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RESEARCH ARTICLES

Asupan Energi, PUFA, Vitamin E, Vitamin B1, dan Vitamin B6 dengan Kadar Hemoglobin Pasien Penyakit Ginjal Kronis

Energy Intake, PUFA, Vitamin E, Vitamin B1, and Vitamin B6 with Hemoglobin Levels in Chronic Kidney Disease Patients

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Abstract

Chronic kidney disease (CKD) is a structural or functional kidney disorder that lasts for three months or longer despite poor health. Patients with kidney disease are at risk of developing anemia, the primary etiology of which is decreased erythropoietin. Energy intake, polyunsaturated fatty acids (PUFA), vitamin E, vitamin B1, and vitamin B6 play a role in erythropoiesis. The purpose of this study was to analyze the association between energy intake, PUFA, vitamin E, vitamin B1, and vitamin B6 with Hb levels in CKD patients undergoing hemodialysis at Ciamis Regional General Hospital. This study used a cross-sectional design. The sampling technique in this study used non-probability sampling with quota sampling with a sample size of 74 subjects. Energy intake, PUFA, vitamin E, vitamin B1, and vitamin B6 were obtained through 3 x 24-hour non-consecutive food recalls. Data on subjects' hemoglobin levels used pre-hemodialysis hemoglobin levels obtained from subjects' medical records. Bivariate analysis used the Spearman-Rank correlation test. The results of the study showed that there was an association between energy intake (*p-value* = 0.000; ρ = 0.534), PUFA (*p-value* = 0.002; ρ = 0.367), vitamin E (*p-value* = 0.001; ρ = 0.370), vitamin B1 (*p-value* = 0.001; ρ = 0.370), and vitamin B6 (*p-value* = <0.001; ρ = 0.471) with Hb levels. It was concluded that energy intake, PUFA, vitamin E, vitamin B1, and vitamin B6 with Hb levels in CKD patients undergoing hemodialysis. Adequate energy intake and a diet rich in PUFA, vitamin E, vitamin B1, and vitamin B6 ciuld help prevent anemia in CKD patients undergoing hemodialysis.

Keywords: energy intake, hemoglobin, polyunsaturated fatty acid, vitamin B, vitamin E

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Abstrak

Penyakit ginjal kronis adalah abnormalitas struktur ginjal atau fungsi ginjal yang muncul selama minimal 3 bulan dengan implikasi kesehatan. Pasien dengan penyakit ginjal berisiko mengalami anemia dengan etiologi utama penurunan eritropoietin. Asupan energi, polyunsaturated fatty acid (PUFA), vitamin E, vitamin B_1, dan vitamin B_6 berperan dalam eritropoiesis. Tujuan penelitian ini adalah untuk menganalisis hubungan antara asupan energi, PUFA, vitamin E, vitamin B1, dan vitamin B6 dengan kadar Hb pada pasien PGK yang menjalani hemodialisis di Rumah Sakit Umum Daerah Ciamis. Penelitian ini menggunakan desain cross-sectional. Teknik sampling pada penelitian ini menggunakan non-probability sampling dengan cara quota sampling dengan jumlah sampel 74 responden. Asupan energi, PUFA, vitamin E, vitamin B1, dan vitamin B6 diperoleh dengan 3 x 24 hour non-consecutive food recall. Data kadar hemoglobin responden menggunakan data kadar hemoglobin pre-hemodialisis yang diperoleh dari data rekam medis responden. Analisis bivariat menggunakan uji korelasi Spearman-Rank. Hasil penelitian menunjukkan bahwa terdapat hubungan antara asupan energi (p-value = <0,001; ρ = 0,534), PUFA (p-value = 0,002; ρ = 0,367), vitamin E (p-value = 0,001; ρ = 0,370), vitamin B1 (p-value = 0,001; ρ = 0,370), dan vitamin B6 (p-value = 0,000; ρ = 0,471) dengan kadar Hb. Dapat disimpulkan bahwa asupan energi, PUFA, vitamin E, vitamin B1, dan vitamin B6 dengan kadar Hb pada pasien PGK yang menjalani hemodialisis. Asupan energi yang cukup serta pemberian diet yang kaya akan PUFA, vitamin E, vitamin B1, dan vitamin B6 dapat membantu mencegah anemia pada pasien PGK yang menjalani hemodialisis.

Kata Kunci: *asupan energi, hemoglobin, polyunsaturated fatty acid, vitamin B, vitamin E*

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Highlight:

- Energy intake shows a significant positive correlation with hemoglobin levels in CKD patients. Maintaining adequate energy consumption is vital to prevent malnutrition-induced anemia and suppress elevated hepcidin levels that inhibit iron absorption.
- Both PUFA and Vitamin E intake are significantly associated with higher hemoglobin levels. PUFA plays a critical role in reducing chronic inflammation that impairs erythropoiesis, while Vitamin E acts as an antioxidant that protects red blood cell membranes from oxidative stress.
- Vitamin B1 and Vitamin B6 consumption correlate positively with hemoglobin levels in hemodialysis patients. Vitamin B1 supports active transport in iron metabolism and cellular defense, while Vitamin B6 serves as a key coenzyme in heme synthesis to prevent sideroblastic anemia.

INTRODUCTION

A structural or functional disorder of the kidneys that persists for three months or more with health implications is known as chronic kidney disease (CKD). CKD is categorized according to albuminuria, glomerular filtration rate, and etiology (Stevens et al., 2024). An estimated glomerular filtration rate of less than 60 mL/min/1.73 m^2 is indicative of chronic kidney disease (CKD). Chronic kidney disease (CKD) is characterized by a progressive loss of kidney function that necessitates renal replacement treatment, such as dialysis or transplantation (Vaidya, 2022).

The median global prevalence of CKD, according to data from the International Society of Nephrology (ISN) Global Kidney Health Atlas (ISN-GKHA), is 9.5% (Bello et al., 2024). The prevalence of CKD in Indonesia, according to the 2023 Indonesian Health Survey, was 0.18%, with 21.1% of patients undergoing hemodialysis. The prevalence of CKD in West Java is higher than the national prevalence, which is 0.20% (Kemenkes, 2023).

Patients with kidney disease are at risk of developing anemia, known as CKD anemia. Common types of CKD anemia are normocytic, normochromic, and hypoproliferative. CKD anemia is associated with poor treatment outcomes, decreased quality of life, and an increased risk of death (Badura et al., 2024). An individual is considered anemic if their hemoglobin levels are less than 13 g/dL for men and less than 12 g/dL for women (Babitt et al., 2021). Anemia is present in up to 20% of patients with stage 3 CKD. Anemia will eventually occur in at least 90% of patients who become dependent on dialysis (Badura et al., 2024; Fishbane and Coyne, 2020). Anemia management guidelines in Indonesia use a hemoglobin level threshold of 10 g/dL for supportive therapy. A 2020 report from the Perhimpunan Nefrologi Indonesia (PERNEFRI) showed that 81% (110,074) of CKD patients had hemoglobin levels <10 g/dL (PERNEFRI, 2020).

CKD anemia has a multifactorial etiology. However, the primary etiology of CKD anemia is decreased erythropoietin (EPO) production in the kidneys. Red blood cell formation is stimulated by the hormone EPO. Hypoxia-inducible factor (HIF), a transcription factor that controls the production of the EPO gene, is downregulated in response to decreased EPO levels (Kaplan et al., 2018). Uremia, which shortens the lifespan of red blood cells and results in anemia, is more common in patients with CKD (Dias et al., 2020). Hemodialysis therapy carries the risk of losing several water-soluble nutrients to the dialysis fluid (Hashmi et al., 2024). This condition is exacerbated by the anorexia often experienced by CKD patients, leading to limited energy and other nutrient intake, which contributes to CKD anemia (Marumoto et al., 2020).

There has been no previous research examining the association between energy intake and Hb levels in CKD patients. Previous studies have examined the association between energy and protein intake with protein energy wasting, energy intake with the risk of cardiovascular mortality, and energy intake with prognosis in CKD patients. Adequate energy intake is essential for effective erythropoiesis regulation (Rahmatina et al., 2025). Inadequate energy intake and imbalanced macronutrient intake increase hepcidin concentrations, which can decrease iron absorption and mobilization and disrupt erythrocyte production (Antosiak-Cyrak et al., 2025). However, research shows that there is no significant relationship between energy intake and Hb levels (Zalfa et al., 2024).

Previous studies have mostly discussed the relationship between protein and iron intake and Hb levels and there has been no research that has discussed the relationship between polyunsaturated fatty acids (PUFA), vitamin E, vitamin B1, and vitamin B6 with Hb levels, especially in CKD patients. PUFA intake plays a role in the inflammatory process in the body (Mititelu et al., 2025). PUFA, especially docosahexaenoic acid (DHA, omega 3), can modulate the inflammatory process and control anemia, thus improving the erythropoiesis-resistance index (ERI) in hemodialysis patients (Ruperto et al., 2021). Recombinant human erythropoietin is poorly responded by 11–15% of hemodialysis patients, resulting in lower hemoglobin levels and a higher incidence of anemia. Research by Rusu et al. (2013) showed that vitamin E can improve the responsiveness of recombinant human erythropoietin and increase Hb levels. CKD patients undergoing hemodialysis often experience vitamin B_1 (thiamine) deficiency (Wang et al., 2024). Vitamin B1, which also aids in iron uptake and use, has an indirect effect on iron metabolism (Listabarth et al., 2020), so vitamin B1 deficiency has the potential to cause anemia. Vitamin B6 is a key coenzyme in the synthesis of heme (Joyce et al., 2018). Anemia can result from a vitamin B6 deficiency, particularly microcytic, hypochromic, and sideroblastic anemia (Yasuda et al., 2022). Hemodialysis patients are at risk for vitamin B_6 deficiency because of decreased food intake, poor nutritional absorption, altered metabolism of vitamin B6, increased dialysis-related losses, and nutrient-drug interactions (Jankowska et al., 2017). However, research by Atia et al. (2025) showed that vitamin B6 deficiency was not significantly associated with anemia in pediatric CKD patients on HD.

Ciamis Regional General Hospital is one of the hospitals in East Priangan that provides hemodialysis services. The number of patients undergoing hemodialysis therapy in November 2024 was quite large, namely 150 patients with a frequency of HD 2 times/week and a duration of HD more than 12 months. The average hemoglobin (Hb) level of CKD patients in the Hemodialysis Unit of Ciamis Regional General Hospital was <10 g/dL, indicating that most CKD patients undergoing hemodialysis therapy had low Hb levels. Based on these data, the aim of this study was to analyze the association between energy intake, PUFA, vitamin E, vitamin B_1, and vitamin B_6 with Hb levels in CKD patients undergoing hemodialysis at Ciamis Regional General Hospital.

METHODS

This study was a quantitative study using a cross-sectional design. The population of this study were all CKD patients undergoing hemodialysis at the Hemodialysis Unit of Ciamis Regional Hospital. The number of outpatient hemodialysis patients recorded in November 2024 was 150. The research was conducted in April 2025. The sampling technique employed in this study was non-probability sampling with quota sampling. Based on Lemeshow's and David (1997) formula with a total population of 150 individuals, a 95% confidence interval, an estimated proportion of 50%, and a 10% margin of error, the minimum required sample size for this study was 60 respondents. To ensure higher statistical power and account for potential data loss, a larger sample consisting of 72 subjects was ultimately involved in this research.

The inclusion criteria for the sample were patients who had undergone regular hemodialysis twice a week at the Hemodialysis Unit of Ciamis Regional Hospital for at least 3 consecutive months as recorded in their medical records, had no history of cancer, HIV/AIDS, heart failure, chronic obstructive pulmonary disease (COPD), hepatic cirrhosis, thalassemia, or sickle cell anemia, and were not undergoing Erythropoietin Stimulating Agent (ESA) therapy or iron supplementation. The exclusion criteria for the sample were inpatient CKD patients who had received a previous blood transfusion, were experiencing bleeding, were unconscious and unable to communicate.

Data collection was assisted by 4 enumerators with the following criteria: 8th semester Nutrition undergraduate students who had passed the Nutritional Status Assessment and Food Consumption Assessment courses. Prior to data collection, enumerators were given training on data collection procedures and 24-hour food recall interviews. Data of energy, PUFA, vitamin E, vitamin B_1, and vitamin B_6 intake were obtained through 3x24 non-consecutive food recalls consisting of two workdays and one day off. The 24-hour food recall interview on the first day was conducted in the Hemodialysis Unit of Ciamis Regional Hospital, while the 24-hour food recall on the second and third days was conducted via video call. A food photo book was used to facilitate subjects and researchers in estimating the size and weight of food consumed. This book was compiled by the Research and Development Agency of the Ministry of Health of the Republic of Indonesia in 2014. Food recall results were inputted using the Nutrisurvey application. Subjects' Hb levels were measured using pre-hemodialysis Hb levels obtained from subjects' medical records. Subjects' Hb levels were measured using a hematology analyzer in the Ciamis Regional General Hospital laboratory.

All data were measured using a ratio scale. Data were entered into SPSS software for statistical analysis. The Kolmogorov-Smirnov test for normality showed that all variables were non-normally distributed. Univariate analysis used the median. Bivariate analysis used the Spearman-Rank correlation test. This study has received ethical approval from the Health Research Ethics Committee of Dian Nuswantoro University, under the research number 000923/UNIVERSITAS DIAN NUSWANTORO/2025.

RESULTS AND DISCUSSIONS

Subject characteristics

Table 1 shows the distribution of characteristics of the 72 study subjects. Most of the study subjects were pre-elderly individuals aged 44-59 years (56.9%), female (56.9%), with elementary school education (31.9%), and unemployed (76.4%).

Table 1. Distribution of research subject characteristics

Variable	n	%
Age		
Adults (19-44 years)	15	20.8
Pre-elderly (44-59 years)	41	56.9
Elderly (≥60 years)	16	22.2
Gender		
Male	31	43.1
Female	41	56.9
Education Level		
Elementary School	23	31.9
Junior High Scool/ Islamic Junior High School	18	25
Senior High School/Vocational High School	16	22.2
Diploma 3	2	2.8
Bachelor's Degree/Diploma 4	12	16.7
Master’s Degree	1	1.4
Occupation		
Unemployed	55	76.4
Employed	17	23.6

Source: Primary data, 2025

Analysis of the association between energy, PUFA, and Vitamin (E, B_1, B_6) intakes with hemoglobin levels

Univariate analysis results showed that the median energy intake was 892.12 kcal. The median PUFA intake was 8.325 g. The median vitamin E intake was 2.72 mg. The median vitamin B_1 intake was 0.26 mg. The median vitamin B_6 intake was 0.48 mg. The median Hb level was 7.65 g/dL.

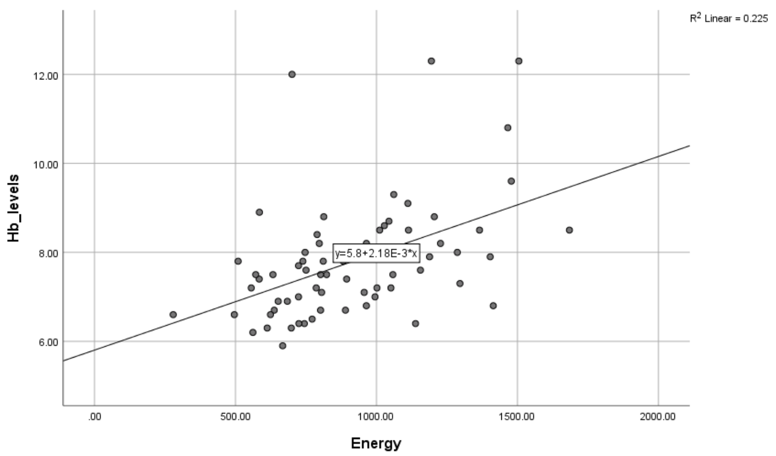
Table 2. Univariate analysis results

Variable	Median (n=72)	Min (n=72)	Min (n=72)
Energy (kcal)	892.12	279.10	1684.12
PUFA (g)	8.325	1.20	31.99
Vitamin E (mg)	2.72	0.20	6.38
Vitamin B_1 (mg)	0.26	0.17	0.61
Vitamin B_6 (mg)	0.48	0.25	1.16
Hb levels (g/dL)	7.65	5.90	12.30

Source: Primary data, 2025

In this study, the second and third 24-hour food recalls were conducted via video call because it was not possible to meet the subjects in person. This situation could have introduced bias in estimating the amount of each food consumed by the subjects. However, the researchers attempted to obtain detailed amounts of each food item using a food photo book.

Based on the Spearman-Rank correlation analysis, a *p-value* of <0.001 (< 0.05) was obtained, indicating a significant association between energy intake and Hb levels. The correlation coefficient of 0.534 indicates a strong, positive association, indicating that the higher the energy intake, the higher the subjects' Hb levels. Based on the scatterplot (Figure 1), the data distribution forms a straight predictive line from the bottom left to the top right, indicating that the higher the energy intake, the higher the subjects' Hb levels. The results of this study are in line with research Utari et al. (2019) which shows that energy intake is significantly related to Hb levels (*p-value* 0.001) with a correlation coefficient of 0.659 which means a strong, positive association, indicating that the higher the energy intake, the higher the subjects' Hb levels.



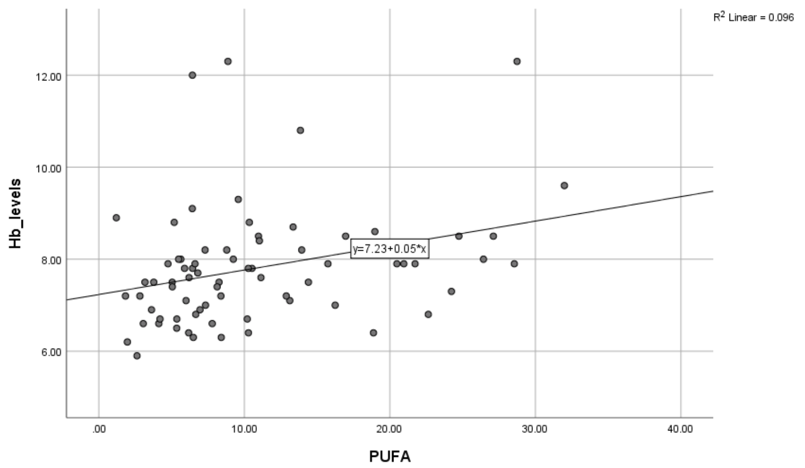
p-value = 0.000 $\rho = 0.534$

Figure 1. Scatter plot graph of the association between energy intake and Hb levels

A low-energy (deficient) diet can increase hepcidin levels and decrease dietary iron absorption (Hayashi et al., 2022; Hennigar et al., 2021). Hepcidin is a 25-amino acid peptide hormone that plays a role in reducing iron concentrations in the body's circulation.

Hepcidin binds to and signals the degradation of the cellular iron exporter, ferroportin (Nemeth and Ganz, 2023). The cells and organs involved in iron transport, such as reticuloendothelial macrophages and small intestinal absorptive epithelial cells, are the main sources of ferroportin expression. If ferroportin levels decrease due to increased hepcidin, iron recycling will be inhibited and the ability of dietary iron to enter the portal circulation will be hampered (Correnti et al., 2024). Hepcidin influences erythrocyte formation through this route, making it a crucial regulator of systemic iron homeostasis. Limited iron erythropoiesis and anemia can result from elevated hepcidin levels (Pagani et al., 2019).

Based on the results of the Spearman-Rank correlation test analysis, a *p-value* of 0.002 (< 0.05) was obtained, which means there is a significant association between PUFA intake and Hb levels. The correlation coefficient of 0.367 indicates a sufficient level of association strength with a positive value indicating that the higher the PUFA intake, the higher the subject's Hb levels. Based on the scatter plot graph (Figure 2), it is known that the data distribution forms a straight predictive line from the bottom left to the top right, indicating that the higher the PUFA intake, the higher the subject's Hb levels. Previous studies have not examined the relationship between PUFA intake and Hb levels in CKD patients. However, research Yaméogo et al., (2017) showed that blood PUFA concentrations were related to Hb levels in children with moderate acute malnutrition. Research (Hayford et al., 2021) showed that mice conditioned on an n-3 PUFA-deficient (n-3FAD) diet and given omega-3 PUFA supplementation had higher Hb levels than the untreated n-3 PUFA-sufficient group.



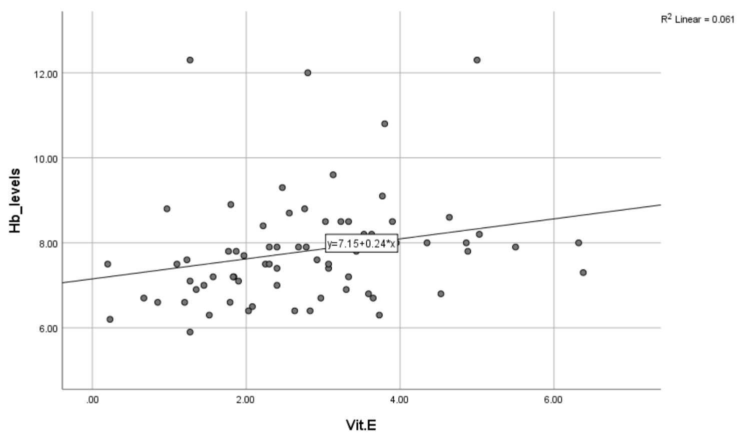
p-value = 0.002 $\rho = 0.367$

Figure 2. Scatter plot graph of the association between PUFA intake and Hb levels

One risk factor for CKD patients is chronic low-grade inflammation, which accelerates the disease's progression (Mihai et al., 2018). The primary cause of inflammation in individuals with chronic kidney disease (CKD) is the progressive increase of metabolites including endotoxin, homocysteine, hyperphosphatemia, and proinflammatory chemicals as kidney function declines(Huang et al., 2024). This inflammation can trigger renal anemia. Proinflammatory factors can inhibit erythroid progenitor cell proliferation, affect iron transport, inhibit EPO synthesis and activity, and affect erythrocyte longevity (Libregts et al., 2011). Thus, reducing inflammation can lower the prevalence of anemia in those with CKD (Fu et al., 2024).

PUFA is one nutrient that is important for inflammation. While omega-6 PUFAs can cause inflammation and weaken the immune system, omega-3 PUFAs, such as EPA and DHA, have anti-inflammatory properties (Panezai and Dyke, 2023). Omega-3 PUFA (EPA and DHA) intake can reduce levels of pro-inflammatory mediators in plasma and in inflamed tissues. PUFA intervention can consistently inhibit interleukin-6, tumor necrosis factor alpha (TNF-α), C-reactive protein, and leukotriene B4. This occurs due to reduced signaling from nuclear factor kappa beta (NFκβ), a key transcription factor in the inflammatory response (Falsetta dan Chrysilla, 2025). Research conducted by Ruperto et al. (2021) shows that DHA supplementation can improve anemia and address the inflammatory response in CKD patients undergoing hemodialysis. However, in this study, the researchers did not calculate the intake of omega-3 PUFA and omega-6 PUFA, so it cannot be explained whether omega-3 PUFA or omega-6 PUFA played a greater role in the Hb levels of the research subjects.

Based on the Spearman-Rank correlation analysis, a *p-value* of 0.001 (< 0.05) was obtained, indicating a significant association between vitamin E intake and Hb levels. The correlation coefficient of 0.370 indicates a moderately strong association, with a positive value indicating that the higher the vitamin E intake, the higher the subjects' Hb levels. Based on the scatterplot (Figure 3), the data distribution forms a straight predictive line from the bottom left to the top right, indicating that the higher the vitamin E intake, the higher the subjects' Hb levels. No previous research has examined the association between vitamin E intake and Hb levels in CKD patients. Research Laila and Fathunikmah (2017) suggests that vitamin E supplementation can increase Hb levels. However, research Agustina (2019), showed different results, indicating no association between vitamin E intake and Hb levels.

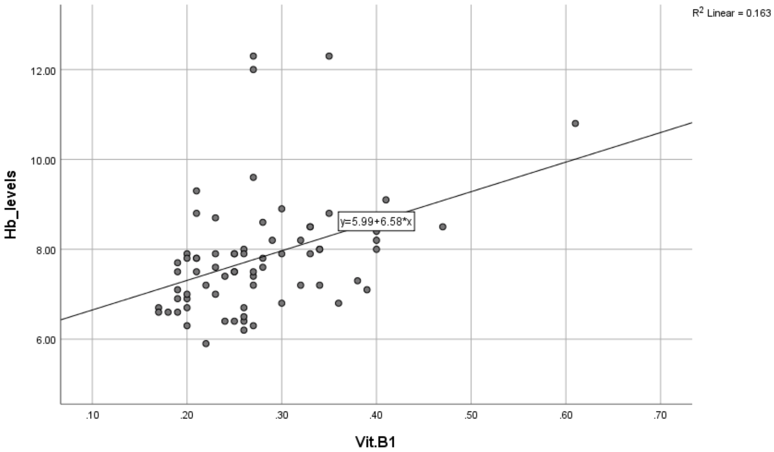


p-value = 0.001 $\rho = 0.370$

Figure 3. Scatter plot graph of the association between vitamin E intake and Hb levels

As previously explained, CKD patients undergoing hemodialysis are at risk of developing anemia due to increased inflammation. Hemolytic anemia is a type of anemia that occurs when damage occurs to the erythrocyte membrane, causing oxidative damage, which triggers erythrocyte lysis. This shortens the survival rate of mature erythrocytes. As an antioxidant, vitamin E is essential for preventing oxidative damage to the erythrocyte membrane (Loy, 2022). Vitamin E administration has been demonstrated in animal experiments to increase the quantity of erythroid precursor colony-forming units (Jilani et al., 2015). Vitamin E also affects iron status in the body, so vitamin E deficiency can cause iron deficiency. By keeping iron in a ferrous form, vitamin E's antioxidant properties can improve iron absorption (Jilani et al., 2015).

Based on the *Spearman-Rank* correlation analysis (Figure 4), a *p-value* of 0.001 (<0.05) was obtained, indicating a significant association between vitamin B_1 intake and Hb levels. The correlation coefficient of 0.370 indicates a moderately strong association, with a positive value indicating that the higher the vitamin B_1 intake, the higher the subjects' Hb levels. The scatterplot (Figure 4) shows that the data distribution forms a straight predictive line from the bottom left to the top right, indicating that the higher the vitamin B_1 intake, the higher the subjects' Hb levels. No previous studies have examined the relationship between vitamin B_1 intake and Hb levels in CKD patients. However, research Pinzon et al. (2020) shows that parenteral vitamin B_1 administration can increase Hb levels in CKD patients undergoing hemodialysis.

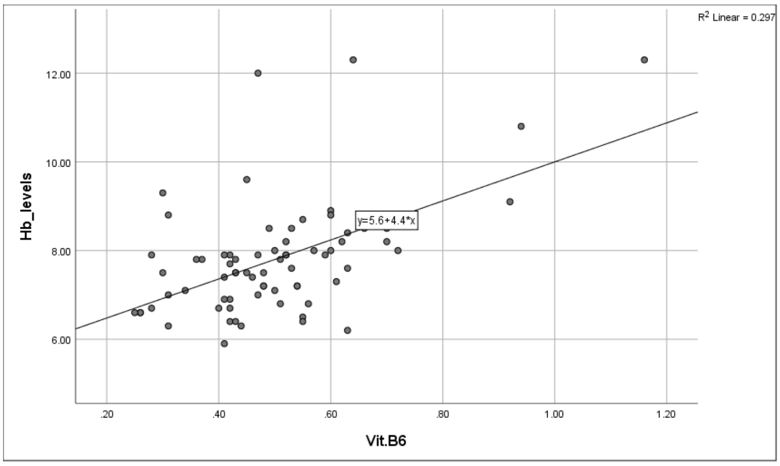


p-value = 0.001 $\rho = 0.370$

Figure 4. Scatter plot graph of the association between vitamin B1 intake and Hb levels

Approximately 25% of stage 5 CKD patients experience vitamin B_1 deficiency. Vitamin B_1 levels decrease further after patients undergo dialysis (Dizdar et al., 2020). Factors influencing this deficiency include low dietary intake, intradialysis loss, decreased bioavailability, long-term diuretic use, malabsorption, and the production of the thiamine antagonist oxythiamine by the intestinal microflora (Jankowska et al., 2017; Saka et al., 2018). Vitamin B_1 is an antioxidant that can protect cells from oxidative damage. In patients with vitamin B_1 deficiency, increased oxidative stress has the potential to damage erythrocytes, resulting in hemolytic anemia (Fernandes et al., 2017). Vitamin B_1 deficiency can also trigger increased inflammation characterized by increased inflammatory markers (De Andrade et al., 2014). Anemia can result from chronic inflammation that obstructs the body's ability to absorb and use iron (De Andrade et al., 2014). Vitamin B1 is a micronutrient essential for the synthesis of neurotransmitters, including acetylcholine. Iron metabolism and hematopoiesis regulation may be impacted by disruptions in nervous system function, especially in the autonomic nervous system (Obayashi et al., 2000).

Based on the *Spearman-Rank* correlation analysis, a *p-value* of <0.001 (< 0.05) was obtained (Figure 5), indicating a significant association between vitamin B_6 intake and Hb levels. The correlation coefficient of 0.471 indicates a moderately strong association, with a positive value indicating that the higher the vitamin B_6 intake, the higher the subjects' Hb levels. The scatterplot (Figure 5) shows that the data distribution forms a straight predictive line from the bottom left to the top right, indicating that the higher the vitamin B_6 intake, the higher the subjects' Hb levels. No previous studies have examined the relationship between vitamin B_6 intake and Hb levels in CKD patients. However, research Pinzon et al. (2020) shows that parenteral vitamin B_6 administration can increase Hb levels in CKD patients undergoing hemodialysis.



p-value = <0.001 $\rho = 0.471$

Figure 5. Scatter plot graph of the association between vitamin B6 intake and Hb levels

The European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines recommend increasing usage of vitamins B1 and B6 because CKD patients are susceptible to developing these nutritional deficiencies (Berger et al., 2022). Vitamin B_6 deficiency can cause sideroblastic anemia (pyridoxine-responsive anemia). This anemia is characterized by disruption of the final pathway of heme synthesis. This results in the formation of immature erythrocytes. Vitamin B_6 deficiency causes iron that cannot be used to synthesize heme to be stored in the mitochondria of immature erythrocytes, which causes the mitochondria to not function normally and the development and production of erythrocytes to be ineffective (Loy, 2022).

CONCLUSIONS

This study shows a significant association between energy, PUFA, vitamin E, vitamin B_1, and vitamin B_6 intake and Hb levels in CKD patients undergoing hemodialysis. Based on these findings, it is hoped that CKD patients undergoing hemodialysis will pay more attention to their energy, PUFA, vitamin E, vitamin B_1, and vitamin B_6 intake by increasing their consumption of foods containing these nutrients to prevent anemia. Therefore, nutritional education is needed about the importance of fulfilling the needs of energy, PUFA, vitamin E, vitamin B1, and vitamin B6 to prevent anemia in CKD patients undergoing HD.

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CONFLICT OF INTEREST (special english article)

The authors declare that they have no conflict of interest

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