World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

SERUM VITAMIN D LEVELS AMONG PATIENTS WITH RENAL FAILURE COMPARED TO HEALTHY CONTROLS IN GEZIRA STATE, SUDAN

Ahmed O. Ahmed [1], Khalid Abdelsamea Mohamedahmed [2, 3, *], ani M. Abdalla [4], Yousif A. Mohammed [5], Adil Mergani [6, 7], Amir M. Dafalla [6], Bakri Y. M. Nour [7], Amira S. Khalafalla [5], Abuagla M. Dafalla [5, 8] and Marwa A. Ahmed [9]

[1] Department of Medical Laboratories, National Cancer Institute, University of Gezira, Wad Medani, Sudan.
[2] Department of Hematology and Immunology Faculty of Medical Laboratory Sciences, University of Gezira, Wad Medani, Sudan.
[3] Department of Medical Laboratory Sciences, Faculty of Applied Medical Sciences, Jerash University, Jerash, Jordan.
[4] Department of Medical Laboratories, Health Services Directorate, University of Gezira, Wad Medani, Sudan.
[5] Department of Clinical Chemistry, Faculty of Medical Laboratory Sciences, University of Gezira, Wad Medani, Sudan.
[6] Department of Molecular Biology, Institute of Nuclear Medicine, Molecular Biology and Oncology (INMO), University of Gezira, Sudan.
[7] Department of Parasitology, Blue Nile Natural Institute for Communicable Diseases, University of Gezira, Wad Madani, Sudan.
[8] Kampala International University (KIU), School of Biomedical, Uganda.
[9] Department of Medical Laboratories, Albarakat Medical Complex, Wad Madani, Sudan.
* Corresponding Author

ORCID Details
Khalid Abdelsamea Mohamedahmed: 0000-0001-7084-6106

World Journal of Advanced Research and Reviews, 2026, 31(03), 447–454

Publication history: Received on 27 July 2026; revised on 07 September 2026; accepted on 09 September 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.31.3.2288

ABSTRACT

Background: Vitamin D deficiency is a frequent metabolic disturbance in patients with chronic kidney disease (CKD) and contributes to mineral-bone disorder, cardiovascular risk, and poor disease outcomes. This study aimed to evaluate serum 25-hydroxyvitamin D [25(OH)D] concentrations among patients with renal failure compared with healthy controls in Gezira State, Sudan.

Methods: A hospital-based cross-sectional case–control study was conducted at Gezira Hospital for Renal Diseases and Surgery, Wad Medani, Sudan, from December 2024 to October 2025. The study included 70 patients diagnosed with renal failure and 73 apparently healthy age- and sex-matched controls. Venous blood samples were collected and analyzed for serum 25(OH)D concentrations using a chemiluminescence immunoassay (CLIA) method. Data were analyzed using SPSS version 26.0, and comparisons between groups were performed using the independent-samples *t*-test and chi-square test, with a p-value < 0.05 considered statistically significant.

Results: The mean serum vitamin D level among renal failure patients was significantly lower (9.7 ± 5.9 ng/mL) compared to controls (23.0 ± 7.3 ng/mL, $p < 0.001$). Most patients were older than 50 years (52.9%) and predominantly male (55.7%). Vitamin D deficiency was observed across all demographic and clinical subgroups of renal failure patients, with no significant variation by age, gender, residence, marital status, education level, duration of renal failure, or comorbidities ($p > 0.05$ for all). Although those taking vitamin D supplements exhibited slightly higher mean levels (11.12 ± 7.59 ng/mL) than non-supplemented patients (9.61 ± 5.84 ng/mL), the difference was not statistically significant ($p = 0.587$).

Conclusion: Serum vitamin D levels were markedly reduced in patients with renal failure compared with healthy individuals, irrespective of demographic or clinical factors. These findings highlight the importance of routine assessment and supplementation of vitamin D as part of the comprehensive management of renal failure in Sudanese patients.

Keywords: Vitamin D Deficiency; 25-Hydroxyvitamin D; Renal Failure; Chronic Kidney Disease; Sudan; Chemiluminescence Immunoassay; Case–Control Study; Micronutrient Deficiency.

1 INTRODUCTION

Renal failure and chronic kidney disease (CKD) are serious global public health issues that are linked to high rates of morbidity, mortality, and medical expenses. Vitamin D plays a major role in the disruption of immunological control, cardiovascular homeostasis, and mineral and bone metabolism, all of which are important aspects of the complicated pathophysiology of chronic kidney disease (CKD). In populations with chronic kidney disease (CKD), vitamin D deficiency is quite common and is known to be an independent risk factor for unfavorable outcomes, such as faster loss in renal function, cardiovascular events, and fracture risk [1,2,3].

Renal hydroxylation of 25-hydroxyvitamin D [25(OH)D] is essential for the synthesis of active vitamin D (1,25-dihydroxyvitamin D) [4], and this process gradually deteriorates as glomerular filtration rate decreases [5-6]. Beyond its traditional function in maintaining calcium-phosphate homeostasis, vitamin D has pleiotropic effects, such as anti-inflammatory, anti-fibrotic, and cardioprotective qualities, which are increasingly known to influence the course of chronic kidney disease (CKD) and its consequences [7-8]. According to recent research, low 25(OH)D levels may actively cause endothelial dysfunction, proteinuria, and tubulointerstitial damage by reducing renal oxidative stress and modifying the renin-angiotensin-aldosterone system [9-10].

Vitamin D deficiency affects 70% to 90% of people with chronic kidney disease (CKD) worldwide, and its severity frequently corresponds with the stage of the disease [11-12]. Its pathophysiology has been better understood, but therapy is still inconsistent, and recommendations for the best screening, supplementing methods, and goal levels differ, especially in settings with low resources [13-14]. Data on vitamin D status in renal patients is still limited in sub-Saharan Africa, where the prevalence of CKD is increasing and healthcare resources are frequently limited. Although studies from other sun-rich nations, like Saudi Arabia and India, have shown high rates of hypovitaminosis D among CKD patients, suggesting that environmental ultraviolet exposure alone is insufficient to maintain adequate levels in the context of renal impairment, the region's abundant sunlight may theoretically protect against deficiency [15-16].

Renal impairment may exacerbate vitamin D insufficiency even in areas with historically high sun exposure, according to a previous Sudanese study on diabetic patients that reported significantly lower serum 25(OH)D levels in individuals with nephropathy [17]. However, there is a crucial knowledge vacuum about the extent and causes of deficiency in this clinical population because a direct comparison between patients with renal failure and healthy controls has not been carried out in Sudan.

Characterizing vitamin D status in renal failure is crucial for developing context-appropriate clinical guidelines because of Sudan's high CKD burden, nutritional vulnerabilities, and systemic healthcare issues. Therefore, the purpose of this study was to measure and compare serum 25(OH)D concentrations between patients with renal failure and age- and sex-matched healthy controls in Gezira State, Sudan, and to look for correlations with clinical and demographic factors. The results are meant to aid in the creation of focused screening and intervention plans to lessen vitamin D insufficiency and its aftereffects in kidney disease patients from Sudan.

2 MATERIALS AND METHODS

This was a hospital-based cross-sectional case–control study was conducted at Gezira Hospital for Renal Diseases and Surgery, Wad Medani, Sudan, between December 2024 and October 2025. The study compared serum 25(OH)D concentrations between renal failure patients (cases) and age- and sex-matched healthy individuals (controls). The study included 70 renal failure patients undergoing regular follow-up at the hospital's nephrology unit and 73

apparently healthy controls without known renal or hepatic disease. Participants were adults aged between 20 and 70 years. Exclusion criteria included pregnancy, use of vitamin D supplements, or medications affecting vitamin D metabolism such as corticosteroids or anticonvulsants. The sample size was calculated based on the formula for comparing two independent means, with a type I error (α) of 0.05 and power (1−β) of 80%. Substituting values yielded an estimated minimum of 70 participants per group, ensuring adequate statistical power. Venous blood samples (5 mL) were collected under aseptic conditions and centrifuged at 3000 rpm for 10 minutes to obtain serum. Serum 25(OH)D concentration was measured using a chemiluminescence immunoassay (CLIA) method. Renal function was assessed by measuring serum creatinine and urea levels using an automated analyzer (Beckman Coulter AU480). Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical data as frequency and percentage. Comparisons between groups were performed using the independent-samples t-test for continuous variables and chi-square test for categorical variables. A p-value < 0.05 was considered statistically significant. Ethical approval was obtained from the Ethics Committee of the Faculty of Medical Laboratory Sciences, University of Gezira. Written informed consent was secured from all participants prior to data and sample collection.

3 RESULTS

As shown in Table 1, the study included 70 patients diagnosed with renal failure and 73 apparently healthy controls. Most patients (28.6%) were above 60 years of age, while the largest proportion of controls (27.4%) were between 51–60 years, indicating a slightly older age distribution among cases. Males represented 55.7% of the renal failure group and 53.4% of controls, whereas females constituted 44.3% and 46.6%, respectively.

Urban residents accounted for 68.6% of cases compared to 54.8% of controls, suggesting greater hospital access among urban populations. In contrast, a higher proportion of rural participants was observed among controls (45.2%). Regarding marital status, most renal failure patients were married (78.6%), compared with 58.9% among controls.

Educational status varied notably: 65.7% of patients had no formal education compared with 20.5% of controls, while university education was more common among controls (45.2%) than cases (17.1%). These sociodemographic patterns may influence both health literacy and vitamin D deficiency risk, highlighting socioeconomic and educational disparities among individuals with renal failure.

Table 1: Sociodemographic characteristics of renal failure patients and controls:

Variable	Category	Case N= 70		Control N= 73	
		Frequency	Percent	Frequency	Percent
Age	20 – 30 Year	12	17.1	12	16.4
	31 – 40 Year	7	10	15	20.5
	41 – 50 Year	14	20	15	20.5
	51 – 60 Year	17	24.3	20	27.4
	Above 60 Year	20	28.6	11	15.1
Gender	Male	39	55.7	39	53.4
	Female	31	44.3	34	46.6
Residence	Urban	48	68.6	40	54.8
	Rural	22	31.4	33	45.2
Marital Status	Single	15	21.4	30	41.1
	Married	55	78.6	43	58.9
Education Level	No formal education	46	65.7	15	20.5
	Primary education	1	1.4	5	6.8
	Secondary education	11	15.7	10	13.7
	University or higher	12	17.1	33	45.2

As presented in Table 2, the mean serum vitamin D concentration among patients with renal failure was markedly lower (9.7 ± 5.9 ng/mL) compared with the control group (23.0 ± 7.3 ng/mL). The difference between the two groups was statistically significant ($p < 0.001$).

Table 2: Comparison of serum vitamin D levels between renal failure patients and healthy controls

Study subjects	Mean	Std. Deviation	P. value
Case (n= 70)	9.7	5.9	<0.001
Control (n= 73)	23.0	7.3	

Table 3 presents the mean serum vitamin D levels among patients with renal failure according to demographic and clinical characteristics. The overall mean vitamin D concentration was 9.72 ± 5.93 ng/mL, indicating a general trend of vitamin D deficiency among participants.

No statistically significant differences in serum vitamin D levels were observed across age groups ($p = 0.128$), gender ($p = 0.250$), place of residence ($p = 0.617$), marital status ($p = 0.835$), or educational level ($p = 0.784$). Although patients aged 41–50 years exhibited the highest mean value (13.18 ± 8.98 ng/mL), those above 60 years showed the lowest (7.95 ± 3.69 ng/mL).

Similarly, the duration of renal failure was not significantly associated with vitamin D levels ($p = 0.785$). Patients with more than three years of renal failure had a slightly higher mean (10.57 ± 9.61 ng/mL) than those with shorter disease duration. The presence of comorbidities such as diabetes mellitus or hypertension also did not show significant variation in vitamin D status ($p = 0.684$).

Although patients receiving vitamin D supplementation had somewhat higher mean values (11.12 ± 7.59 ng/mL) compared to non-supplemented individuals (9.61 ± 5.84 ng/mL), the difference was not statistically significant ($p = 0.587$).

Table 3: Serum Vitamin D Levels among Renal Failure Patients According to Demographic and Clinical Characteristics (N = 70)

Variables	Category	N	Mean (ng/mL)	SD (ng/mL)	P. value
Age (years)	20 – 30 Year	12	8.63	3.83	0.128
	31 – 40 Year	7	10.39	5.22	
	41 – 50 Year	14	13.18	8.98	
	51 – 60 Year	17	9.45	5.82	
	Above 60 Year	20	7.95	3.69	
Gender	Male	39	10.45	5.68	0.250
	Female	31	8.80	6.19	
Residence	Urban	48	9.49	6.25	0.617
	Rural	22	10.21	5.25	
Marital Status	Single	15	9.52	3.16	0.835
	Married	55	9.77	6.50	
Education Level	No formal education	46	9.57	6.45	0.784
	Primary	1	13.90	–	
	Secondary	11	10.80	4.86	
	University or higher	12	8.93	5.00	
Duration of Renal Failure	<1 year	45	9.61	4.91	0.785
	1–3 years	10	8.94	2.44	

	>3 years	15	10.57	9.61	
Associated Disease	Diabetes mellitus	15	9.91	5.63	0.684
	Hypertension	36	9.12	4.10	
	Glomerulonephritis	1	15.30	–	
	None	18	10.43	8.87	
Vitamin D Supplementation	Yes	5	11.12	7.59	0.587
	No	65	9.61	5.84	

This is a correlation matrix showing the linear relationships between five medical variables in 70 subjects. The Pearson correlation coefficients range from -1 to 1. Only one statistically significant correlation was found: between Urea and Creatinine, which has a moderate negative correlation ($r = -0.260$, $p = 0.030$). All other variable pairs, such as Vitamin D with Age or Duration, show very weak correlations that are not statistically significant ($p > 0.05$), meaning no meaningful linear associations were detected in this sample.

Table 3: Correlation of serum vitamin D levels and urea, creatinine, age and duration:

		Age	Duration	Urea	Creatinine
Vitamin D	Pearson Correlation	-.149	.052	.036	.079
	Sig. (2-tailed)	.218	.667	.770	.517
	N	70	70	70	70

4 DISCUSSION

This study examined the relationship between serum vitamin D levels and clinical, biochemical, and demographic characteristics in patients with renal failure as compared to healthy controls. The main conclusions were that patients with renal failure had significantly lower mean serum vitamin D levels than controls, and that most variables within the patient group did not significantly correlate with vitamin D levels, with the exception of a moderately inverse connection between urea and creatinine.

Current studies on vitamin D metabolism in chronic kidney disease (CKD) are consistent with the significantly reduced blood vitamin D concentration in renal failure patients (9.7 ± 5.9 ng/mL) compared to healthy controls (23.0 ± 7.3 ng/mL). Reduced 1α-hydroxylase activity in renal failure hinders the conversion of 25-hydroxyvitamin D to active 1,25-dihydroxyvitamin D, and proteinuria can worsen deficiency by causing vitamin D-binding protein to be lost in the urine (18-19). According to current KDIGO criteria, which categorize levels <20 ng/mL as inadequate, the severe deficiency detected (mean <12 ng/mL) puts this cohort at substantial risk for CKD-mineral and bone disorder (CKD-MBD) (20).

The lack of significant variation in vitamin D levels across demographic factors (age, gender, residence, and education) within the renal failure cohort indicates that disease-related metabolic dysregulation takes precedence over conventional sociodemographic determinants of nutritional status once renal failure is established (21). This result is in line with recent research demonstrating that vitamin D level and CKD stage have a stronger correlation than traditional risk variables (22). The idea that vitamin D deficiency is an early and enduring aspect of renal pathology rather than a result of disease progression is further supported by the lack of correlation with the length of the disease or comorbidities such diabetes and hypertension (23).

Notably, in this sample, serum vitamin D did not significantly correlate with traditional renal function markers (creatinine, urea). This could be because the link between glomerular filtration rate and vitamin D metabolism becomes non-linear in established renal failure, and deficiencies can arise even in early-stage chronic kidney disease (CKD) (24). A number of current clinical realities may be reflected in the observed moderately negative correlation between urea and creatinine ($r = -0.260$, $p=0.030$). These realities include the variable effects of various CKD etiologies on these parameters, the influence of muscle mass and nutritional status (particularly affecting creatinine generation), or the impact of conservative kidney management strategies that differentially affect urea and creatinine levels (25-26). Although patients receiving vitamin D supplementation had somewhat higher mean values compared to non-supplemented individuals. These findings suggest that vitamin D deficiency is common among renal failure patients

regardless of demographic or clinical characteristics, emphasizing the need for routine screening and supplementation in this population.

Important social determinants of health in CKD populations are highlighted by the sociodemographic differences seen, especially the considerably lower educational attainment and distinct residence distribution among renal failure patients. According to recent studies, health literacy, which is impacted by educational attainment, has a major impact on CKD outcomes and self-management (27). In contrast, research demonstrating complicated regional differences in CKD care suggest that urban living in this situation may reflect diagnostic availability rather than protective characteristics (28).

Despite the small sample size, the non-significant tendency toward greater vitamin D levels in supplemented patients is consistent with the ongoing discussions on the best ways to replenish vitamin D in CKD. Since response might vary and be impacted by variables such inflammation and genetic polymorphisms in vitamin D metabolism pathways, current guidelines advocate customized dose based on serial monitoring (29-30). Calls for more aggressive or customized regimens are supported by the slight difference seen here, which indicates that conventional supplements may not be sufficient for some patients (31).

5 CONCLUSION

In conclusion, this study demonstrates a severe and widespread deficiency of serum vitamin D in Sudanese patients with renal failure, which is independent of their demographic or clinical characteristics. The presence of renal failure appears to be the primary determinant of this deficiency. These findings highlight an urgent need to integrate routine screening for vitamin D status into the standard management protocol for all renal failure patients in this setting. Furthermore, the development and implementation of structured supplementation and management guidelines, potentially including the use of active vitamin D analogues in advanced CKD, are crucial to address this modifiable risk factor. Future longitudinal studies are warranted to investigate the impact of optimized vitamin D repletion on hard clinical endpoints such as fracture risk, cardiovascular events, and the progression of kidney disease in the Sudanese population.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

We are grateful to staff of the Faculty of Medical Laboratory Sciences, University of Gezira for their cooperation, and our acknowledgement extended to the participants enrolled in this study.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

REFERENCES

[1] Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2024 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int. 2024;105(4S):S117-S314. doi: 10.1016/j.kint.2023.10.018.

[2] Abbas AOI, Gameel FEMH, Abdulla MHA, Elshaikh RH, Waggiallah HA, Mohamedahmed KA, et al. Correlation between Kidd blood group (Jk) and renal function tests in the End Stage of Chronic Kidney Disease (ESCKD) patients. Medical Science. 2023;27:e67ms2703. doi: 10.54905/disssi/v27i131/e67ms2703.

[3] Abbas MI, Ahmed MK, Mohamedahmed KA, et al. Detection of Anti-Nuclear Antibody in Patients with Acute Kidney Injury Attending Gezira Hospital for Renal Disease and Surgery, Sudan (2022). IJAHMR. 2025;9(7):4-9.

[4] Al Ali MAO, Mohamedahmed KA, Babker AM. Role of platelet indices and vitamin D in forecasting deterioration of glycemic control and vascular complications in type 2 diabetes. Italian Journal of Medicine, 2025;19(1):1875. doi: 10.4081/itjm.2025.1875.

[5] Kim CS, Kim SW. Vitamin D and chronic kidney disease. Korean J Intern Med. 2014;29(4):416-27. doi: 10.3904/kjim.2014.29.4.416.

[6] Kandula P, Dobre M, Schold JD, Schreiber MJ Jr, Mehrotra R, Navaneethan SD. Vitamin D supplementation in chronic kidney disease: a systematic review and meta-analysis of observational studies and randomized controlled trials. Clin J Am Soc Nephrol. 2011;6(1):50-62. doi: 10.2215/CJN.03940510.

[7] Molina P, Carrero JJ, Bover J, Chauveau P, Mazzaferro S, Torres PU, et al. Vitamin D, a modulator of musculoskeletal health in chronic kidney disease. J Cachexia Sarcopenia Muscle. 2017;8(5):686-701. doi: 10.1002/jcsm.12218.

[8] Patel TV, Singh AK. Role of vitamin D in chronic kidney disease. Semin Nephrol. 2009;29(2):113-21. doi: 10.1016/j.semnephrol.2009.01.004.

[9] Gembillo G, Siligato R, Amatruda M, Conti G, Santoro D. Vitamin D and Glomerulonephritis. Medicina (Kaunas). 2021;57(2):186. doi: 10.3390/medicina57020186.

[10] Kaur G, Singh J, Kumar J. Vitamin D and cardiovascular disease in chronic kidney disease. Pediatr Nephrol. 2019;34(12):2509-2522. doi: 10.1007/s00467-018-4088-y.

[11] Aggarwal M, Sahoo SP, Bhandari HS, Kriplani J, Mithal A. Prevalence of vitamin D deficiency in post renal transplant patients. Indian J Endocrinol Metab. 2012;16(2):274-6. doi: 10.4103/2230-8210.93751.

[12] Kumar R, Tebben PJ, Thompson JR. Vitamin D and the kidney. Arch Biochem Biophys. 2012;523(1):77-86. doi: 10.1016/j.abb.2012.03.003.

[13] Bello AK, Okpechi IG, Levin A, Ye F, Damster S, Arruebo S, et al. An update on the global disparities in kidney disease burden and care across world countries and regions. Lancet Glob Health. 2024;12(3):e382-e395. doi: 10.1016/S2214-109X(23)00570-3.

[14] Jørgensen HS, Vervloet M, Cavalier E, Bacchetta J, de Borst MH, Bover J, etal. The role of nutritional vitamin D in chronic kidney disease-mineral and bone disorder in children and adults with chronic kidney disease, on dialysis, and after kidney transplantation-a European consensus statement. Nephrol Dial Transplant. 2025;40(4):797-822. doi: 10.1093/ndt/gfae293.

[15] Alsuwadia AO, Farag YM, Al Sayyari AA, Mousa DH, Alhejaili FF, Al-Harbi AS, et al. Prevalence of vitamin D deficiency in Saudi adults. Saudi Med J. 2013;34(8):814-8.

[16] Alfieri, C.; Ruzhytska, O.; Vettoretti, S.; Caldiroli, L.; Cozzolino, M.; Messa, P. Native Hypovitaminosis D in CKD Patients: From Experimental Evidence to Clinical Practice. Nutrients 2019;(11):1918. https://doi.org/10.3390/nu11081918.

[17] Aljack HA, Abdalla MK, Idris OF, Ismail AM. Vitamin D deficiency increases risk of nephropathy and cardiovascular diseases in Type 2 diabetes mellitus patients. J Res Med Sci. 2019;24:47. doi: 10.4103/jrms.JRMS_303_18.

[18] Edmonston D, Wolf M. FGF23 at the crossroads of phosphate, iron economy and erythropoiesis. Nat Rev Nephrol. 2020;16(1):7-19. doi: 10.1038/s41581-019-0189-5.

[19] Bosworth C, de Boer IH. Impaired vitamin D metabolism in CKD. Semin Nephrol. 2013;33(2):158-68. doi: 10.1016/j.semnephrol.2012.12.016.

[20] Kidney Disease: Improving Global Outcomes (KDIGO) CKD-MBD Update Work Group. KDIGO 2017 Clinical Practice Guideline Update for the Diagnosis, Evaluation, Prevention, and Treatment of Chronic Kidney Disease-Mineral and Bone Disorder (CKD-MBD). Kidney Int Suppl (2011). 2017;7(1):1-59. doi: 10.1016/j.kisu.2017.04.001.

[21] Obaid AA, Mujalli A, Farrash WF, Tayeb RH, Bougeis RJ, Aljehani AA, et al. Relationship of Vitamin-D Deficiency with Kidney Disease in Patients with Type-2 Diabetes Mellitus (T2DM) in the Makkah Region: A Cross-Sectional Study. Diabetes Metab Syndr Obes. 2024;17:11-17. doi: 10.2147/DMSO.S445314.

[22] Jean G, Souberbielle JC, Chazot C. Vitamin D in Chronic Kidney Disease and Dialysis Patients. Nutrients. 2017;9(4):328. doi: 10.3390/nu9040328.

[23] Moe SM, Chertow GM, Parfrey PS, Kubo Y, Block GA, Correa-Rotter R, et al. Cinacalcet, Fibroblast Growth Factor-23, and cardiovascular disease in Hemodialysis: The Evaluation of Cinacalcet HCl Therapy to Lower Cardiovascular Events (EVOLVE) Trial. Circulation. 2015;132(1):27-39. doi: 10.1161/CIRCULATIONAHA.114.013876.

[24] Capelli I, Cianciolo G, Gasperoni L, Galassi A, Ciceri P, Cozzolino M. Nutritional vitamin D in CKD: Should we measure? Should we treat? Clin Chim Acta. 2020;501:186-197. doi: 10.1016/j.cca.2019.11.010.

[25] Kalantar-Zadeh K, Jafar TH, Nitsch D, Neuen BL, Perkovic V. Chronic kidney disease. Lancet. 2021;398(10302):786-802. doi: 10.1016/S0140-6736(21)00519-5.

[26] Levey AS, Coresh J, Tighiouart H, Greene T, Inker LA. Measured and estimated glomerular filtration rate: current status and future directions. Nat Rev Nephrol. 2020;16(1):51-64. doi: 10.1038/s41581-019-0191-y.

[27] Taylor DM, Fraser S, Dudley C, Oniscu GC, Tomson C, Ravanan R, et al. Health literacy and patient outcomes in chronic kidney disease: a systematic review. Nephrol Dial Transplant. 2018;33(9):1545-1558. doi: 10.1093/ndt/gfx293.

[28] Duff R, Awofala O, Arshad MT, Lambourg E, Gallacher P, Dhaun N, et al. Global health inequalities of chronic kidney disease: a meta-analysis. Nephrol Dial Transplant. 2024;39(10):1692-1709. doi: 10.1093/ndt/gfae048.

[29] Zittermann A, Ernst JB, Gummert JF, Börgermann J. Vitamin D supplementation, body weight and human serum 25-hydroxyvitamin D response: a systematic review. Eur J Nutr. 2014;53(2):367-74. doi: 10.1007/s00394-013-0634-3.

[30] Bhan I, Burnett-Bowie SA, Ye J, Tonelli M, Thadhani R. Clinical measures identify vitamin D deficiency in dialysis. Clin J Am Soc Nephrol. 2010;5(3):460-7. doi: 10.2215/CJN.06440909.

[31] Bover J, Massó E, Gifre L, Alfieri C, Soler-Majoral J, Fusaro M, et al. Vitamin D and Chronic Kidney Disease Association with Mineral and Bone Disorder: An Appraisal of Tangled Guidelines. Nutrients. 2023 Mar 24;15(7):1576. doi: 10.3390/nu15071576.