

ASSOCIATION BETWEEN ESTIMATED GLOMERULAR FILTRATION RATE AND SERUM SODIUM LEVELS IN PATIENTS WITH CHRONIC KIDNEY DISEASE ON PRE-DIALYSIS

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ABSTRACT

Chronic Kidney Disease (CKD) is a progressive disease characterized by nephron damage and a decrease in glomerular filtration rate. Decreased kidney function can disrupt fluid and electrolyte homeostasis, including serum sodium levels. This study aimed to analyze the relationship between GFR and serum sodium levels in pre-dialysis CKD patients at RSI Sakinah Mojokerto. This was a quantitative study with a correlational analytical design and a retrospective approach. The population consisted of 215 pre-dialysis CKD patients, with a sample of 80 respondents selected using purposive sampling. GFR data were calculated using the CKD-EPI formula based on creatinine levels, and serum sodium levels were obtained from medical records. Analysis was performed using Spearman's Rho test with $\alpha < 0.05$. The majority of respondents were in Stage 4 of renal function decline, totaling 57 individuals (71.25%). Most experienced hyponatremia, totaling 65 individuals (81.25%), while hyponatremia was found in 5 individuals (6.25%). Spearman's Rho test showed a p-value of 0.022 with a correlation coefficient of $r = 0.255$, indicating a significant association with a weak correlation between GFR and serum sodium levels. Monitoring of LFG and serum sodium levels should be performed routinely to evaluate disease progression, detect electrolyte disturbances early, and help prevent complications in pre-dialysis CKD patients.

Keywords: *Chronic Kidney Disease, Glomerular Filtration Rate, Pre-dialysis, Serum Sodium Levels.*

INTRODUCTION

Chronic kidney disease (CKD) is a progressive structural or functional disorder of the kidneys lasting more than 3 months and characterized by a decline in glomerular filtration rate (GFR) (Rahmawati, 2017). As a serious global health issue, CKD often goes undetected in its early stages due to its minimal clinical manifestations (Sony et al., 2025). Functionally, this significant decline in GFR serves as the primary indicator of the severity of structural damage to the kidneys (Hendrawan et al., 2025). This condition causes the kidneys to lose their ability to adequately regulate electrolyte balance, particularly in excreting sodium. This excretory failure triggers sodium retention and increased osmolarity, which chronically increases the workload on the remaining nephrons through a mechanism of pathological hyperfiltration, thereby creating a cycle of continuous deterioration in kidney function (Rossitto et al., 2021).

According to the WHO (2020), chronic kidney disease affects more than 10% of the world's population, meaning there are 800 million individuals living with this condition (Marni et al., 2023; Marroquin et al., 2022). Data from the Indonesian Health Survey (SKI) show that the prevalence of chronic kidney disease at the national level reaches 0.18% of Indonesia's total population, equivalent to 638,178 people, while in East Java it stands at 0.12%, or approximately 98,738 people (SKI, 2023).

The progression of chronic kidney disease (CKD) is strongly influenced by metabolic risk factors and nutritional intake that trigger an imbalance in serum sodium levels

(Borrelli et al., 2020). Elevated serum sodium levels cause systemic fluid retention, which increases the intravascular volume load and exerts excessive osmotic pressure on the nephrons (Canaud et al., 2022). This mechanism activates the renin-angiotensin-aldosterone system (RAAS), which triggers damage to the capillary endothelium and a pathological increase in intraglomerular pressure (Mallamaci & Tripepi, 2024). In the long term, this condition results in nephron sclerosis, which disrupts the filtration process and leads to the accumulation of serum creatinine (Goodbred & Langan, 2023). The accumulation of these waste products is directly correlated with a decrease in eGFR, indicating impaired waste excretion (Hendrawan et al., 2025). Given that dysnatremia is closely associated with the risk of neurological complications and increased mortality, monitoring serum sodium levels and eLFG values are vital, ongoing variables in determining patient prognosis (Cole et al., 2019).

Monitoring biochemical stability, particularly eGFR values and serum sodium levels, is a crucial step in ensuring the optimal excretion of metabolic waste. Although minimal, residual kidney function remains vital for fluid regulation; therefore, clinical efforts must remain focused on strict fluid and sodium management. Adherence to fluid intake restrictions and a low-sodium diet has been shown to be significant in preventing fluid overload and minimizing Interdialytic Weight Gain (IDWG). Therefore, education regarding a low-sodium diet is a critical foundation for controlling blood pressure, preventing edema-related complications, and maintaining the effectiveness of the treatment regimen. The success of this strategy depends heavily on the patient's sustained, holistic adherence, which includes discipline in pharmacotherapy, fluid restriction, and a low-sodium diet and is supported by psychosocial interventions from family members to improve the patient's quality of life.

METHOD

This study used a quantitative correlational design with a retrospective approach to analyze the relationship between estimated glomerular filtration rate and serum sodium levels in patients with chronic kidney disease who had not yet undergone hemodialysis. This study was conducted at the Medical Records Department of RSI Sakinah Mojokerto, Indonesia. The study population consisted of 215 medical records of pre-dialysis Chronic Kidney Disease patients, of whom 80 respondents were selected as the sample using purposive sampling. Inclusion criteria for this study included: medical records of patients with Chronic Kidney Disease who were initially diagnosed at RSI Sakinah Mojokerto and had complete laboratory data covering serum creatinine levels (used to calculate GFR) and serum sodium levels from the same examination period. Meanwhile, medical records of patients with chronic kidney disease referred from other hospitals, as well as patients with incomplete data, were excluded from the study (exclusion criteria).

Data were collected using a single primary instrument, namely a medical record data collection observation sheet, to record respondent characteristics (gender, age, past medical history), serum creatinine levels, and serum sodium levels. Glomerular Filtration Rate (GFR) values were not measured directly but were calculated mathematically using the international standard formula from the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI). All results of supporting laboratory tests recorded in previous medical records had undergone

testing using standardized clinical equipment with high validity and reliability at the RSI Sakinah Mojokerto laboratory.

Data collection was conducted over a one-month period from April to May 2026 through a retrospective review of patient medical records. Prior to collecting clinical data, the researchers coordinated with the Medical Records Unit at RSI Sakinah Mojokerto after obtaining research approval. Since this study used secondary data from medical records without direct physical interaction with patients, the researchers employed a structured document review method, in which they meticulously recorded each creatinine level parameter for GFR calculation and serum sodium levels directly into an observation sheet. This approach was used to ensure that all clinical parameters were accurately recorded and to minimize missing or incomplete laboratory data.

The collected data were analyzed using IBM SPSS Statistics software, in which descriptive statistics were used to summarize the characteristics of the respondents and the study variables (GFR stage and serum sodium level categories) in the form of frequency distributions and percentages. The relationship between glomerular filtration rate and serum sodium levels was tested using Spearman's Rho nonparametric analysis with a significance level of $p\text{-value} < 0.05$. Ethical approval for this study was obtained from the Health Research Ethics Committee of Bina Sehat PPNI University, No.80/KEP/UBS-PPNI/IV/2026. Permission to conduct this study was obtained from RSI Sakinah Mojokerto.

FINDING AND DISCUSSION

RESEARCH RESULT

UNIVARIATE ANALYSIS

Table 1: Respondent Characteristics (n = 80)

Respondent Characteristics	Frequency (f)	Percentage (%)
Age		
18-19 years old	0	0
20-44 years old	41	51,3
45-59 years old	30	37,5
≥60 years old	9	11,3
Total	80	100
Gender		
Male	34	42,5
Female	46	57,5
Total	80	100
Past Medical History		
Diabetes Mellitus	45	56,25
Hypertension	30	37,5
None	5	6,25
Total	80	100

Source: Secondary Data, 2026

Based on Table 1, the data collected during the study at RSI Sakinah Mojokerto show the following distribution: more than half of the respondents were in the 20–44 age group (51.3% or 41 people), the majority of respondents were women (57.5% or 46 people), and most respondents had a history of diabetes mellitus (56.25% or 45 people).

Distribution of Estimated Glomerular Filtration Rates and Serum Sodium Levels

Table 2: Study Variables

Variable	Frequency (f)	Percentage (%)
Glomerular Filtration Rate		
Stage 1	0	0
Stage 2	0	0
Stage 3	22	27,5
Stage 4	58	72,5
Stage 5	0	0
Total	80	100
Serum Sodium Level		
Normal : 135-145 mmol/L	10	12,5
Low : <135 mmol/L	5	6,25
High : >145 mmol/L	65	81,25
Total	80	100

Source: Secondary Data, 2026

The majority of respondents fell into the stage 4 glomerular filtration rate category, totaling 58 people (72.5%), and the majority of respondents fell into the high serum sodium level category, totaling 65 people (81.25%).

BIVARIATE ANALYSIS

Association Between Estimated Glomerular Filtration Rate and Serum Sodium Levels

Table 3: Association Glomerular Filtration Rate and Serum Sodium Levels

Glomerular Filtration Rate	Serum Sodium Levels						Total		r value Spearman Rho	P value
	Normal		Low		High					
	N	%	N	%	N	%	N	%		
Stage 1	0	0	0	0	0	0	0	0	0,022	0,255
Stage 2	0	0	0	0	0	0	0	0		
Stage 3	4	18	3	14	15	68	22	100		
Stage 4	6	10	2	4	50	86	58	100		
Stage 5	0	0	0	0	0	0	0	0		
Total	10	12,5	5	6,25	65	81,25	80	100		

Source: Secondary Data, 2026

Based on the results of the Spearman's Rho statistical test, a p-value of 0.022 was obtained with $\alpha < 0.05$, indicating that there is a significant association between glomerular filtration rate (GFR) and serum sodium levels in patients with chronic kidney disease who have not yet undergone hemodialysis at RSI Sakinah Mojokerto. The correlation coefficient (r) of 0.255 indicates a weak positive correlation.

DISCUSSION

Estimated Glomerular Filtration Rate

The study results show that the majority of pre-dialysis Chronic Kidney Disease (CKD) patients at RSI Sakinah Mojokerto were in Stage 4, totaling 58 respondents (72.5%), while 22 respondents (27.5%) were in Stage 3 no patients were found in Stages 1, 2, or 5. The predominance of Stage 4 indicates that most patients only seek healthcare services once their kidney function has severely declined (eGFR 15–29 mL/min/1.73 m²). Pathophysiologically, this condition is triggered by progressive nephron damage that reduces the population of functional nephrons. In the early stages of damage, the remaining nephrons undergo adaptive hyperfiltration to maintain renal homeostasis. However, long-term increases in intraglomerular pressure actually trigger glomerulosclerosis, interstitial fibrosis, and tubular atrophy, which accelerate the decline in renal filtration function. Consequently, the kidneys' ability to excrete metabolic waste and maintain fluid and electrolyte homeostasis is severely impaired, indicating that the patient is approaching the stage of end-stage renal failure (Inker, L.A & Titan, 2021).

This GFR estimate is clinically influenced by the respondents' physiological characteristics, one of which is gender. This study was dominated by female patients, totaling 46 respondents (57.5%). Gender differences affect the estimated GFR value because women biologically have lower muscle mass than men, which results in lower daily serum creatinine production. Therefore, the use of the CKD-EPI formula is considered highly appropriate for compensating for this biological bias by incorporating the gender variable, thereby minimizing both underestimation and overestimation of kidney function in women (Inker, L.A & Titan, 2021; Levey et al., 2015). In addition to sex, age also influences changes in GFR values. The majority of participants in this study were in the 20–44 age range (51.3%). Although a decline in GFR is physiologically common with advancing age due to nephron aging, renal blood flow degeneration, and glomerulosclerosis (KDIGO, 2024), the high prevalence of reduced GFR in this working-age group indicates the presence of other pathological factors accelerating the decline beyond the normal aging process.

The decline in eGFR among this working-age population is closely associated with the respondents' medical history, with the majority having a history of diabetes mellitus (56.25%) and hypertension (37.5%). These chronic diseases serve as the primary initiating and progressive factors in kidney damage. Diabetes mellitus induces glomerular microvascular angiopathy, while chronic hypertension triggers afferent arteriolar sclerosis. These two pathological conditions progressively reduce renal perfusion, damage nephron architecture, and result in a sharp decline in glomerular filtration rate (Hall & Hall, 2021; KDIGO, 2024). Consequently, the accumulation of uncontrolled demographic factors and comorbidities accelerates patients' progression to severe kidney failure (Stage 4), even at a younger age.

Kadar Natrium Serum

The majority of non-dialysis CKD patients at RSI Sakinah Mojokerto had high serum sodium levels (hypernatremia, >145 mmol/L), totaling 65 respondents (81.25%). Meanwhile, 10 respondents (12.5%) had normal serum sodium levels (135–145 mmol/L), and only 5 respondents (6.25%) had low serum sodium levels (hyponatremia, <135 mmol/L).

The predominance of hypernatremia in this study population indicates a serious disturbance in the body's fluid and electrolyte regulation, consistent with declining kidney function.

Under normal physiological conditions, the kidneys maintain serum sodium homeostasis through the integrated processes of glomerular filtration, reabsorption, and tubular excretion. However, in patients with CKD, progressive nephron damage reduces the kidneys' capacity to excrete excess sodium, thereby triggering sodium retention in the circulation (Arzhan et al., 2021). In participants with diabetes mellitus as a comorbidity, this hypernatremia is exacerbated by hyperglycemia, which induces osmotic diuresis. Excess glucose in the tubules draws excessive amounts of water into the urine, causing massive loss of free water. This fluid loss, which exceeds the rate of sodium excretion, triggers intracellular dehydration and plasma hemoconcentration, which directly increases serum sodium concentration.

At the same time, the comorbidity of hypertension further exacerbates this retention through chronic activation of the Renin-Angiotensin-Aldosterone System (RAAS). RAAS activation stimulates excessive secretion of the hormone aldosterone, which forces the renal tubules to continue reabsorbing sodium back into the bloodstream, even though glomerular filtration capacity has severely decreased. Consequently, the pathological synergy between mechanical filtration failure, osmotic diuresis due to diabetes, and increased hormonal reabsorption due to hypertension leads the majority of patients to develop significant hypernatremia (Arzhan et al., 2021; Hall & Hall, 2021).

Conversely, the finding of a small proportion of patients with hyponatremia (<135 mmol/L) is closely associated with the phenomenon of translocational hyponatremia resulting from uncontrolled diabetes mellitus. When an extreme spike in plasma glucose (hyperglycemia) occurs, glucose molecules act as active osmotic agents in the intravascular space, drawing water out of the intracellular compartment into the extracellular space to dilute the glucose concentration. This sudden increase in water volume within the blood vessels causes a dilutional effect, resulting in laboratory-detected low serum sodium levels even though the body's total sodium content has not actually decreased (dilutional hyponatremia). This condition is further exacerbated by reduced glomerular filtration rate (GFR) in Stages 3 and 4, which inherently limits the kidneys' functional capacity to excrete this excess free fluid (Hall & Hall, 2021).

Meanwhile, the maintenance of serum sodium levels within the normal range in some participants reflects a more stable clinical condition, influenced by controlled glycemia and renal compensatory mechanisms that remain effective. Normal sodium levels in CKD patients with diabetes indicate good treatment adherence, thereby keeping daily blood glucose levels stable and preventing transcellular fluid shifts. Furthermore, the sensitivity of ADH and aldosterone in regulating sodium reabsorption in the tubules is assumed to remain optimal, supported by the remaining functional nephrons that perform compensatory hyperfiltration to maintain electrolyte stability. Thus, fluctuations in serum sodium levels in pre-dialysis CKD patients at the study site are not determined solely by a decline in glomerular mechanical function but result from a dynamic interaction with the patients' blood glucose metabolic status (Arzhan et al., 2021).

Association Between Estimated Glomerular Filtration Rate and Serum Sodium Levels

Based on the results of the Spearman's Rho correlation test on 80 respondents, a p-value of 0.022 ($p < 0.05$) was obtained, with a correlation coefficient (r) of 0.255. These results indicate that there is a significant association between glomerular filtration rate (GFR) and serum sodium levels in non-dialysis patients with chronic kidney disease (CKD) at RSI Sakinah Mojokerto, with a weak strength of association and a positive correlation. The cross-tabulation results show that the majority of respondents in Stage 4 had hypernatremia, namely 50 out of 58 respondents (86%), while hyponatremia was found in a small proportion of respondents, namely 3 respondents (14%) in Stage 3 and 2 respondents (4%) in Stage 4.

Theoretically, the kidneys play a major role in maintaining sodium homeostasis through glomerular filtration, tubular reabsorption, and sodium excretion according to the body's needs. A decrease in GFR due to a reduction in the number of functional nephrons impairs the kidneys' ability to maintain fluid and electrolyte balance, thereby increasing the risk of dysnatremia. Progressive nephron damage also limits the kidneys' adaptive mechanisms, preventing optimal sodium regulation. However, serum sodium levels are influenced not only by kidney function but also by various other factors such as hydration status, sodium intake, hormonal activity, medication use, and the body's compensatory mechanisms. Therefore, the relationship between GFR and serum sodium levels in patients with CKD is generally not strong because it is influenced by many interacting factors (Hall & Hall, 2021).

Then, adequate infrastructure also supports the success of online learning implementation. Based on the result, it was found that the students agreed to the implementation of online learning due to its accessibility which is easy to do anywhere and supported by adequate equipment (laptop, gadget, internet connection, etc.). These findings are in line with the findings of Elyas (2018) revealed that online learning can be accessed from anywhere that has access to the internet. The last positive perception came from learning activity. Based on the questionnaire result, the majority of students have been able to organize themselves to be more independent and disciplined. This is proved by they do assignments independently and are on time during online learning. These findings similar to Kusuma (2020) revealed that the implementation of online learning had an impact on the independence of student learning in Geometry courses during distance learning. However, the result showed that online learning also made some students give negative perceptions such as some students agreeing that the lecturer gives a lot of assignments. This finding in line with findings from Maqbulin (2021) revealed that one of the students' problems in the process of online learning during the pandemic was many tasks that students had to finish. A study from Cahyawati and Gunarto (2020) also found that students argued that their workload is more than during face-to-face learning.

Next, the management of learning by lectures. The result showed that students agreed that the delivery of material is done directly during the meeting rather than just sending some links. This is shown that implementation of online learning will run better if there is direct interaction between lecture and students. The similar finding from Sun, et.al. (2022) the findings demonstrated that interaction between educators and students not only have a beneficial effect on learning outcomes, but also have an impact on learning outcomes through the mediating effects of psychological environment and learning engagement. Then, the result also showed that some students also experienced slight problems with internet

network connectivity. The similar findings from Adnan (2020) revealed that internet connectivity, financial, and the lack of interaction with teachers were some problems faced by students' in online learning.

CONCLUSION

Based on the results of a study conducted on 80 patients with chronic kidney disease who had not yet undergone hemodialysis at RSI Sakinah Mojokerto, it can be concluded that there is a statistically significant positive correlation between glomerular filtration rate and serum sodium levels. The Spearman's Rho test results indicate that changes in GFR are accompanied by changes in serum sodium levels in the same direction, with the strength of the relationship between the variables classified as weak but significant ($r = 0.255$; $p = 0.022$). These findings indicate that declining kidney function in patients with CKD, particularly in stage 4, is associated with an increased risk of sodium imbalance, as indicated by elevated serum sodium levels. Therefore, routine monitoring of glomerular filtration rate and serum sodium levels is crucial to help manage fluid and electrolyte balance and slow the progression of CKD toward end-stage renal disease.

For future researchers, it is recommended to consider other factors that may influence serum sodium levels, such as the use of diuretic medications, lifestyle, salt intake, and the patient's hydration status. Additionally, studies with larger sample sizes and longitudinal designs are needed to analyze the relationship between glomerular filtration rate and serum sodium levels in patients with chronic kidney disease more thoroughly and accurately.

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