.38 (±1.07) to 4.83 (±0.98) after the program (p = 0.009), whereas the control group showed a non-significant increase in serum potassium levels (p = 0.388). Other studies also demonstrated a significant ($p < 0.05$, respectively) reduction in potassium levels and/or dietary potassium intake when structured educational interventions, including personalized or telehealth-based approaches, were in place (Naseri-Salahshour et al., 2020; Çavdar & Şahin, 2021; Ribeiro et al., 2020). Düzalan & Çinar (2018) found providing in-person nutrition education to HD patients led by nurses resulted in a non-significant reduction ($p = 0.673$) of serum potassium levels 5.28 (±0.65) to 5.19 (±0.56). Although most studies reported reductions in potassium levels, one study observed a significant increase ($p = 0.02$), with average serum potassium rising from 4.9 (±0.59) to 5.09 (±0.67) following a one-on-one nutrition education intervention, though the levels remained within the normal range (Beer et al., 2018). The findings collectively emphasize the value of structured nutritional interventions in managing serum potassium levels for patients with ESRD.

Phosphorus management is another crucial area impacted by nutritional education, given abnormal phosphorus levels can contribute to bone density loss and fractures (Singh et al., 2023; Valente et al., 2022; Jarupala et al., 2023; Ribeiro et al., 2020). Yin and associates (2021) found an intensive education program ongoing for six months significantly ($p < 0.001$) increased the proportion of patients achieving target serum phosphorus levels of <1.78 mmol/L from 43.5% to 54.9%. Ribeiro et al. (2020) revealed combining group and private nutrition education sessions, following the transtheoretical model, over four months significantly ($p < 0.001$) reduced

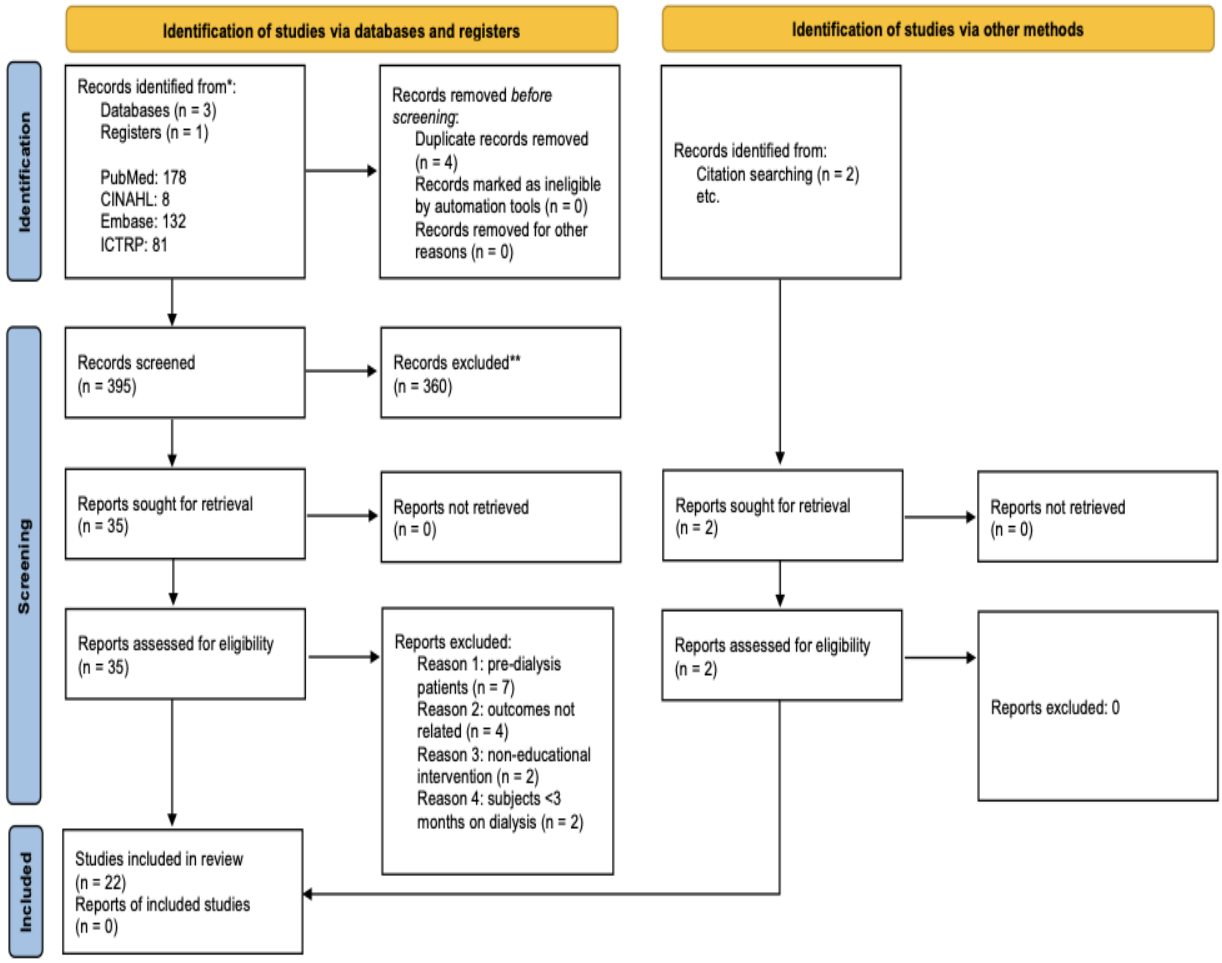

Fig. 1: Figure 1: PRISMA (Preferred Reporting Items forSystematic Reviews and Meta-Analyses) flow diagram.

serum phosphorus levels lowering from 5.2 mg/dL (±1.4) pre-intervention to 4.3 mg/dL (±1.1) post-intervention. Other studies also demonstrated significant ($p < 0.05$, respectively) reductions in phosphorus levels with education interventions of various formats (Naseri-Salahshour et al., 2020; Feng et al., 2022; Valente et al., 2022; Steiber et al., 2015; Martins et al., 2017). Brauer and colleagues (2019) identified the Phosphate Education and Planning (PEP) talks model provided non-significant reduction (-0.31 mg/dL) in serum phosphorus levels, particularly by addressing patient-specific barriers to phosphate control, such as binder non-adherence and dietary challenges. Lim et al. (2018) highlighted the importance of education on the proper timing of phosphate binder intake, improving adherence with proper timing but not significant ($p = 0.087$). Beer and researchers (2018) showed reductions ($p = 0.37$) in serum phosphorus levels that were also not statistically significant. While most interventions showed notable reductions in phosphorus levels, some yielded non-significant results.

Calcium regulation was also monitored to assess the impact of education interventions in hemodialysis patients. Intensive, doctor-led dietary educa-

tion programs demonstrated a marked increase in calcium levels ($p < 0.05$) as part of broader interventions focused on managing mineral imbalances (Feng et al., 2022). Other results showed non-significant ($p = 0.16$) changes in calcium levels despite improvements in other biochemical markers (Naseri-Salahshour et al., 2020). This variability suggests although education can improve some biochemical markers, managing calcium levels may require more focused strategies to achieve improved outcomes.

Serum albumin serves as a marker of nutritional status, with low levels often linked to malnutrition and increased inflammation, both of which are common in ESRD patients (Lodebo & Shah, 2018). Parveen et al. (2018) conducted a study providing nutrition education via leaflets, diet chart, and counseling sessions at baseline and 3 follow-ups each 45 days apart. Significant ($p < 0.0001$) improvement in albumin levels were noted after the final follow-up; average albumin increased from 3.27 g/dL to 4.03 g/dL. Valente et al. (2022) reported a non-significant ($p = 0.317$) change in albumin levels, with an average increase from 3.9 g/dL to 4.0 g/dL following telehealth-delivered dietary counseling through phone calls. Another study utilized a web-based nutrition algorithm to identify patients at nutritional risk (Stieber et al., 2015). Once the patients were identified, the necessary nutrition education and interventions were conducted by dietitians through a renal-modified Nutrition Care Process (NCP). No significant ($p = 0.863$) change in serum albumin levels. Beer et al. (2018) conducted a study providing individualized dietetic education following evidence-based guidelines which resulted in no significant ($p = 0.93$) changes in serum albumin. The findings demonstrate mixed outcomes regarding the impact of nutrition education on serum albumin levels in HD patients. The results suggest while educational interventions may enhance nutritional awareness, their direct effect on serum albumin levels may be limited and influenced by other clinical or patient-specific factors.

Nutritional Status and Dietary Adherence

Nutritional status and dietary adherence are critical for hemodialysis patients because poor nutrition can lead to protein-energy wasting (PEW), weakened immunity, muscle loss, and increased risk of infections (Sahathevan et al., 2020; Lodebo & Shah, 2018; Ribeiro et al., 2020). Beer and colleagues (2018) found individualized dietetic interventions conducted over a seven-month period resulted in significant ($p = 0.02$) improvements in malnutrition rates, measured using the subjective global assessment (SGA), reducing the percentage of malnourished patients from 43.5% to 28.9%. Parveen et al. (2018) demonstrated targeted dietary counseling improved key nutritional markers, including serum albumin and muscle mass ($p < 0.0001$). Similarly, Chen et al. (2022) observed significant improvements in dietary quality and muscle mass ($p < 0.05$, respectively) following nutrition education for patients and nursing staff. Hajira and authors (2017) noted the dietary counseling group resulted in significant ($p <0.0001$) improvements in mid-upper arm circumference and tricep fat fold measurements. Educational interventions significantly ($p < 0.004$, respectively) improved adherence to dietary guidelines (Dsouza et al., 2023; de Freitas et al., 2020; Düzalan & Çinar, 2018) as well as significant improvements ($p < 0.05$, respectively) in fluid restrictions and/or interdialytic weight gains (Dsouza et al., 2023; Oller et al., 2018; Düzalan & Çinar, 2018; Valente et al., 2022). Dsouza et al. (2023) provided nutrition education and a booklet to their intervention group along with reinforcement and addressing patients' concerns. The intervention group demonstrated a significant ($p < 0.001$) improvement in dietary restriction and significant ($p = 0.048$) improvement in fluid restriction. Düzalan & Çinar (2018) measured the effects of nutrition education on a scale for 'Dietary Behaviours in Haemodialysis Patients' (SDBHP) which resulted in a significant ($p < 0.001$) improvement. Additionally, Sevick et al. (2016) demonstrated intervention patients with significant ($p = 0.05$) reduction in sodium intake eight weeks after nutrition education provided, but not sustained after 16 weeks ($p = 0.32$). This same study had non-significant ($p = 0.79$) effects on interdialytic weight gain. The results support consistent ongoing dietary counseling not only improves key nutritional markers, such as serum albumin and muscle mass, but also lowers malnutrition rates, enhances body composition, and promotes long-term adherence to dietary and fluid restrictions.

Quality of Life

Two studies demonstrated nutritional education, one delivered in person and the other through an e-learning program, significantly ($p < 0.05$) improved the quality of life (QoL) of hemodialysis patients post intervention measured by conducting questionnaires (Ebrahimi et al., 2016; Naseri-Salahshour et al., 2020). De Frietas et al. (2020) noted dietary counseling by Registered Dietitians led to improvements in both physical and mental QoL scores, though the changes were not statistically significant ($p > 0.295$, respectively). The findings suggest while nutritional education may enhance the QoL for HD patients, more research is needed to determine whether these interventions consistently lead to significant improvements.

Knowledge & Self-Management Behaviors

The inclusion of a knowledge-attitude-behavior health education model significantly ($p < 0.05$) improved both disease-related knowledge and self-management behaviors among hemodialysis patients. Liu et al. (2016) reported after six months, the intervention group demonstrated significantly higher self-management behavior scores across several domains, including body mass control, dietary management, medication adherence, and physical activity ($p < 0.001$) compared to the control group. The findings highlight the effectiveness in providing patients with the skills needed to manage their health more effectively.

Quality/Risk Assessment

The quality of the included studies was moderate to high, as assessed using the Cochrane Risk of Bias Tool. Most studies demonstrated low risk of selection bias, with clear inclusion criteria and systematic allocation methods, and low risk of reporting bias due to transparent outcome reporting. Performance bias was a common limitation, as blinding was not feasible in educational interventions, but objective measures, such as serum potassium, phosphorus, and albumin levels, reduced detection bias. Attrition bias was generally low, with most studies achieving high retention rates and accounting for missing data. The findings suggest the included studies provide a robust basis for evaluating the impact of nutrition education interventions on hemodialysis patients.

4 | DISCUSSION

Nutritional education interventions for ESRD patients undergoing hemodialysis have demonstrated various results across multiple health outcomes. This review synthesized findings from diverse studies, revealing structured nutritional counseling positively impacts biochemical markers, dietary adherence, nutritional status, and quality of life.

Key Findings

The most significant findings centered on improvements in potassium and phosphorus management, which were consistently observed across most studies (Valente et al., 2022; Jarupala et al., 2023; Naseri-Salahshour et al., 2020; Çavdar & Şahin, 2021; Düzalan & Çinar, 2018; Yin et al., 2021; Feng et al., 2022; Ribeiro et al., 2020; Steiber et al., 2015; Martins et al., 2017). The aforementioned biochemical markers are vital for reducing the risk of complications such as cardiac arrhythmias and bone disorders in ESRD patients (Rafique, Z., et al., 2022; Singh, A., 2023). Guidelines from professional organizations, such as the National Kidney Foundation (2024), emphasize the importance of maintaining serum potassium within a narrow range to prevent cardiovascular risks and advocate for phos-

Table 3: Relevant Results of Selected Studies

Reference	Study design	Duration	Participants	Number of Groups	Location	Intervention	Control	Outcomes measured	Results/Conclusions
Beer et al., 2018	Pre-test post-test study	7 months	152 hemodialysis patients	1 group (before and after intervention)	Perth, Australia	Individualized dietetic education following evidence-based guidelines	None	Malnutrition rates (SGA), BMI, hand grip strength, serum albumin, serum potassium, phosphate levels	Significant reduction in malnutrition rates from 43.5% to 28.9% (p=0.02). Significant hand grip strength decreased (p=0.02). Significant potassium levels increased (p=0.02), no significant changes in serum albumin (p=0.93) and phosphate levels (p=0.37). The study highlights the importance of continuous and individualized education in reducing malnutrition rates among hemodialysis patients.
Brauer, A., Marcussen, K., & Paul, S. K. (2019)	Quasi-experimental study	6 months	46 hemodialysis patients with hyperphosphatemia	1 group (before and after intervention)	Madison, WI, USA	Phosphate Education and Planning (PEP) talks	None	Serum phosphate levels, patient-identified barriers	Not significant but improvement (−0.31 mg/dL) in serum phosphate levels after the PEP talks. Identified barriers included cost, lack of dietary resources, and adherence issues. Positive feedback from patients on the PEP talk series.
Çavdar & Şahin, 2021	Prospective intervention study	4 months	68 hemodialysis patients	2 (34 intervention, 34 control)	Kayseri, Turkey	Nutrition education focusing on reducing potassium intake, including face-to-face sessions and a handbook about potassium in hemodialysis treatment.	No intervention	Serum potassium levels, potassium knowledge score.	Significant reduction in serum potassium levels in the intervention group ($p < 0.001$) compared to the control group. The potassium knowledge score also significantly increased in the intervention group ($p < 0.001$), while no significant changes were observed in the control group.
Chen et al., 2022	Quasi-experimental study	2 years	94 hemodialysis patients	4 groups (27 Non-C, 25 CN, 23 CP, 19 CPN)	Northern Taiwan	HEI-HD-based nutritional educational course for patients; nurses; patients and nurses; non-course for patients and nurses	Non-C group (only education booklet)	Dietary quality (HEI-HD score), muscle mass (SMM)	HEI-HD-based education for both patients and nurses improved dietary quality ($p < 0.05$) and maintained muscle mass ($p < 0.05$). The CPN group showed significant improvements in dietary quality ($p < 0.05$) and muscle mass ($p < 0.05$) compared to the Non-C group.
de Freitas et al., 2020	Randomized Clinical Trial	1 year	87 hemodialysis patients	2 groups (47 intervention, 40 control)	Porto Alegre, Brazil	Dietary counseling on sodium restriction	Standard Care	Anthropometric, clinical, sodium intake, quality of life	Significant decrease in total sodium intake in both groups. Greater reduction in intervention group: total sodium ($p < 0.0001$), processed meat ($p = 0.003$), packaged seasonings ($p = 0.015$), instant noodles ($p = 0.017$). No significant changes in quality of life ($p = 0.295$ for physical, $p = 0.462$ for mental) or clinical parameters (IDWG, BMI, blood pressure; $p > 0.05$).

Dsouza et al., 2023	Randomized Controlled Trial	1 year	160 hemodialysis patients	2 groups (80 intervention, 80 control)	Manipal, India	Educational intervention with booklet	Standard care	Knowledge on disease management, fluid adherence, dietary adherence	Significant increase in knowledge ($p < 0.001$) and adherence to fluid ($p = 0.019$) and dietary restrictions ($p = 0.004$) in the intervention group. No significant correlation between knowledge and adherence ($p = 0.324$). No significant changes in clinical outcomes ($p > 0.05$).
Düzalan & Çinar, 2018	Quasi-experimental	Unspecified	80 hemodialysis patients	2 (40 intervention, 40 control)	Istanbul, Turkey	Educational intervention on dietary and fluid management provided by nurses. The intervention group received tailored education sessions focusing on dietary restrictions and fluid management.	No intervention	Dietary knowledge, dietary behaviors, serum sodium levels, pre-dialysis weight, diastolic blood pressure.	Significant improvement in dietary knowledge ($p < 0.001$) and behaviors ($p < 0.001$) post-intervention. Significant reduction in pre-dialysis weight ($p < 0.001$), serum sodium levels ($p < 0.001$), and diastolic blood pressure ($p < 0.05$) in the intervention group compared to the control group.
Ebrahimi et al., 2016	Randomized Controlled Trial	16 weeks	99 hemodialysis patients	2 groups (49 control, 50 experimental)	Shahroud, Iran	Face-to-face nutritional education sessions twice a week for 12 weeks	No nutrition education	Knowledge about dietary needs, quality of life (QOL)	Significant improvements in knowledge ($p<0.001$) and QOL ($p<0.001$) in the experimental group. No significant changes in knowledge ($p=0.22$) and QOL ($p=0.43$) in the control group. The study supports the positive impact of nutritional education on patients' knowledge and QOL.
Feng et al., 2022	Observational Study	21 months	120 hemodialysis patients with hyperphosphatemia	2 groups (60 observation, 60 control)	Chengdu, China	Doctor-led intensive diet education	Routine nursing guidance	Serum parathyroid hormone (iPTH), calcium (Ca), phosphorus (P), calcium-phosphorus product (Ca × P), serum creatinine (Scr), blood urea nitrogen (BUN), EQ-5D-3L scores, disease-related knowledge, compliance scores	Significant improvement in blood iPTH ($p < 0.05$), Ca ($p < 0.05$), P ($p < 0.05$), and Ca×P ($p < 0.05$) levels, higher patient satisfaction ($p < 0.05$), better EQ-5D-3L scores ($p < 0.05$) in the observation group compared to the control group.
Hajira et al., 2017	Prospective cohort study	2 months	100 ESRD hemodialysis patients	1 group (before and after	Peshawar, Pakistan	Dietary Counselling	None	Energy intake, protein intake, fat intake, mid-upper arm circumference,	Significant improvements in energy intake ($p=0.010$), protein intake ($p=0.003$), fat intake ($p=0.002$), mid-upper arm

			with protein energy wasting	interventio n)				tricep fat fold, serum cholesterol levels	circumference (p<0.0001), tricep fat fold (p<0.0001), and serum cholesterol levels (p=0.039).
Jarupala et al., 2023	Randomi zed Controlle d Trial (RCT)	12 months	250 hemodialys is patients	2 groups (125 interventio n, 125 control)	Udupi and Mangal ore, India	Dietary education program, personalized plans, nutritional counseling	Standard care without specific nutritional intervention	Sodium, hemoglobin, potassium levels	Significant improvement in reduced serum sodium ($p < 0.001$), hemoglobin ($p < 0.001$), and potassium ($p = 0.009$) levels in the intervention group compared to the control group.
Lim et al., 2018	Randomi zed controlled trial	3 months	70 hemodialys is patients	2 groups (48 education, 22 control)	Suwon, Korea	Individualized dietary and pharmacological education sessions	No education	Serum phosphate levels, dietary phosphate intake, phosphate-to-protein ratio, PG-SGA score, MMAS-8 score, proper timing of phosphate binder intake	No significant difference in achieving calcium-phosphate product < 55 between groups (75.0% vs. 72.7%, p=0.430). Higher proper phosphate binder intake in the education group (p=0.087) and lower dietary phosphate-to-protein ratio (p=0.193). No significant changes in serum phosphate levels (p=0.505), dietary phosphate intake (p=0.851), PG-SGA score (p=0.363), or MMAS-8 score (p=0.445). The study highlights the importance of continuous and individualized educational efforts.
Liu et al., 2016	Randomi zed Controlle d Trial	6 months	86 hemodialys is patients	2 groups (43 control, 43 interventio n)	Harbin, China	Knowledge-attitude-behavior health education model	Usual care and general education models	Disease-related knowledge, self-management behavior (control of body mass, reasonable diet, correct drug intake, physical activity, correct fistula care, disease condition monitoring, psychological and social behaviors)	The intervention group showed significantly higher disease-related knowledge ($p < 0.001$) and self-management behavior scores ($p < 0.001$) compared to the control group. The knowledge-attitude-behavior model shows effectiveness in improving patient outcomes.
Martins et al., 2017	Prospecti ve Interventi onal Study	4 months	179 CKD 5D patients with hyperphosp hatemia	1 (before and after interventio n)	São Paulo, Brazil	Nutritional education program utilizing the transtheoretical model of behavior change (TMBC).	None	Serum phosphorus levels, iPTH levels, adherence to sevelamer treatment, impact of literacy levels on outcomes.	Significant reduction in serum phosphorus levels: from 6.8 ± 1.1 mg/dl to 5.5 ± 1.3 mg/dl in the positive change group ($P < 0.05$). No significant change in the negative change group: from 6.8 ± 1.5 mg/dl to 6.5 ± 1.7 mg/dl ($P > 0.05$).

Naseri-Salahshour et al., 2020	Single-blind randomized controlled trial	2 months	94 hemodialysis patients	2 groups (48 intervention, 46 control)	Arak, Iran	E-learning-based nutritional education program via Telegram	No nutritional education	Quality of life (KDQOL), serum electrolyte levels (Na, K, P, Ca, Mg)	Significant improvements in QOL scores (p=0.001) and reductions in serum sodium (p=0.001), potassium (p=0.018), and phosphorus (p=0.016) levels in the intervention group compared to the control group. Magnesium levels improved significantly (p=0.012), but no significant difference in calcium levels (p=0.16). The study supports the effectiveness of e-learning in improving QOL and electrolyte balance in hemodialysis patients.
Oller et al., 2018	Quasi-experimental, non-randomized clinical trial	5 weeks	192 hemodialysis patients	2 (86 intervention, 106 control)	São Paulo, Brazil	Educational and motivational intervention using video based on Bandura's Theory.	No intervention	Percentage of weight loss during interdialytic periods.	Significant decrease in the pattern of weight gain in interdialytic periods ($P < 0.05$). Intervention group had a 3.54 times higher chance of reaching the goal of 100% weight loss compared to the control group. No significant change in self-efficacy and coping strategies ($P > 0.05$).
Parveen et al., 2018	Pre-test post-test study	6 months	60 hemodialysis patients	1 group (before and after intervention)	Kadapa, India	Dietary counseling through information leaflets and diet charts	None	Albumin, cholesterol, BMI, hemoglobin, muscle mass	Significant improvements in albumin levels ($p<0.0001$), cholesterol levels ($p<0.0001$), BMI ($p<0.0001$), hemoglobin levels ($p<0.0001$), and muscle mass ($p<0.0001$) after dietary counseling. The study supports the effectiveness of dietary counseling in reducing PEW (Protein Energy Wasting) and improving nutritional status in hemodialysis patients.
Ribeiro et al., 2020	Quasi-experimental study	4 months	83 hemodialysis patients	1 group (before and after intervention)	Minas Gerais, Brazil	Nutritional intervention based on transtheoretical model	None	Metabolic markers (creatinine, urea, phosphorus, potassium), dietary intake (calories, macronutrients, micronutrients), behavior	Significant reduction in serum concentrations of creatinine ($p < 0.001$), urea ($p < 0.001$), phosphorus ($p < 0.001$), and potassium ($p < 0.001$). Increased intake of calories ($p = 0.034$), protein ($p < 0.001$), and micronutrients ($p < 0.001$). Improved behavior change stages ($p < 0.001$). Patients progressed from contemplation to action and maintenance

								change stages (contemplation to action)	stages, indicating a successful adoption of healthier dietary behaviors.
Sevick et al., 2016	Randomized Clinical Trial	16 weeks	179 hemodialysis patients (160 completed)	2 groups (90 intervention, 89 control)	Western Pennsylvania	Technology-supported behavioral intervention for reducing dietary sodium intake using hand-held computers	Attention Control group shown educational modules on HD diet without additional intervention	Interdialytic weight gain (IDWG), dietary sodium intake	No significant difference in average IDWG observed between groups (p=0.43). Significant reduction in dietary sodium intake at 8 weeks (-372 mg/day; p=0.05) within the intervention group, but not sustained at 16 weeks (-191 mg/day; p=0.32).
Steiber et al., 2015	Prospective Observational Study	3 months	100 hemodialysis	1 group (100 patients)	Multiple countries: USA, New Zealand, Ireland, Australia, Brazil	Web-based nutrition algorithm to identify patients at nutritional risk. Once these patients were identified, the necessary nutrition education and interventions were conducted by dietitians through a renal-modified Nutrition Care Process (NCP).	None	Risk factors identified by algorithm, nutrition care process chains, patient outcomes (protein intake, PTH, phosphorus levels).	Significant increase in protein intake by 0.11 g/kg/day (P = 0.022). Significant decrease in PTH levels by 176.85 pg/mL (P = 0.011). Significant decrease in serum phosphorus levels by 0.91 mg/dL (P = 0.006). No significant change in serum albumin levels (P = 0.863).
Valente et al., 2022	Observational Study	2 months	156 hemodialysis patients	1 group (before and after intervention)	Portugal	Telehealth-delivered dietary counseling via phone calls	None	Biochemical and nutritional parameters (potassium, phosphorus, albumin, hemoglobin, % of IDWG)	Significant reduction in serum potassium ($p < 0.001$) and phosphorus levels ($p < 0.001$). Decrease in prevalence of hyperkalemia ($p < 0.001$) and hyperphosphatemia ($p < 0.001$). Improvements in %IDWG ($p = 0.013$) when contact was made directly with patients or caregivers.
Yin et al., 2021	Non-randomized, single-arm trial	6 months	366 hemodialysis patients with hyperphosphatemia	1 (before and after intervention)	Zhuhai, China	Intensive education program on phosphate control using the First Principles of Instruction model.	None	Serum phosphorus levels, knowledge of hyperphosphatemia, adherence to phosphate binders.	Significant increase in controlled serum phosphorus from 43.5% to 54.9% (P<0.001). Improvement in knowledge scores from 59.0 ± 18.9 to 80.6 ± 12.4 (P<0.001). Increase in high adherence to phosphate binders from 21.9% to 44.5% (P<0.001).

Table 4: Risk of Bias Summary

Reference	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias
Beer et al., 2018	Moderate	High	Low	Low	Low
Brauer, A., Marcussen, K., & Paul, S. K. (2019)	Low	Moderate	Low	Moderate	Low
Caydar & Sahin, 2021	Low	Moderate	Low	Low	Low
Chen et al., 2022	Moderate	High	Low	Low	Low
de Freitas et al., 2020	Low	Moderate	Low	Low	Low
Dsouza et al., 2023	Low	Moderate	Low	Low	Low
Düzalan & Çinar, 2018	Low	Moderate	Low	Low	Low
Ebrahimi et al., 2016	Low	Moderate	Low	Low	Low
Feng et al., 2022	Low	Moderate	Low	Low	Low
Hajira et al., 2017	Low	Moderate	Low	Low	Low
Jarupala et al., 2023	Low	Moderate	Moderate	Low	Low
Lim et al., 2018	Low	Moderate	Low	Low	Low
Liu et al., 2016	Low	Moderate	Low	Low	Low
Martins et al., 2017	Low	Moderate	Low	Low	Low
Naseri-Salahshour et al., 2020	Low	Moderate	Low	Low	Low
Oller et al., 2018	Low	Moderate	Low	Low	Low
Parveen et al., 2018	Moderate	High	Low	Low	Low
Ribeiro et al., 2020	Moderate	High	Low	Low	Low
Sevick et al., 2016	Low	Moderate	Low	Low	Low
Steiber et al., 2015	Low	Moderate	Low	Low	Low
Valente et al., 2022	Low	High	Low	Low	Low
Yin et al., 2021	Moderate	Moderate	Low	Low	Low

Key: Low Moderate High

phorus control to avoid mineral and bone disorders. Studies demonstrated tailored nutritional interventions, including telehealth counseling (Valente et al., 2022), intensive education programs (Yin et al., 2021), and personalized dietary plans (Jarupala et al., 2023), significantly improved serum potassium and phosphorus levels. For instance, Ribeiro and colleagues (2020) utilized a combination of group and private sessions following the transtheoretical model, achieving significant reductions in serum phosphorus levels over four months. The findings underscore the clinical significance of targeted nutritional education interventions in managing these markers, ultimately reducing the risk of severe complications in ESRD patients. Therefore, enhancing education programs focused on potassium and phosphorus management may be essential for improving patient outcomes in dialysis settings.

Albumin levels, in contrast, showed more variable outcomes. Parveen et al. (2018) reported a significant positive increase in albumin levels following a targeted nutritional education program consisting of counseling sessions, diet charts, and follow-ups every 45 days, suggesting consistent, structured interventions may enhance nutritional markers. However, other studies reported either non-significant improvements (Valente et al., 2022; Steiber et al., 2015) or no impact (Beer et al., 2018). For example, Valente and team (2022) implemented telehealth dietary counseling, which led to a slight increase in albumin levels, but the changes were not statistically significant. Similarly, Beer et al. (2018) provided individualized, evidence-based dietetic education over seven months but found no significant changes in albumin levels. Albumin levels can also be influenced by other factors, such as comorbidities, further complicating the interpretation of the outcomes (Gremese et al., 2023). Dialysis clinics often set a higher albumin goal (e.g., $\geq$4.0 g/dL) compared to the standard reference range (~3.5–5.0 g/dL). This higher target is based on evidence suggesting higher serum albumin levels are associated with better survival rates in ESRD patients (Weng et al., 2016). Low albumin levels in dialysis patients are not only indicative of poor nutrition but also correlate with chronic inflammation and increased C-reactive protein (CRP) levels, which reflect an inflammatory state common in ESRD.

The findings suggest while nutritional interventions may benefit some patients, addressing albumin levels requires a more individualized approach incorporating strategies to reduce inflammation and manage comorbid conditions along with dietary modifications.

Improvements in nutrition status and dietary adherence were noted across several studies, with patients showing better compliance with dietary restrictions and reduction of malnutrition rates (Beer et al., 2018; Valente et al., 2022; Chen et al., 2022). Beer et al. (2018) demonstrated individualized dietetic interventions for hemodialysis patients significantly reduced malnutrition, with malnutrition rates dropping from 43.5% to 28.9% over a seven-month period utilizing one-on-one individualized counseling methods. Addressing malnutrition is essential, as it not only enhances clinical markers but also supports patients' resilience against common ESRD complications such as muscle wasting, infections, and protein-energy wasting (Sahathevan et al., 2020; Lodebo & Shah, 2018; Ribeiro et al., 2020). The Academy of Nutrition and Dietetics (2023), recommends regular monitoring and intervention to address malnutrition, underscoring the role of dietitians in providing individualized, evidence-based nutritional counseling. The findings align with current professional recommendations from the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines (2020), reinforcing the importance of nutritional education as a tool to help patients adhere to dietary guidelines.

Although reported less consistently, some studies indicated positive effects on self-management behaviors and quality of life. Patients participating in structured educational interventions showed better management of dietary and fluid intake, as well as improved long-term adherence to health recommendations (Ebrahimi et al., 2016; Naseri-Salahshour et al., 2020; Liu et al., 2016). The findings suggest, beyond biochemical markers, nutritional education can play a critical role in fostering patient autonomy and self-efficacy, helping patients manage their conditions more effectively. Improving these behaviors is consistent with guidance from the American Society of Nephrology (2024), which advocate for patient-centered care that includes behavioral counseling and education to enhance patient engagement and adherence.

Overall, the review found improvements across multiple outcomes, including improved biochemical markers, enhanced nutritional status, increased dietary adherence, and improved quality of life when compared to no specific nutritional intervention or pre-nutritional intervention. Notably, all types of nutrition education interventions—whether minimal, such as brief counseling or distribution of educational materials, or more thorough interventions, such as personalized sessions or ongoing telehealth programs—demonstrated some form of positive impact on patient health (Chen et al., 2022; Dsouza et al., 2023; de Freitas et al., 2020; Ribeiro et al., 2020). The positive outcomes support the potential of nutrition education to influence both clinical and behavioral aspects of care for ESRD patients. However, the extent of improvements varied depending on the design and delivery of the educational interventions, with more personalized and interactive approaches, such as individualized counseling and telehealth, showing better outcomes (Valente et al., 2022; Beer et al., 2018; Düzalan & Çınar, 2018). The findings undergird the necessity of prioritizing structured, patient-centered nutrition education as a core component of standard care for ESRD patients.

The National Kidney Foundation (NKF) and the Academy of Nutrition and Dietetics (AND) play crucial roles in shaping nutrition care guidelines for ESRD patients (National Kidney Foundation, 2020; Academy of Nutrition and Dietetics, 2020). NKF's KDOQI provides evidence-based clinical practice guidelines covering all stages of chronic kidney disease (CKD) and dialysis. Their guidance emphasizes managing potassium, phosphorus, and fluid intake. The review findings align with the guidelines, reinforcing structured dietary education can improve clinical outcomes (National Kidney Foundation, 2020; Anderson & Nguyen, 2018). Furthermore, the Renal-Specific Dietetic Practice Group (DPG) highlight the role of dietitians in tailoring interventions to patient needs; ensuring education is personalized, addressing both medical and cultural needs, and ensuring equitable nutrition care across different hemodialysis clinics (Academy of Nutrition and Dietetics, 2020). The evidence from this

review supports the professional organizations' recommendations, demonstrating the effectiveness of structured, patient-centered nutritional education in improving biochemical markers, dietary adherence, and overall patient health outcomes in ESRD.

The KDOQI nutrition guidelines (2020), updated in collaboration with the AND, advocate for individualized dietary counseling by renal dietitians, given the diverse needs of dialysis patients. The guidelines recommend a combination of patient education and regular nutritional assessments to help individuals maintain healthy lab markers and manage fluid restrictions effectively. Additionally, both NKF and AND highlight the importance of aligning educational efforts with behavioral counseling techniques, such as motivational interviewing, to improve dietary adherence. The recommendations underscore the critical role of dietitians in delivering personalized, evidence-based care, ultimately enhancing the health outcomes and quality of life for dialysis patients.

Quality/Risk Assessment

The review incorporated a risk of bias assessment using the Cochrane Risk of Bias Tool, ensuring a transparent and consistent evaluation of each study's reliability. The moderate to high quality of the included studies supports confidence in this review's findings. Low risks of selection and reporting bias show that the evidence is reliable and clearly presented. However, performance bias was common as participants were often aware of receiving educational interventions, potentially influencing their dietary behaviors and adherence. The use of objective biochemical measures reduced detection bias, and high retention rates added to the reliability of the findings. The studies varied in methodological quality, with some utilized well-structured designs, such as randomized controlled trials, while others used observational or single-group interventions, which are more prone to bias. The variability in study quality and differences in intervention design, presented challenges to combine results and make direct comparisons. Despite these limitations, following PRISMA guidelines and using structured tools for bias assessment helped make this review more reliable and strengthened its findings.

Strengths and Limitations

The strengths of this review lie in its comprehensive inclusion of 22 studies, which utilized a variety of study designs and intervention formats, such as in-person counseling, telehealth sessions, and educational booklets. This diversity provided a broad perspective on the effectiveness of nutritional education for hemodialysis patients, highlighting the adaptability of educational methods to various settings and patient needs. Additionally, following the PRISMA guidelines ensured a systematic approach to the study selection. The use of Cochrane Risk of Bias Tool also strengthened the evaluation by offering a transparent, consistent method for assessing study reliability, ultimately reinforcing the validity of the review's findings.

However, this same diversity also presents a limitation. The variability in intervention designs, delivery methods, and outcomes measured makes it challenging to draw direct comparisons between studies. Additionally, the differences in duration, content, and intensity of educational interventions may have contributed to inconsistent findings. Additionally, some studies had small sample sizes or short follow-up periods, which may limit the generalizability of the results. The limitations highlight the need for more standardized, rigorously designed studies to better assess the long-term impact of nutritional education interventions, enabling clearer comparisons and more generalizable results across diverse hemodialysis populations.

Application for Practitioners

For practitioners, the findings emphasize the importance of incorporating structured nutritional education programs into the routine care of ESRD patients on hemodialysis. Given the beneficial improvements observed in potassium and phosphorus management, increased compliance with diet and fluid restrictions, and overall improvement in malnutrition rates, dietary counseling should be considered a core component of patient care in a dialysis setting. Personalized, interactive, and consistent nutritional counseling also promotes individualized patient care.

Tailored interventions, such as telehealth, in-person counseling, or individualized dietary plans, could be particularly useful for improving patient adherence to dietary recommendations. Additionally,

incorporating behavior change models into educational programs could further enhance patient self-management, leading to better long-term health outcomes.

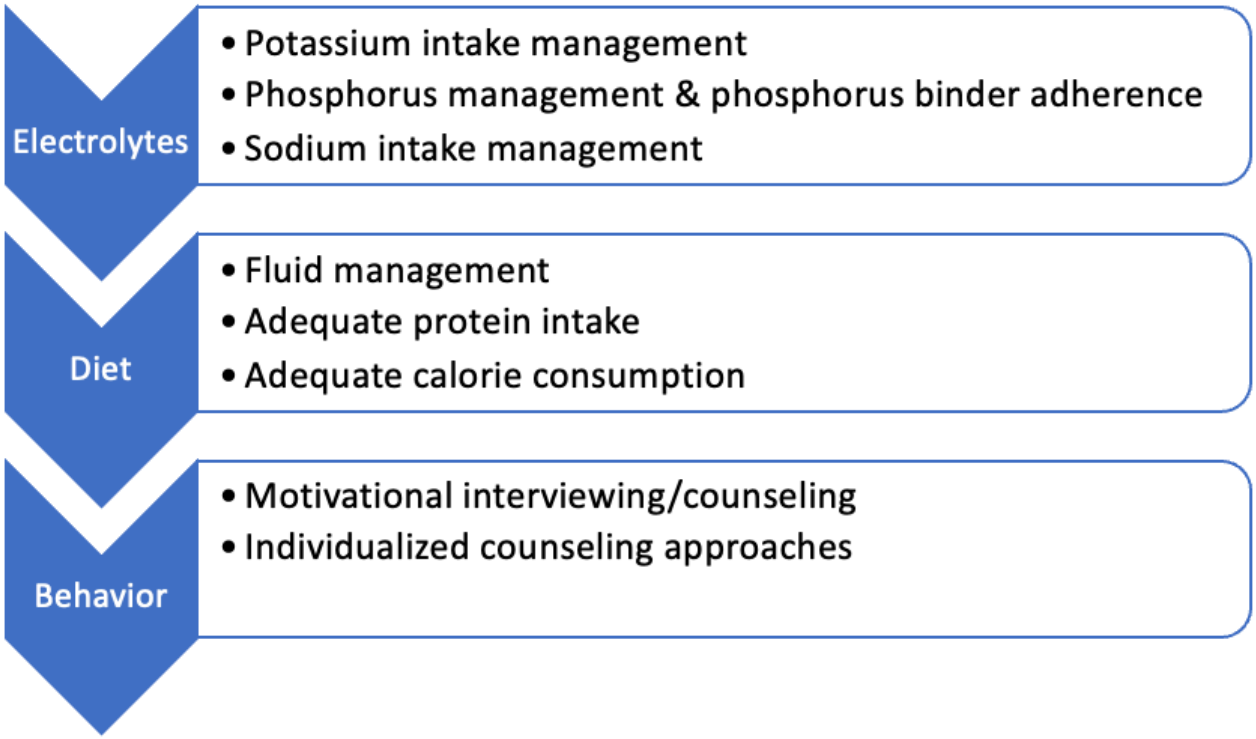

Fig. 2: Components of Nutritional Education

5 | CONCLUSION

Nutrition education is a critical component of standard care for ESRD patients undergoing hemodialysis, yet the approach to delivering this education remains unstandardized. This review highlights the significant positive impacts of dietary counseling on multiple patient outcomes, particularly in managing potassium and phosphorus levels, improving nutritional status, enhancing dietary adherence, and contributing to better quality of life (Valente et al., 2022; Jarupala et al., 2023; Naseri-Salahshour et al., 2020; Çavdar & Şahin, 2021; Düzalan & Çinar, 2018; Yin et al., 2021; Feng et al., 2022; Ribeiro et al., 2020; Steiber et al., 2015; Martins et al., 2017; Beer et al., 2018; Valente et al., 2022; Chen et al., 2022; Ebrahimi et al., 2016; Naseri-Salahshour et al., 2020; Liu et al., 2016).

Despite the benefits, the variability in approaches and outcomes highlight the need for a more standardized and consistent delivery of nutrition education. By establishing standardization, healthcare teams can ensure that all patients receive effective and comprehensive dietary guidance, ultimately leading to more predictable and sustained improvements in clinical outcomes. Moving forward, future research should focus on refining standardized approaches to maximize the potential of nutrition education, making it a universally powerful tool in improving the health and well-being of ESRD patients across all dialysis settings.

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