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Impact of Personalized Dietary Counseling and Nutritional Interventions on the Control of Hyperphosphatemia in Hemodialysis Patients. A mini review

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الملخص

الخلفية: تُعد فرط فوسفات الدم حالة شائعة لدى مرضى الغسيل الكلوي الدموي نتيجة انخفاض وظيفة الكلى، وترتبط بارتفاع معدلات الوفيات وحدوث مضاعفات مثل أمراض القلب والأوعية الدموية. ويُعد التحكم في مستوى الفوسفور في الدم أمرًا صعبًا بسبب وجود إضافات الفوسفات المخفية في الأغذية المصنعة وضعف الالتزام بالعلاج. كما أن الأغذية فائقة التصنيع، وخاصة ذات المصدر الحيواني، تزيد بشكل مستقل من خطر فرط فوسفات الدم، مما يبرز أهمية التركيز الغذائي على الأغذية الطبيعية. ويسهم الإرشاد الغذائي المخصص والرعاية متعددة التخصصات في تحسين ضبط الفوسفات والنتائج الصحية للمرضى.

الهدف: تقييم فعالية الإرشاد الغذائي والتدخلات الغذائية المصممة بشكل فردي في خفض مستويات الفوسفور في الدم لدى مرضى الغسيل الكلوي المصابين بفرط فوسفات الدم .تقييم مستوى المعرفة الغذائية لدى مرضى الغسيل الكلوي الدموي المشخَّصين بفرط فوسفات الدم.

المنهجية: جرى تحديد الدراسات المتعلقة بفرط فوسفات الدم لدى مرضى الغسيل الكلوي الدموي من خلال بحث منهجي في قواعد البيانات العلمية الرئيسة، بما في ذلك PubMed و Google Scholar وResearch Square وScience Direct، إضافة إلى الاستعانة بإرشادات الممارسة السريرية الصادرة عن KDIGO لعام 2024، وذلك للفترة الممتدة من 2020 إلى 2025. وشملت هذه الدراسات تجارب عشوائية محكومة، وتجارب سريرية من المرحلتين الثانية والثالثة، ودراسات مقطعية أُجريت دوليًا في دول مثل العراق والصين وقطر ورومانيا والولايات المتحدة الأمريكية. وركز الاختيار على المرضى البالغين المصابين بمرض الكلى المزمن في المرحلة الخامسة والخاضعين للغسيل الكلوي الدموي المنتظم مع ارتفاع مستويات الفوسفور في الدم. وتضمنت التدخلات المدروسة روابط فوسفات دوائية حديثة (مثل تينابانور وASP3325)، إلى جانب الإرشاد الغذائي المكثف والمُخصص وبرامج التعليم متعددة التخصصات. وجُمعت الأدلة من مجلات علمية محكّمة متخصصة في أمراض الكلى وتغذية مرضى الكلى، مما وفر مراجعة متعمقة للاستراتيجيات العلاجية الحالية وعوامل الخطورة.

الاستنتاج: يتطلب التدبير الفعّال لفرط فوسفات الدم لدى مرضى الغسيل الكلوي الدموي اعتماد استراتيجيات غذائية شخصية مدعومة بتعليم مكثف متعدد التخصصات بدلًا من القيود الغذائية الصارمة. ويُعد التعامل مع إضافات الفوسفات المخفية في الأغذية فائقة التصنيع والأدوية أمرًا بالغ الأهمية. وتُظهر العوامل الدوائية (مثل تينابانور و AP306) فعالية في خفض مستويات الفوسفور في الدم، إلا أنها قد تُسبب آثارًا جانبية معدية معوية. إن الجمع بين النظام الغذائي المُخصص، والتعليم، والعلاج الدوائي، والدعم المجتمعي يُسهم في تحسين ضبط الفوسفور والنتائج الصحية للمرضى.

الكلمات المفتاحية: فرط فوسفات الدم، الغسيل الكلوي الدموي، المعرفة والدعم الأسري والاجتماعي، المدخول الغذائي من الفوسفور.

Abstract

Background: Hyperphosphatemia is common in hemodialysis patients due to reduced kidney function and is linked to higher mortality and complications like cardiovascular disease. Controlling serum phosphorus is difficult because of hidden phosphate additives in processed foods and poor treatment adherence. Ultra processed foods, especially animal-based, independently increase hyperphosphatemia risk, highlighting the need for dietary focus on natural foods. Personalized nutritional counseling and multidisciplinary care improve phosphate control and patient outcomes.

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Aim and objects: 1- To assess the effectiveness of tailored dietary counseling and interventions in reducing serum phosphorus levels among hemodialysis patients with Hyperphosphatemia. 2- To evaluation the level of dietary knowledge among hemodialysis patients diagnosed with Hyperphosphatemia.

Methods and Materials: Studies on Hyperphosphatemia in hemodialysis patients were identified through systematic searches of major scientific databases, including PubMed, Google Scholar, Research Square, and Science Direct, supplemented by KDIGO 2024 Clinical Practice Guidelines, covering the period from 2020 to 2025. These studies encompass randomized controlled trials, phase 2 and 3 clinical trials, and cross-sectional analyses conducted internationally in countries such as Iraq, China, Qatar, Romania, and the United States. The selection focused on adult patients with stage 5 chronic kidney disease undergoing maintenance hemodialysis with elevated serum phosphate levels, Investigated interventions include novel phosphate binders (e.g., tenapanor and ASP3325) alongside intensive, individualized nutritional counseling and multidisciplinary education programs. Evidence was gathered from peer-reviewed journals specializing in nephrology and renal nutrition, providing an in-depth review of current therapeutic strategies and risk factors.

Conclusion: Effective management of hyperphosphatemia in hemodialysis patients requires personalized nutritional strategies supported by intensive multidisciplinary education rather than strict dietary restrictions. Addressing hidden phosphate additives in ultra processed foods and medications is crucial. Pharmacologic agents like tenapanor and AP306 effectively reduce serum phosphate but may cause gastrointestinal side effects. Combining personalized diet, education, pharmacologic therapy, and community support optimizes phosphate control and patient outcomes**.**

Keywords: Hyperphosphatemia, hemodialysis, Knowledge and family social support, Dietary phosphorus intake

INTRODUCTION

Chronic Kidney Disease (CKD) and End-Stage Renal Disease (ESRD) are commonly associated with Hyperphosphatemia, a condition that markedly increases mortality and cardiovascular risk. Numerous studies, have highlighted the alarming global prevalence of Hyperphosphatemia, demonstrating that even slight elevations in serum phosphorus can negatively affect clinical outcomes, (Muhammad F, 2023), (Ajeeta A, *et .al*, 2023),. Many evidence emphasize the importance of a comprehensive "3D" management strategy encompassing diet, drugs, and dialysis (Suhair A,2023), while also accounting for key physiological regulators like parathyroid hormone (PTH) and fibroblast growth factor-23 (FGF-23). (Anjay R, et.al ,2020). Although restricting phosphate-rich foods remains a cornerstone of management, attention must also be given to hidden phosphate additives and the necessity of maintaining adequate protein intake, (Jinmei Y ,2021), underscoring the critical role of targeted patient education. Furthermore, evidence confirms that intensive dietary and medical nutrition interventions are effective in lowering serum phosphate levels and significantly improving overall patient survival. (Haitham S, et .al, 2023) (Elena M, *et. al*,2023).

II- Clinical prevalence and Pathophysiology of Hyperphosphatemia in Hemodialysis Patients

Hyperphosphatemia occurs when phosphorus from food accumulates in the blood due to impaired renal function (Kim, 2023) Because phosphorus reabsorption is maximally inhibited and renal excretion cannot increase once estimated glomerular filtration rate (eGFR) falls below 30 ml/min/1.73 m2, hyperphosphatemia in patients with chronic kidney disease (CKD) is explained by a decrease in the kidneys' ability to remove phosphorus. The most well-known adverse effects of hyperphosphatemia, however, are related to parathyroid glands. High serum phos and low calcium both encourage parathyroid cell growth (Alsultan *et al.*, 2023). Hyperphosphatemia, which is associated with an increased mortality rate, is frequently experienced by patients undergoing hemodialysis for end-stage renal disease. (Jung *et al.*, 2022) Hyperphosphatemia, a common comorbidity of chronic kidney disease, affects 50–74% of patients with renal disorders. (Anand & Aoyagi, 2023) Hyperphosphatemia is a secondary complication in patients with established renal failure. Approximately 80% of the Malaysian patients in this study had elevated serum phosphate levels (Ng et al., 2020) .Patients with chronic kidney disease (CKD) in advanced stages require dialysis to efficiently remove phosphate (Pi) from the extracellular pool, particularly when they become severely oliguric or anuric *(Portales-Castillo et al.*, 2023).

Dialysis-dependent stage 5 CKD patients were observed to have an average serum phosphate level of 5.71 mg/dL, compared to non-dialysis stage 5 patients who had a mean level of 4.89 mg/dL. Out of 166 participants studied, 56% were found to have hyperphosphatemia. *(Muhammad Ali et al.*, 2025). In a separate group of 150 individuals, 67 participants (44.7%) exhibited hyperphosphatemia, characterized by serum phosphorus levels equal to or exceeding 5.5 mg/dL (Kim, 2023).

The average serum phosphorus across this group was 5.77 mg/dL, exceeding the normal reference range of 3.5–5.5 mg/dL. (Kim, 2023). Among Chinese hemodialysis patients, the prevalence of serum phosphorus levels ≥1.78 mmol/L was reported at 50.2% (Xinju *et al.*, 2025). Similarly, in a study involving Syrian dialysis patients, 63.1% (92 participants) had hyperphosphatemia, with serum phosphate levels above 5.5 mg/dL, while the remaining 36.9% (54 participants) maintained levels within the normal range (Alsultan *et al.*, 2023). A Turkish study corroborated these findings, reporting that 66.4% of hemodialysis patients experienced hyperphosphatemia. (Khalil Abdallah, 2023).Approximately half of the patients receiving maintenance hemodialysis for advanced chronic kidney disease (CKD) in Qatar experience hyperphosphatemia as a frequent complication (Ghazi Daradkeh *et al.*, 2022). In the United States, the prevalence of hyperphosphatemia is notably high among individuals undergoing long-term hemodialysis, with serum phosphate levels exceeding the recommended target of 5.5 mg/dL in about two-thirds of these patients. Such elevated phosphate levels are associated with an increased risk of cardiovascular issues. Specifically, 60% of hemodialysis patients with end-stage kidney disease in the US have serum phosphate levels above this threshold (Portales-Castillo *et al.*, 2023).

Hyperphosphatemia stems from impaired kidney excretion, resulting in mineral metabolism disorders. This imbalance can lead to vascular calcification and stiffness, structural and functional heart alterations, kidney osteodystrophy, and a higher mortality risk. The condition is further influenced by factors such as deficiencies in the active form of vitamin D, 1,25-Dihydroxycholecalciferol (1,25[OH]2D), and fibroblast growth factor 23 (FGF23) . (Ghazi Daradkeh *et al.*, 2022) .

Patients with CKD often exhibit irregular calcium and phosphorus metabolism, which contributes to the development of renal osteodystrophy. Progressive loss of nephron function in earlier CKD stages leads to phosphate retention. Combined with inadequate levels of active vitamin D, hyperphosphatemia may induce hypocalcemia. Attempts to compensate for low calcium levels can trigger secondary hyperparathyroidism, causing significant bone damage . (Khalil Abdallah, 2023).

Patients undergoing dialysis for chronic renal failure experience significantly reduced glomerular filtration rates, which hinder the elimination of phosphates from the body. Despite receiving dialysis two to three times per week, these patients often develop hyperphosphatemia. This is attributed to the limited capacity of standard dialysis regimens to adequately remove phosphate. Typically, around 1 g of phosphate is removed during a single hemodialysis (HD) session, amounting to approximately 3 g per week for those on a thrice-weekly schedule. Due to this insufficient removal, high phosphorus levels are commonly observed in patients with end-stage renal disease .(Portales-Castillo *et al.*, 2023) .

Pathophysiology: Chronic elevation of serum phosphate levels can lead to vascular calcification and structural changes in blood vessels. Additionally, it has been proposed that elevated phosphate levels may be associated with functional abnormalities in blood vessels that are potentially more reversible. Elevated serum phosphate is an independent predictor of pre-HD high blood pressure, vasoconstriction, and markers of endothelial cell dysfunction. (Jung *et al.*, 2022) .

Hyperphosphatemia frequently arises as a consequence of chronic kidney disease (CKD) and is linked to adverse clinical outcomes such as vascular calcification, cardiovascular disease, and increased mortality rates. Furthermore, it contributes to a higher risk of secondary hyperparathyroidism, bone fractures, progression of CKD, skeletal muscle atrophy, and immune deficiencies (Muhammad Ali *et al.*, 2025). (Portales-Castillo *et al.*, 2023). The presence of hyperphosphatemia also indicates inadequate elimination of toxins, reflecting suboptimal dialysis efficacy (Xinju et al., 2025) .

III-Limitations of Conventional Hemodialysis in Achieving Optimal Phosphorus Control

Conventional hemodialysis technique removes a limited amount of phosphorus compared to the weekly intake in ESKD patients on hemodialysis. Though dialysis patients usually require about 6,300 to 10,500 mg of phosphorus weekly, the current three times weekly of hemodialysis removes about 600 to 1,200 mg in each session , which is about 700 to 900 mg in four hours and about 2,100 to 2,700 mg weekly (Anjay R, *et .al*, 2020),(Ghazi D, *et. al*, 2022) ,(Muhammad D, *et .al*,

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2020). Despite the improvements in hemodialysis technique, the efficiency of hemodialysis in the removal of phosphorus has still not changed. More specifically, hemodialysis removes phosphorus almost completely from the extracellular space with very limited capacity from cells and bone, that is, the intracellular space. As such, serum levels of phosphorus can fall after hemodialysis but regularly normalize shortly after dialysis (Eleanor L, 2024).The lack of a globally defined serum phosphate target guidelines worldwide further contributes to less-than-optimal phosphorus control in patients with chronic kidney disease. , although KDIGO guidelines indicate the need to maintain serum phosphate within the normal range, they do not define an exact target, which results in great variability in clinical practice and a higher prevalence of Hyperphosphatemia, serum phosphate greater than 5.5 mg/dL, in united sates compared with Europe and Japan (murilo .G, *et. al* ,2023). Consequently, phosphorus control strategies-common dietary restriction, phosphate binders, and conventional dialysis-are commonly inadequate to achieve and sustain the recommended serum phosphate level for most patients (Steven F, *et.al*, 2021). Thus, clearance, phosphate is easily retained in the body; therefore, dialysis alone is poorly effective in maintaining (Jinmei Y, *et .al*, 2021). The continuously high phosphate levels are therefore due to an imbalance between phosphate excretion during dialysis and intestinal phosphate absorption from diet, supplements, and medications. There has been a lack of efficacy for oral phosphate-binding agents despite proper use. clinical Evidence supporting the effectiveness of a low phosphate diet with discontinuation of oral phosphate binders before dialysis delay post-dialysis phosphate rebound, underscoring the need for alternative or supporting strategies to long-term improve of Hypophosphatemia in hemodialysis patients (Eleanor L, 2024).

Many evidence demonstrate that conventional hemodialysis represents a fundamentally limited approach to phosphorus management in dialysis patients (Dwyer, *et. al*, 2022).and Most hemodialysis patient are not achieving and maintaining target phosphorus level of <5.5 mg/dl. The percentage of patients with all mineral bone disease markers within recommended ranges remained essentially unchanged from 2010 (31%) to 2021 (30%) (S. Doshi, *et. al*, 2022). "Conventional dialysis is also typically insufficient" for phosphate control, though removal may be augmented by increased frequency, duration, or enhanced methods like Hemodiafiltration (M. Vallée, *et. al*, 2021).

IV-Dietary Phosphorus Intake: Sources, Bioavailability, and Path Physiological Implications

Phosphorus is the sixth most abundant element in the human body and is essential for cellular metabolism and tissue structure. Approximately 85% of total body phosphorus is stored in bones and teeth, 14% in soft tissues, and only about 1% is present in the extracellular fluid, including serum.(Raju S, 2025)(Mengjing W, *et. al*, 2023). In the blood, most phosphorus is protein-bound, with smaller fractions associated with calcium, magnesium, and sodium. Serum phosphorus levels are tightly regulated within a narrow range (2.5–4.5 mg/dL) by fibroblast growth factor-23, parathyroid hormone, and vitamin D. Disruption of this balance, particularly in chronic kidney disease (CKD), contributes to Hyperphosphatemia and is associated with strong evidence from a comprehensive review to vascular calcification, impaired cardiac function, renal osteodystrophy, and increased mortality (Raju S, 2025) (Anjay R, *et .al*, 2020) (ying y, *et.al* ,2023) (Chao Z, *et.al* ,2021)

Phosphate homeostasis depends on intestinal absorption, bone and soft tissue storage, renal excretion, and hormonal regulation (Mengjing W, *et. al*, 2023). Dietary phosphorus is the primary source of phosphorus loading. Phosphorus exists in organic and inorganic forms. Organic phosphorus from animal-based foods, mainly phosphoproteins and phospholipids, has higher bioavailability (40–60%) compared with plant-based phosphorus (20–40%), which exists largely as phytate and is poorly absorbed due to the absence of phytase in humans. In contrast, inorganic phosphorus found in food additives, preservatives, supplements, and pharmaceuticals is highly bioavailable, with absorption rates of approximately 90%. Many hemodialysis patients consume 6,300–10,500 mg of phosphorus per week, contributing substantially to phosphorus burden (C. Vaishnavi D, *et .al*, 2022)) (Chao Z, et.al ,2021).Pharmacological approaches such as phosphate binders, calcimimetics, and hemodialysis provide only partial phosphorus removal, and non-adherence to phosphate binder therapy can further elevate serum phosphorus levels and negatively affect health-related quality of life. (Mengjing W, et. al, 2023).

Systematic review of clinical trials and observational data on phosphorus control in hemodialysis patients with CKD-MBD; current management options including phosphate binders have benefits and limitations with variable clinical outcome and diverse phosphate binder strategies (H. Ogata, *et .al*, 2022) and, (A. Rastogi N, *et.al* ,2020). Several evidence including a systemic review and meta-analysis, have associated reductions in serum phosphate with improved patients' survival. According to the large study sample associating elevated serum phosphate levels with increased mortality and the retrospective evidence associating reductions in serum phosphate with a survival benefit, the target for serum phosphate is defined in the KDIGO guidelines as the "normal range." The normal serum phosphate level is variably defined. Ranges of 0.9 to 1.5 mmol/L are typical in healthy individuals, (Robert T *et.al*,2021), High phosphorus diet lead to exceeds the kidney's capacity to excrete phosphate, it leads to Hyperphosphatemia and pathological phosphorus deposition in vascular and cardiac tissues,. (Mengjing W,et. al, 2023).Many evidence available which give strong support to this condition , High dietary intake level lead to Hyperphosphatemia contributes to cardiovascular tissue calcification, particularly in CKD patients with reduced urinary clearance. (Rubio-A, et.al,2022),(Ying Y, et.al, 2023), (Hiroaki O, et.al,2023),(Nikunj R,t et.al,2023).Understanding main dietary phosphorus sources, their bioavailability, and their contribution to phosphorus loading is therefore important for maintaining phosphate homeostasis and effectively managing Hyperphosphatemia, especially in patients with CKD or those undergoing hemodialysis (Ghazi D,et. al, 2022).

V-The protein phosphorus balance challenges in nutrition of hemodialysis

The challenges surrounding the protein-phosphorus balance in the nutritional management of individuals undergoing hemodialysis are multifaceted. Reliably controlling phosphorus intake solely through dietary protein restriction is difficult because the phosphorus content within protein-rich foods varies significantly depending on the source. Evidence suggests that dietary protein restriction can, in some cases, be more harmful than beneficial for patients on maintenance hemodialysis. Severe protein limitation often leads to protein-energy wasting, a condition strongly associated with increased mortality within this patient population (Shi & Fan, 2025).

Protein-rich foods are inherently high in phosphorus; hence, an increased intake of dietary protein often correlates with hyperphosphatemia. In hyperphosphatemic patients, deprivation of phosphorus through dietary interventions may inadvertently lead to insufficient protein consumption, which can exacerbate malnutrition and increase mortality risk. Importantly, the phosphorus-to-protein ratio is not constant across different foods, making effective management of phosphorus intake by solely controlling protein consumption exceedingly challenging. Achieving an optimal dietary protein intake becomes a paradox in patients undergoing maintenance dialysis since dietary restrictions focused on reducing phosphorus may inadvertently intensify nutritional deficiencies. Consequently, strategies to regulate dietary phosphorus without imposing severe protein limitations are pivotal in managing such conditions [(Shi & Fan, 2025).

The complexity of a renal diet necessitates close monitoring of nutrient intake, particularly in balancing phosphorus restriction with adequate protein consumption. A significant challenge lies in the high phosphorus content of many processed foods, which patients often cannot identify due to poor labeling practices by manufacturers. For example, common items such as a cup of milk or other protein-dense foods can contain varying amounts of phosphorus that are not always disclosed on labels.

This lack of transparency poses difficulties for patients attempting to manage their dietary intake of phosphorus effectively (Kim, 2023).

Interventional strategies focusing on specific patient education have proven beneficial. Such strategies encourage assessing and modifying dietary habits to simultaneously lower phosphorus intake while maintaining an appropriate level of protein consumption. Educational programs that emphasize the importance of understanding the protein-phosphorus ratio in foods can foster better adherence to dietary plans while reducing the incidence of protein-energy malnutrition (PEM), which remains a precursor to hyperphosphatemia. Ultimately, personalized nutritional education enables clinicians and patients to collaboratively optimize both protein and phosphorus intake . (Ghazi Daradkeh et al., 2022).

VI- *Impact of individualized Dietary Counseling on Serum Phosphorus Control in Hemodialysis Patients*

Individualized dietary intervention has consistently demonstrated a significant impact on controlling Hyperphosphatemia in hemodialysis patients across diverse populations. A meta-analysis conducted which included 14 trials and 1,284 adult participants, confirmed that phosphate-specific dietary interventions significantly improved serum phosphorus levels compared with control groups, with a mean difference of −0.66 mg/dL (95% CI: −0.95 to −0.36; $p < 0.001$). The study indicate that approximately 50% of hemodialysis patients experience Hyperphosphatemia (serum phosphorus > 5.5 mg/dL), emphasizing the necessity of individualized dietary approaches to address patient-specific needs and preferences **(Saeed, et. al2023),.**Evidence from randomized controlled trials also supports these findings. Study in Iraq, demonstrated that structured dietary interventions combined with continuous education resulted in a 40% reduction in serum phosphorus levels, decreasing from a baseline mean of 6.26 mg/dL to 3.79 mg/dL over four months ($p < 0.001$), while phosphorus levels in the control group showed a progressive increase **(Alhasnawy J,2025)**. And another study similarly , in Sudan, reported that individualized nutritional counseling reduced serum phosphorus from 5.6 mg/dL at baseline to 3.8 mg/dL after six months in the intervention group ($p < 0.05$), whereas the control group consuming a usual diet exhibited only a mild and statistically insignificant reduction **(Abdallah .s ,2023)**.The effectiveness management by dietarian -has also been demonstrated in Middle Eastern and European settings. In Qatar, reported that intensive individualized counseling significantly reduced the dietary phosphate-to-protein ratio from 28.9 to 13.4 mg/g ($p < 0.05$), accompanied by a decline in serum phosphate levels from 2.2 mmol/L to 1.68 mmol/L ($p < 0.05$), supporting improved calcium–phosphorus balance **(Daradke H, et. al.2022)** Likewise, evaluated a medical nutrition therapy (MNT) program in Romania that focused on replacing foods rich in phosphate additives with natural alternatives, resulting in a marked decrease in serum phosphate from 7.322 mg/dL to 5.368 mg/dL after 60 days ($p < 0.001$). about , 72% of patients in study required lower doses of phosphate binders following the intervention**(Moros et al,2023)**.Evidence from South Korea, assessed an adaptive nutrition intervention using real-world data and home-delivered tailored meals. The intervention significantly stabilized serum phosphorus levels by week 8 (estimated change = −0.81 mg/dL; $p < 0.05$) and increased the likelihood of achieving normal phosphorus levels (OR = 1.21) **(Chung ,et. al,2023)**. Another Study in China indicate , implemented an intensive education program based on the "First Principles of Instruction," which increased the serum phosphorus control rate from 43.5% to 54.9% ($p < 0.001$) and significantly improved adherence to phosphate binders from 21.9% to 44.5% ($p < 0.001$) **(Yin et. al,2021)**.Despite these positive outcomes, Hyperphosphatemia remains a multifactorial condition influenced by dietary intake, impaired renal excretion, dialysis adequacy, and psychosocial factors. Elevated serum phosphorus has been associated with nutritional and dialysis-related variables such as serum albumin, total protein, blood urea nitrogen, creatinine, ferritin, interdialytic weight gain, and markers of dialysis stress. Psychological factors, including self-care behaviors, emotional stress, cognitive status, and social support, also play a critical role in phosphorus control and patient prognosis (**Jihyun K, 2023**).

Although dietary counseling has proven effective, there is a notable lack of studies examining integrated management strategies that simultaneously address dietary control, pharmacological therapy, psychological stress, and social support. Few studies have explored these combined factors, particularly among Korean hemodialysis patients, underscoring the need for comprehensive educational programs tailored to individual patient profiles (**Jihyun K, 2023**). Current evidence supports the use of multifaceted approaches combining dietary counseling, phosphate binders, and adequate dialysis to optimize phosphorus control (**Ghazi D, et .al, 2022) (St-Jules et .al, 2021) .**Overall, evidence from international studies and meta-analyses consistently demonstrates that personalized dietary counseling is an essential component of Hyperphosphatemia management in hemodialysis patients. Tailored, frequent, and multidisciplinary educational interventions significantly improve serum phosphorus control while maintaining nutritional adequacy, highlighting the critical role of individualized nutrition therapy in long-term phosphate management (**Saeed ,et. al, 2023**).

VII -Behavioral, Socio cultural, and Demographic Determinants of Dietary Adherence in Hyperphosphatemia in hemodialysis

Prolonged Hyperphosphatemia in end-stage renal disease (ESRD) with Hemodialysis is a critical "silent killer" associated with significantly increased mortality and adverse clinical outcomes. The Evidence found that patients with Hyperphosphatemia had a 2.85-fold higher risk of all-cause mortality compared to those without(AShely Y., 2023). Critically, patient education emerges as a key intervention strategy. Study demonstrated that an intensive education program dramatically improved serum phosphorus control (from 43.5% to 54.9%), increased phosphate control knowledge (from 59.0 to 80.6), and enhanced treatment adherence (from 21.9% to 44.5%). (Jinmei Y, et .al, 2021). Dietary adherence in hemodialysis patients with

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Hyperphosphatemia is influenced by complex interaction of behavioral, sociocultural, demographic, and clinical factors. Knowledge of a low-phosphorus diet alone is insufficient to ensure effective phosphorus control; patients must consistently developed and maintained appropriate behaviors, including correct food selection, avoidance of phosphate additives, proper use of phosphate binders, and adherence to dialysis schedules. Evidence indicates that frequent, individualized dietary counseling delivered by renal dietitians effectively reduces serum phosphorus levels without compromising nutritional status or quality of life. However, relapse to previous dietary habits following discontinuation of counseling highlights the necessity of sustained and continuous dietary support (Ghazi D, et. al, 2022),(Manman G,et. al, 2025).Behavioral change theories, particularly the Health Belief Model, provide a framework for understanding dietary adherence in this patients. Perceived disease severity, benefits of adherence, barriers, and self-efficacy have been identified as key determinants of sustained behavioral change. These constructs help explain why patients with greater awareness and confidence are more likely to adhere to complex dietary restrictions over time (Ghazi D, et. al, 2022),(Manman G, et. al, 2025).

Socio cultural factors, especially family involvement and social support, play a essential role in dietary adherence and phosphate control. Adequate social support has been associated with improved nutritional status, enhanced self-care behaviors, and better serum phosphorus control, whereas limited support and dialysis-related stress are linked to poor adherence and unfavorable clinical outcomes. However, findings across populations remain inconsistent. Studies conducted in Malaysia and Korea have reported variable associations between social support, dietary knowledge, and serum phosphorus levels, suggesting that cultural expectations and population-specific factors modify these relationships (Jihyun K, 2023).

Demographic and clinical characteristics further influence dietary adherence and phosphorus control. Age, nutritional status, cognitive function, dialysis-related stress, and dietary protein intake are closely associated with serum phosphorus levels. Higher protein intake is generally linked to elevated serum phosphorus due to the phosphorus content of protein-rich foods, thereby increasing the risk of Hyperphosphatemia. These findings underscore the importance of individualized management strategies that account for ethnic, demographic, and clinical differences among hemodialysis patients (Jihyun K, 2023)(KDIGO guidelines 2024).

In Egypt, phosphorus-related knowledge was identified as a significant protective factor against Hyperphosphatemia ($p = 0.005$), while poor renal diet knowledge was associated with a 61.0% ,prevalence of Hyperphosphatemia, and protein intake occur as the primary determinant of dietary non-adherence ($p < 0.001$) (Emara ,AboZ, 2022). In Malaysia, a high prevalence of elevated serum phosphorus (82.9%) was reported, with younger age significantly correlated with higher phosphorus levels ($r = -0.297$; $p = 0.009$), and dietary phosphorus intake showing a weak but significant association with serum phosphorus concentrations (Mohd I, et. al, 2020). Similarly, a cross-sectional study in the United States reported a low mean phosphorus knowledge score (55.8%), yet demonstrated a strong positive correlation between awareness of one's serum phosphorus level and overall knowledge ($r = 0.44$; $p < 0.001$) (Schneider, et .al, 2024).The importance of sustained educational interventions is further supported by interventional studies. In Pakistan, fortnightly dietary counseling sessions significantly improved nutritional knowledge, with 67% of participants demonstrating good understanding post-intervention compared with 37% at baseline ($p = 0.01$) (Altaf, et. al, 2025). Comparable findings were reported by (Hosun L, et .al,2020), who observed significant reductions in phosphorus intake in both intensive and control groups, highlighting the effectiveness of structured dietary education even when baseline intake levels varied. Overall, Hyperphosphatemia is a multifactorial condition that cannot be effectively managed through dietary measures alone. Optimal phosphate control requires an integrated approach that combines sustained behavioral adherence, sociocultural support, demographic and clinical considerations, adequate dialysis, and appropriate use of phosphate binders. Consistent evidence supports the central role of renal dietitians and evidence-based Medical Nutrition Therapy in delivering individualized, behavior-focused interventions that promote long-term dietary adherence and effective phosphorus control (Ghazi D, et. al, 2022),(Manman G, et. al, 2025).

VIII-multidisciplinary and patient-centered approaches to nutritional management in hemodialysis

Therefore, improving treatment adherence through improved patient support requires the establishment of a patient-centered, transparent, and interactive

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communication platform.
The need for multidisciplinary collaborative management in nephrology is highlighted by the complexity of these conditions, which limits the efficacy of single-specialty care.
The interdisciplinary management model of the nutrition support team (NST) effectively addresses this issue. In line with the medical philosophies of "patient-centered care," the community-based management model used in this study places a high priority on team-based care and psychological counseling(Shi & Fan, 2025).
An interview study of healthcare professionals' opinions regarding the nutritional management of patients receiving hemodialysis in Australia. Building and maintaining patient motivation to facilitate dietary behavior change, providing consistent nutrition advice, and fostering positive patient-clinician relationships all required organizational support with cooperative multidisciplinary teams and individualized patient care. Current nutritional management of hemodialysis patients may be improved by enhancing service delivery and creating and implementing focused, comprehensive self-management interventions. Nutritional counseling is a crucial function of renal multidisciplinary teams, which include nephrologists, nurses, and dietitians.
The best setting for self-management programs is a cooperative, multidisciplinary team setting that fosters good interteam communication and enhances patient satisfaction and continuity of care. (Stevenson et al., 2018) .
A crucial element of conservative and preservative care is individualized nutritional management based on the patient's sociodemographics, social needs, psychological state, degree of health literacy, and preferences. (Narasaki et al., 2024)
Integrated care based on a team Practice Provide patients with CKD with access to a patient-centered multidisciplinary care team that includes dietary counseling, medication management, education and counseling regarding various KRT modalities, transplant options, dialysis access surgery, and ethical, psychological, and social care. (Levin et al., 2024) .
The guidelines also emphasize the value of a multidisciplinary medical team in improving patients' quality of life.
Phosphorus management success depends on a comprehensive, individualized strategy that incorporates patient engagement techniques, culturally appropriate diets, and education. (Kim, 2023).
During the program planning phase, the hemodialysis center's medical staff assembled the phosphate control team, which included eight registered nurses and three nephrologists who had all worked in hemodialysis for more than five years.
Several methods are used to provide patients with information, including posting posters, setting up lectures in groups, providing intensive one-on-one instruction, using the video, and using the WeChat platform. These methods sustain patients' eagerness to learn new things and enhance interactions between doctors and nurses and patients. In the experience-sharing meeting, patients also shared their experiences, which encouraged them to change their knowledge (Yin et al., 2021) .

IX-Evidence gaps and clinical challenges in personalized nutrition for hyperphosphatemia

Compared with other micronutrients of interest in chronic kidney disease (CKD), such potassium, sodium, calcium, and iron, phosphorus is not currently included on nutrition facts labels in the US and other countries. This represent significant barrier to effective phosphorus management.. As a food manufactuers are not required to measure or disclose the phosphorus content of their goods. Furthermore, because phosphorus-containing additives are widely used in the food supply due to their functional benefits in food processing resulting in hidden sources of dietary phosphorus (Biruete et al., 2023) .

Phosphate salts are often incorporated into food products as additives. These additives serve to extend the duration of usability, and to enhance both the flavor and the physical properties of the food. The majority of prepared foods include phosphate additives, such as disodium phosphate, monosodium phosphate, and potassium triphosphate, to maintain color and prolong shelf life. A significant concern is the fact (Cozzolino et al., 2020).
In this study group, a higher dietary phosphorus intake was associated with elevated serum phosphate levels, irrespective of dialysis status. This suggests that individuals undergoing hemodialysis should carefully monitor their food consumption, particularly given the frequent occurrence of excessive dietary phosphorus intake in this population. Although these results align with previous research, some discrepancies were observed. These differing outcomes may be due to an incomplete database that does not fully account for the phosphorus content in many foods, especially inorganic phosphorus, which is not always included in nutritional labeling
The extra-phosphate load attributed to the broadly use of inorganic phosphorus as meals additives for a number reasons in processed meat, poultry, and fish merchandise is normally unavailable. On the other hand, the use of complicated names or ingredients on food labels may also

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obscure the presence of inorganic phosphorus in foods. In light of elevated serum phosphate level attributed to excessive intake of dietary phosphorus components had been shown to set off increased carotid intima-media thickness , which is a acknowledged chance factor for cardiovascular diseases, greater nice strategies are wished to improve the dietary phosphorus intake of the renal community. The addition data of phosphorus content material to nutrition labels would be of vast gain to the persistent kidney sickness population, which has been referred to as for many years, but receive little attention(*Malaysian Journal of Medicine and Health Sciences (eISSN 2636-9346)*, n.d.) .

a-Scientific Gaps in Bioavailability and Intestinal Absorption

bioaccessibility of 40–60% (higher if meat merchandise are more desirable with phosphorus-containing additives), plant sources ,50% bioaccessibility, as a majority of the phos-phorus is phytate-bound, and subsequently inorganic sources (i.e., phosphorus-containing additives) . it is vital to reflect on consideration on the
difference between phosphorus bioavailability and bio-accessibility, as mentioned above, to clear some of the confusion and emphasize the indispensable want for research. While most of the literature refers to the term ''bioavailability,'' the information are usually that of ''bio-accessibility.'' in contrast the in vitro digestibility (i.e., bioaccessibility) of meat, milk products, plant foods, and beverages. The plant ingredients explored had the lowest bioaccessibility in contrast to animal-based foods, processed foods, and beverages, with necessary variability specifically among plant-based foods. While people do no longer categorical phytase to release the phytate-bound phos-phorus, food producers may also add phytase in cereals and grain processing. Similarly, cooking, soaking, and fer-menting can enhance the amount of bioaccessible phos-phorus.While it is in all likelihood that meals with higher (Cozzolino et al., 2020) .

b-The Conflict Between Protein Adequacy and Phosphorus Control

Insufficient awareness regarding hyperphosphatemia and inadequate dietary compliance are the primary factors contributing to ineffective serum phosphorus regulation. Furthermore, malnutrition stemming from excessively restrictive diets can heighten mortality rates. In patients undergoing hemodialysis, the adherence to nutritional guidelines and medication for managing hyperphosphatemia remains suboptimal, with approximately 30% of those required to use phosphorus binders neglecting their use. Compliance with phosphate binders varies from 22% to 71%, largely influenced by the diverse evaluation methods employed, averaging at 47%. Therefore, comprehensive nutritional and medication education for hemodialysis patients suffering from hyperphosphatemia is crucial for effective management of this condition. A meta-analysis indicated that vigorous health education significantly lowers serum phosphorus levels in maintenance hemodialysis patients. (Yin et al., 2021).

c-Limitations in Clinical Outcome Evidence

Hyperphosphatemia is consistently linked to poor outcomes across various populations, especially in chronic kidney disease (CKD). Basic and animal research has revealed multiple mechanisms through which phosphate causes harm, prompting interventions such as dietary changes and phosphate binders. However, these treatments have yet to show clear benefits in prospective clinical trials regarding major clinical outcomes. Additionally, high dietary phosphate intake may have negative effects even without overt hyperphosphatemia. Consequently, it has been suggested that interventions used for CKD patients with normal phosphate levels could also be applied to those with hyperphosphatemia to prevent phosphate elevation and serve as early cardiovascular risk management. This review discusses phosphate toxicity models, summarizes evidence for treating and preventing hyperphosphatemia, and highlights significant knowledge gaps in this area. (Vervloet & Van Ballegooijen, 2018).
A recent trial demonstrated that replacing phosphate-containing food additives with additive-free foods significantly reduced hyperphosphatemia in patients with end-stage renal disease (ESRD), lowering average serum phosphate levels from 7.2 mg/dl (2.3 mmol/l) to 5.0 mg/dl (1.6 mmol/l). However, long-term studies are needed to better understand the relationship between high phosphate intake—particularly from highly absorbable food additive phosphates—and health outcomes.
Regarding treatment in chronic kidney disease (CKD) populations, the KDIGO guideline for CKD-mineral and bone disorder (CKD-MBD) recommends that patients with stage 5 CKD limit phosphate intake to no more than 1000 mg per day.78 This guideline, however, is primarily based on expert opinion. (Vervloet & Van Ballegooijen, 2018)

d-Implementation Gaps and Socioeconomic Barriers

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The interdisciplinary management model of the Nutrition Support Team (NST) effectively addresses nutritional care challenges. Established in the 1970s, the NST brought together physicians, nurses, nutritionists, and pharmacists to collaborate. Initially, its primary goal was to reduce central venous catheter-related sepsis and mechanical complications. Over time, the NST has consistently demonstrated significant clinical benefits.
Originally focused on inpatient care, the NST identified patients with nutritional problems, performed comprehensive nutritional assessments, and delivered safe, effective nutritional interventions. Today, its scope has expanded to managing hospitalized patients as well as supporting those who require home-based nutritional therapy.
While the NST ensures safe and current nutritional support, its overall impact on clinical outcomes is not yet fully understood, with limited evidence available. Additionally, patient compliance remains a crucial factor affecting the effectiveness of the nutritional interventions (Shi & Fan, 2025) .

E-Phosphorus Management In CKD

Bioaccessibility leads to increased bioavailability; however, there is little information available, and the relationship is most likely not linear. Furthermore, although the kidney nutrition community has welcomed variations in phosphorus bio-accessibility, implementation in nutrition education materials has been sluggish and uneven, confusing individuals with chronic kidney disease.
For instance, whole grains, legumes, and nuts may still be prohibited in materials with food lists. Thus, efforts are required to enhance nutritional education resources for patients and clinicians (Biruete et al., 2023) .

F-Socioeconomic Difficulties

People typically purchase marketed foods due to time constraints, a lack of cooking expertise, and taste preferences. When the phosphate content or quantity of phosphate-based food additives is not disclosed in the marketed foods, it becomes more difficult . By hastening the atrophy of muscles and skin, phosphate additives in animal feed may accelerate the aging process, leading to the development of chronic kidney disease (CKD) and associated calcification . The phosphate bioavailability of marketed food products is 100%, while that of natural food products is between 60 and 80%.
According to reports, thermal processing, like boiling, helps reduce the phosphate content of boiled food by 35–50% and drains out the mineral content of food . However, it is well known that when food is cooked or processed, phosphate salts—particularly monohydrogen phosphate-based salt accelerate the formation of Millard reaction products , which subsequently form uremic toxins and overburden the kidneys (Anand & Aoyagi, 2023) .

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Reference

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