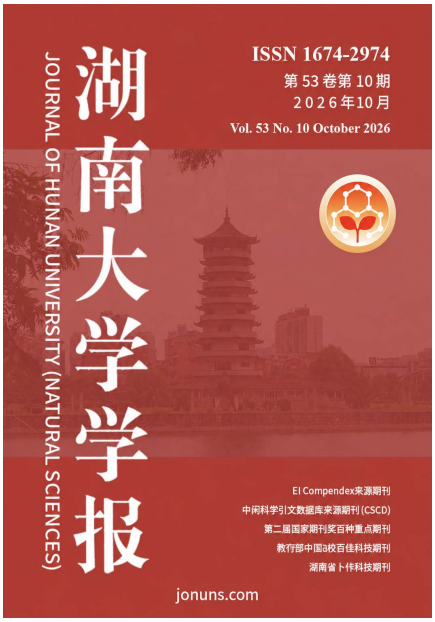


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# Association Between Serum Albumin Levels and Mortality in Patients with Chronic Kidney Disease Undergoing Dialysis: A Retrospective Cohort Study

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**Abstract:** Chronic kidney disease (CKD) is associated with increased mortality, particularly among patients requiring dialysis. Serum albumin reflects nutritional status, systemic inflammation, and physiological reserve and may serve as a marker of adverse clinical outcomes. This study evaluated the association between serum albumin levels and recorded mortality among patients with CKD undergoing peritoneal dialysis or hemodialysis. A retrospective observational study included 124 eligible patients treated at Gatot Soebroto Army Central Hospital, Jakarta, Indonesia, between January 2023 and December 2024. Demographic, clinical, anthropometric, and laboratory data were obtained from medical records. Statistical analyses included group comparisons, categorical association tests, and receiver operating characteristic (ROC) curve analysis. Recorded mortality was 21.8% (27/124). Mean serum albumin levels were significantly lower among deceased patients than among survivors (2.86 ± 0.63 vs. 3.37 ± 0.69 g/dL; $p < 0.001$). Hypoalbuminemia was associated with higher unadjusted odds of mortality (crude OR = 3.03; 95% CI: 1.12–

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8.16; Yates-corrected p = 0.042). Similar associations were observed in both the peritoneal dialysis group (2.89 ± 0.71 vs. 3.45 ± 0.71 g/dL; p = 0.020) and the hemodialysis group (2.84 ± 0.59 vs. 3.29 ± 0.67 g/dL; p = 0.022). ROC analysis yielded an area under the curve (AUC) of 0.712 (95% CI: 0.605–0.820). An exploratory, sample-derived cut-off of 3.15 g/dL provided 70.4% sensitivity and 66.0% specificity for discriminating recorded mortality status, with lower albumin levels associated with mortality. Overall, lower serum albumin levels were associated with recorded mortality in unadjusted analyses. These findings suggest that serum albumin may be a useful marker of adverse clinical outcomes in dialysis patients; however, its independent prognostic value and the proposed cut-off require further validation before clinical application.

**Keywords :** chronic kidney disease; dialysis; serum albumin; hypoalbuminemia; mortality.

# 接受透析治疗的慢性肾脏病患者血清白蛋白水平与死亡风险的关联：一项回顾性队列研究

**摘要：**慢性肾脏病（CKD）与死亡风险增加密切相关，尤其是在需要接受透析治疗的患者中。血清白蛋白水平可反映患者的营养状况、全身性炎症反应及生理储备能力，并可能作为评估不良临床结局的指标。本研究旨在评估接受腹膜透析或血液透析治疗的慢性肾脏病患者血清白蛋白水平与病历记录的死亡结局之间的关联。本研究采用回顾性观察性研究设计，纳入 2023 年 1 月至 2024 年 12 月期间在印度尼西亚雅加达 Gatot Soebroto 陆军中央医院接受治疗的 124 名符合纳入标准的患者。通过查阅病历收集人口学、临床、人体测量学及实验室检查数据。统计分析包括组间比较、分类变量关联检验和受试者工作特征（ROC）曲线分析。研究样本中记录的死亡比例为 21.8%（27/124）。死亡患者的平均血清白蛋白水平显著低于存活患者（2.86 ± 0.63 vs. 3.37 ± 0.69 g/dL；p < 0.001）。低白蛋白血症与较高的未经调整的死亡比值比相关（粗比值比 OR = 3.03；95%置信区间：1.12–8.16；经 Yates 连续性校正的 p = 0.042）。腹膜透析组（2.89 ± 0.71 vs. 3.45 ± 0.71 g/dL；p = 0.020）和血液透析组（2.84 ± 0.59 vs. 3.29 ± 0.67 g/dL；p = 0.022）均观察到类似关联。ROC 曲线分析显示，曲线下面积（AUC）为 0.712（95%置信区间：0.605–0.820）。基于本研究样本探索性确定的血清白蛋白临界值为 3.15 g/dL，以低于该临界值作为区分病历记录中死亡状态的判定标准时，敏感度为 70.4%，特异度为 66.0%，较低的白蛋白水平与死亡结局相关。总体而言，未经混杂因素调整的分析表明，较低的血清白蛋白水平与病历记录的死亡结局存在关联。研究结果提示，血清白蛋白可能是评估透析患者不良临床结局的有用指标；然而，其独立预后预测价值及所提出的临界值仍需进一步验证，方可应用于临床实践。

**关键词：**慢性肾脏病；透析；血清白蛋白；低白蛋白血症；死亡率。

## 1. Introduction

Chronic kidney disease (CKD) is a major and growing global public health challenge. Over the past three decades, the prevalence and incidence of CKD have increased by approximately 40%, largely because of population growth and aging [1]. CKD is characterized by structural or functional abnormalities of the kidneys that persist for at least three months and are associated with adverse health outcomes [2]. According to the KidneyDisease: Improving Global Outcomes (KDIGO) guidelines, CKD is diagnosed when the estimated glomerular filtration rate is below 60 mL/min/1.73 m² or when markers of kidney damage, such as an albumin-to-creatinine ratio of ≥30 mg/g, persist for at least three months [2].

Globally, CKD affected approximately 9.1% of the population in 2017, although its prevalence varies considerably across regions [3]. In Indonesia, national data

showed that the prevalence of CKD increased from 2.0‰ in 2013 to 3.8‰ in 2018 [4]. However, these estimates may not fully reflect the actual disease burden because access to screening and early detection remains limited [3]. The growing impact of CKD is also reflected in the Global Burden of Disease study, in which CKD rose from the 29th leading cause of disability-adjusted life years in 1990 to the 18th in 2019 [5].

As CKD progresses to end-stage kidney disease, kidney replacement therapy, including dialysis or kidney transplantation, may be required to sustain life. Among kidney replacement therapies, hemodialysis and peritoneal dialysis are the two principal dialysis modalities. Their utilization varies according to healthcare systems, clinical considerations, treatment availability, and patient characteristics [6]. Despite advances in dialysis technology and clinical management, mortality among patients receiving dialysis remains high. Previous studies have shown that survival outcomes are influenced by the timing of dialysis initiation, baseline clinical status, and comorbidity burden [7,8]. A higher estimated glomerular filtration rate at dialysis initiation has paradoxically been associated with increased mortality in some populations, possibly because patients who initiate dialysis earlier may have poorer overall health or a greater burden of comorbid disease [7]. Comorbidities also contribute substantially to cardiovascular complications and mortality before and after dialysis initiation [8].

Among the prognostic markers evaluated in dialysis populations, serum albumin has been consistently associated with clinical outcomes and mortality. Albumin is the major circulating plasma protein and plays important roles in maintaining colloid osmotic pressure and transporting endogenous and exogenous substances [9]. Reduced serum albumin levels, or hypoalbuminemia, are commonly observed among hospitalized and critically ill patients and have been associated with adverse outcomes in conditions such as septic shock, heart failure, and acute coronary syndrome [10–13].

In patients with CKD, hypoalbuminemia may reflect a combination of inadequate nutritional intake, systemic inflammation, increased protein catabolism, fluid overload, and metabolic disturbances [14–16]. Malnutrition is a major complication of CKD and is associated with increased susceptibility to infection, prolonged hospitalization, disease progression, and mortality [17,18]. Patients receiving dialysis are particularly vulnerable to nutritional impairment because of dietary restrictions, metabolic alterations, chronic inflammation, nutrient loss during dialysis, and increased catabolic activity [8,19]. Therefore, serum albumin may serve not only as an indicator of nutritional status but also as an integrated marker of systemic inflammation and physiological vulnerability.

Although numerous studies have demonstrated an association between hypoalbuminemia and mortality among dialysis patients, many have been conducted outside Indonesia or have focused on a single dialysis modality. Evidence directly comparing the association between serum albumin and mortality in patients undergoing hemodialysis and peritoneal dialysis within the same Indonesian clinical setting remains limited. Evaluating both modalities may provide a more comprehensive understanding of the clinical value of serum albumin for mortality risk stratification.

Therefore, this study aimed to evaluate the association between serum albumin levels and mortality among patients with CKD undergoing hemodialysis or peritoneal dialysis, both overall and according to dialysis modality. The study also assessed the discriminatory performance of serum albumin for mortality risk stratification.

## 2. Materials and Methods

### 2.1. Study Design

This retrospective observational study used medical record data from 124 patients with chronic kidney disease undergoing hemodialysis or peritoneal dialysis at Gatot Soebroto Army Central Hospital, Jakarta, Indonesia, between January 2023 and December 2024. Demographic, clinical, anthropometric, laboratory, dialysis-related, and recorded mortality data were extracted. The analysis evaluated documented mortality status in the available records rather than mortality over a uniform follow-up interval. Individual cohort-entry dates, dates of death, and complete observation times were not available in the extracted dataset; time-to-event analyses were therefore not performed.

### 2.2. Study Population, Sampling Technique, and Sample Size

All eligible patients identified in the hospital records during the study period were included using total sampling. The final sample comprised 124 patients, including 62 receiving hemodialysis and 62 receiving peritoneal dialysis.

No a priori sample-size calculation is documented in the supplied study materials. The previously reported minimum sample of 98 and unsupported calculation assumptions have therefore been removed.

### 2.3. Inclusion and Exclusion Criteria

The inclusion criteria were: (1) patients diagnosed with chronic kidney disease; (2) patients undergoing maintenance hemodialysis or peritoneal dialysis at Gatot Soebroto Army Central Hospital, Jakarta, Indonesia; and (3) patients receiving dialysis treatment between January 2023 and December 2024.

Records lacking the variables required for a given analysis were not eligible for that analysis. All 124 records in the supplied analysis dataset contained serum albumin measurements. Mortality coding and the handling of duplicate records should be reconciled with the source hospital records.

### 2.4. Operational Definitions of Comorbidities and

**Albumin Status**

Pre-existing comorbidities were identified from physician-documented diagnoses recorded in the patients' medical records before or at the predefined index date. Comorbidity categories were not mutually exclusive, and each patient could have more than one condition.

**Malnutrition** was defined as a documented diagnosis made by the treating physician or clinical nutrition specialist based on the nutritional assessment recorded in the medical record.

**Diabetes mellitus** was defined as a documented physician diagnosis of type 1 or type 2 diabetes mellitus and/or the use of glucose-lowering medication.

**Anemia** was defined as a documented physician diagnosis based on the patient's laboratory findings and clinical assessment recorded in the medical record.

**Hypertension** was defined as a documented physician diagnosis of hypertension and/or the use of antihypertensive medication.

**Cardiac disease** comprised recorded diagnoses of infective endocarditis or hypertensive heart disease in the supplied dataset.

**Atherosclerotic cardiovascular disease** was defined as a documented history of coronary artery disease, myocardial infarction, or peripheral arterial disease.

**Stroke** was defined as a documented previous diagnosis of ischemic or hemorrhagic stroke.

**Cancer** was defined as any physician-diagnosed malignant neoplasm documented in the medical record.

**History of pulmonary tuberculosis** was defined as a documented diagnosis of active or previous pulmonary tuberculosis based on clinical, microbiological, radiological, or physician-recorded findings.

**Hypoalbuminemia** was defined as serum albumin <3.5 g/dL; non-hypoalbuminemia was defined as serum albumin ≥3.5 g/dL. The available serum albumin value for each patient in the extracted dataset was analyzed. The timing of measurement relative to the clinical index event was not documented in that dataset.

### 2.5. Study Variables

The primary outcome was recorded mortality status, categorized as deceased or survivor according to the study dataset coding. The primary exposure was serum albumin, analyzed continuously in g/dL and categorically using a threshold of 3.5 g/dL.

Clinical variables included dialysis modality, recorded as peritoneal or vascular dialysis in the source dataset and analyzed as peritoneal dialysis or hemodialysis, respectively, and recorded duration of dialysis therapy in months. Entries recorded in years were converted to months; six years was converted to 72 months. This variable was not length of hospital stay.

Anthropometric variables included body weight in kilograms, height in centimeters, and BMI in kg/m². BMI was calculated as weight divided by height in meters squared. Underweight was defined as BMI <18.5 kg/m² and obesity as BMI ≥25 kg/m² according to the Asia-Pacific classification [30].

Comorbidities included malnutrition, diabetes mellitus, anemia, hypertension, cardiac disease, atherosclerotic cardiovascular disease, stroke, cancer, and pulmonary tuberculosis. Pre-existing comorbidities were identified from physician-documented diagnoses recorded in the patients' medical records before or at the index date. Each patient could have more than one comorbid condition.

### 2.6. Statistical Analysis

The original analyses were conducted using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). The crude albumin association and ROC estimates were subsequently recalculated from the supplied 124-record dataset using Python. The distribution of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots. Normally distributed continuous variables were presented as mean ± standard deviation and compared between deceased and surviving patients using the independent-samples t-test. Equality of variances was assessed using Levene's test; when this assumption was not met, Welch's t-test was applied. Non-normally distributed variables were presented as median (minimum–maximum) and compared using the Mann–Whitney U test.

Categorical variables were summarized as frequencies and percentages. Hypoalbuminemia and mortality were cross-tabulated directly from the dataset. The crude odds ratio was calculated from the 2 × 2 table, with a log-Wald 95% confidence interval. The corresponding p value was obtained using the chi-square test with Yates continuity correction.

Associations were evaluated using unadjusted analyses. No multivariable logistic regression was performed; adjusted odds ratios were not estimated.

ROC analysis evaluated the ability of lower serum albumin to discriminate between recorded deceased patients and survivors. The empirical AUC was calculated with half credit for tied albumin values. Its 95% confidence interval was estimated using the nonparametric DeLong variance and a normal approximation. The exploratory cut-off was selected by maximizing the Youden index. Discrimination and cut-off selection were evaluated in the same sample without internal or external validation.

The albumin analysis used all 124 available albumin values. No albumin values were imputed. Mortality coding followed the supplied analysis convention, which classified 27 records as deceased and the other 97 as survivors. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

### 2.7. Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical

approval was obtained from the Medical and Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Krida Wacana Christian University (UKRIDA), Jakarta, Indonesia (Approval No. 1998/SLKE/IM/UKKW/FKIK/KEPK/VII/2025). The requirement for individual informed consent was waived because of the retrospective study design and the use of existing medical record data. All patient information was de-identified before analysis, and confidentiality was maintained throughout the study. The study involved no direct contact with patients and did not influence their clinical management.

## 3. Results

A total of 124 patients were included in the study. The mean age was 54.35 ± 11.58 years. Equal numbers of patients underwent peritoneal dialysis and hemodialysis, with 62 patients (50.0%) in each group. During the observation period, 27 patients (21.8%) died, whereas 97 patients (78.2%) remained alive.

**Table 1. Baseline Demographic and Clinical Characteristics and Mortality Outcomes of the Study Population**

| Parameter | Value |
|---|---|
| Age (years) | 54.35 ± 11.58 |
| Male | 55 (44.4) |
| Female | 69 (55.6) |
| Peritoneal dialysis | 62 (50.0) |
| Hemodialysis | 62 (50.0) |
| Duration of dialysis therapy (months) | 14 (5–72) |
| Serum albumin (g/dL) | 3.30 (1.30–4.60) |
| Hypoalbuminemia | 73 (58.9) |
| Non-hypoalbuminemia | 51 (41.1) |
| Body weight (kg) | 60.0 (41.5–90.0) |
| Body height (cm) | 160 (145–176) |
| Body mass index (kg/m²) | 23.72 (16.62–35.25) |
| Underweight | 5 (4.0) |
| Obesity | 38 (30.6) |
| Malnutrition | 43 (34.7) |
| Diabetes mellitus | 17 (13.7) |
| Anemia | 26 (21.0) |
| Hypertension | 32 (25.8) |
| Cardiac disease | 2 (1.6) |
| Atherosclerotic cardiovascular disease | 35 (28.2) |
| Stroke | 1 (0.8) |
| Cancer | 1 (0.8) |
| History of pulmonary tuberculosis | 1 (0.8) |
| Alive | 97 (78.2) |
| Deceased | 27 (21.8) |

*Data are presented as mean ± standard deviation, median (minimum–maximum), or number (percentage), as appropriate.*

† *Comorbidity categories were not mutually exclusive; each patient could have more than one comorbid condition.*

ROC analysis yielded an AUC of 0.712 (95% CI, 0.605–0.820). An exploratory, sample-derived cut-off of 3.15 g/dL, with lower values indicating mortality, yielded 70.4% sensitivity and 66.0% specificity.

Table 2 summarizes recorded mortality within selected clinical categories by dialysis modality. Among patients with hypoalbuminemia, 21 of 73 died and 52 survived; among those without hypoalbuminemia, 6 of 51 died and 45 survived. Hypoalbuminemia was associated with higher unadjusted odds of recorded mortality (crude OR, 3.03; 95% CI, 1.12–8.16; Yates-corrected p = 0.042). Other conditions are presented descriptively because several categories contained few patients.

Serum albumin showed moderate discrimination between deceased patients and survivors in this sample. ROC analysis yielded an AUC of 0.712 (95% CI, 0.605–0.820). An exploratory, sample-derived cut-off of 3.15 g/dL, with lower values indicating mortality, yielded 70.4% sensitivity and 66.0% specificity. The threshold and its performance have not been independently validated.

Values in Table 2 are deaths/number of patients with the condition (%). Percentages use condition-specific denominators within each dialysis group. A dash indicates that a percentage is undefined because the denominator is zero. Hypoalbuminemia showed a crude OR of 3.03 (95% CI, 1.12–8.16; Yates-corrected p = 0.042).

**Table 2. Mortality Among Patients with Selected Clinical Conditions, Stratified by Dialysis Modality**

| Clinical condition | Peritoneal dialysis, n/N (%) | Hemodialysis, n/N (%) | Overall, n/N (%) |
|---|---|---|---|
| Hypoalbuminemia | 8/34 (23.5) | 13/39 (33.3) | 21/73 (28.8) |
| Underweight | 0/1 (0.0) | 1/4 (25.0) | 1/5 (20.0) |
| Obesity | 1/16 (6.3) | 5/22 (22.7) | 6/38 (15.8) |
| Malnutrition | 1/17 (5.9) | 6/26 (23.1) | 7/43 (16.3) |
| Diabetes mellitus | 0/6 (0.0) | 3/11 (27.3) | 3/17 (17.6) |
| Anemia | 1/11 (9.1) | 4/15 (26.7) | 5/26 (19.2) |
| Hypertension | 3/13 (23.1) | 6/19 (31.6) | 9/32 (28.1) |
| Cardiac disease | 0/0 | 1/2 (50.0) | 1/2 (50.0) |
| Atherosclerotic cardiovascular disease | 3/13 (23.1) | 8/22 (36.4) | 11/35 (31.4) |
| Cancer | 0/0 | 1/1 (100.0) | 1/1 (100.0) |
| Stroke | 0/0 | 1/1 (100.0) | 1/1 (100.0) |
| History of pulmonary tuberculosis | 0/0 | 1/1 (100.0) | 1/1 (100.0) |

**Table 3. Comparison of Clinical and Anthropometric Parameters Between Deceased Patients and Survivors in the Overall Dialysis Cohort**

| Parameter | Deceased | Survivors | 95% CI of the Mean Difference | *p* value |
|---|---|---|---|---|
| Age (years) | 57.85 ± 9.21 | 53.38 ± 12.02 | −0.47 to 9.42 | 0.076 |
| Duration of therapy (months) | 13 (7–29) | 14 (5–72) | — | 0.597 |
| Serum albumin (g/dL) | 2.86 ± 0.63 | 3.37 ± 0.69 | −0.80 to −0.21 | <0.001 |
| Body weight (kg) | 59.87 ± 10.05 | 61.70 ± 10.53 | −6.32 to 2.66 | 0.412 |
| Body height (cm) | 160 (150–171) | 160 (145–176) | — | 0.740 |
| BMI (kg/m²) | 23.15 ± 3.32 | 23.94 ± 3.58 | −2.30 to 0.73 | 0.304 |

Data are presented as mean ± standard deviation for normally distributed variables and median (minimum–maximum) for non-normally distributed variables. The 95% confidence intervals represent the mean difference calculated as deceased patients minus survivors. Age, serum albumin, body weight, and BMI were compared using the independent-samples t-test, whereas duration of dialysis therapy and body height were compared using the Mann–Whitney U test. A two-sided p value <0.05 was considered statistically significant.

Serum albumin levels were significantly lower in deceased patients than in survivors (2.86 ± 0.63 versus 3.37 ± 0.69 g/dL; mean difference, −0.51 g/dL; 95% CI, −0.80 to −0.21; p <0.001). No statistically significant differences were observed between the groups in age, duration of dialysis therapy, body weight, body height, or BMI.

**Table 4. Comparison of Clinical and Anthropometric Parameters Between Deceased and Surviving Patients Stratified by Dialysis Modality**

| Parameter | PD, deceased (n = 11) | PD, survivors (n = 51) | PD *p* value | HD, deceased (n = 16) | HD, survivors (n = 46) | HD *p* value |
|---|---|---|---|---|---|---|
| Age (years) | 53.73 ± 7.12 | 52.18 ± 11.75 | 0.676 | 60.69 ± 9.56 | 54.72 ± 12.31 | 0.083 |
| Duration of therapy (months) | 13 (7–14) | 13 (5–72) | 0.522 | 15.5 (7–29) | 15.5 (11–32) | 0.716 |
| Serum albumin (g/dL) | 2.89 ± 0.71 | 3.45 ± 0.71 | 0.020 | 2.84 ± 0.59 | 3.29 ± 0.67 | 0.022 |

| Parameter | PD, deceased (n = 11) | PD, survivors (n = 51) | PD *p* value | HD, deceased (n = 16) | HD, survivors (n = 46) | HD *p* value |
|---|---|---|---|---|---|---|
| Body weight (kg) | 56.27 ± 10.77 | 61.06 ± 10.43 | 0.175 | 62.34 ± 9.03 | 62.41 ± 10.72 | 0.982 |
| Body height (cm) | 161.00 ± 5.85 | 161.22 ± 7.11 | 0.926 | 160 (150–171) | 160 (150–176) | 0.627 |
| BMI (kg/m²) | 20.89 (18.73–28.34) | 23.24 (17.63–30.08) | 0.040 | 24.25 ± 3.26 | 24.56 ± 4.12 | 0.786 |

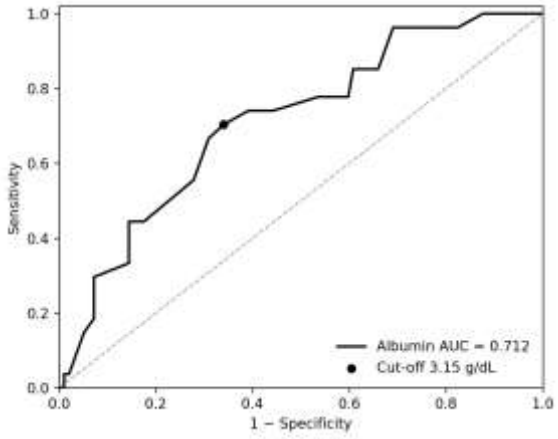


Figure 1. Recalculated receiver operating characteristic curve of serum albumin for discrimination of recorded mortality status in the overall cohort (n = 124). AUC, 0.712 (95% CI, 0.605–0.820; DeLong method). The exploratory cut-off of 3.15 g/dL yielded 70.4% sensitivity and 66.0% specificity; lower albumin values indicated mortality. The curve and threshold were derived and evaluated in the same sample without validation.

**Table 4. Comparison of Clinical and Anthropometric Parameters Between Deceased and Surviving Patients Stratified by Dialysis Modality**

| Parameter | PD, deceased (n = 11) | PD, survivors (n = 51) | PD *p* value | HD, deceased (n = 16) | HD, survivors (n = 46) | HD *p* value |
|---|---|---|---|---|---|---|
| Age (years) | 53.73 ± 7.12 | 52.18 ± 11.75 | 0.676 | 60.69 ± 9.56 | 54.72 ± 12.31 | 0.083 |
| Duration of therapy (months) | 13 (7–14) | 13 (5–72) | 0.522 | 15.5 (7–29) | 15.5 (11–32) | 0.716 |
| Serum albumin (g/dL) | 2.89 ± 0.71 | 3.45 ± 0.71 | 0.020 | 2.84 ± 0.59 | 3.29 ± 0.67 | 0.022 |
| Body weight (kg) | 56.27 ± 10.77 | 61.06 ± 10.43 | 0.175 | 62.34 ± 9.03 | 62.41 ± 10.72 | 0.982 |
| Body height (cm) | 161.00 ± 5.85 | 161.22 ± 7.11 | 0.926 | 160 (150–171) | 160 (150–176) | 0.627 |
| BMI (kg/m²) | 20.89 (18.73–28.34) | 23.24 (17.63–30.08) | 0.040 | 24.25 ± 3.26 | 24.56 ± 4.12 | 0.786 |

Data are presented as mean ± standard deviation for normally distributed variables and median (minimum–maximum) for non-normally distributed variables. Comparisons between deceased patients and survivors within each dialysis modality were performed using the independent-samples t-test or Mann–Whitney U test, as appropriate. A two-sided p value <0.05 was considered statistically significant. BMI, body mass index; HD, hemodialysis; PD, peritoneal dialysis.

When the analysis was stratified by dialysis modality, serum albumin levels were significantly lower among deceased patients than among survivors in both the PD group (2.89 ± 0.71 versus 3.45 ± 0.71 g/dL; p = 0.020) and the HD group (2.84 ± 0.59 versus 3.29 ± 0.67 g/dL; p = 0.022). In the PD group, BMI was also significantly lower among deceased patients than among survivors (p = 0.040). No statistically significant differences were observed for the remaining clinical and anthropometric parameters in either dialysis modality.

Further comparative analyses were conducted to examine differences in clinical and anthropometric parameters according to survival status. In the overall dialysis cohort, serum albumin levels were significantly lower among deceased patients than among survivors, whereas age, duration of dialysis therapy, body weight, body height, and BMI did not differ significantly between the groups (Table 3).

After stratification by dialysis modality, serum albumin levels remained significantly lower among deceased patients in both the PD and HD groups. BMI was significantly lower among deceased patients only in the PD group, whereas no significant differences were identified for the other evaluated parameters (Table 4).

The recalculated serum albumin ROC curve is presented in Figure 1. ROC analysis yielded an AUC of

0.712 (95% CI, 0.605–0.820). An exploratory, sample-derived cut-off of 3.15 g/dL, with lower values indicating mortality, yielded 70.4% sensitivity and 66.0% specificity.

## 4. Discussion

In the present study, several baseline clinical and anthropometric variables, including age, duration of dialysis therapy, body weight, body height, and body mass index (BMI), were not significantly different between deceased patients and survivors in the overall dialysis cohort. Although deceased patients were older than survivors, the difference did not reach statistical significance. This finding differs from previous studies reporting a stronger association between older age and mortality among dialysis patients, particularly in elderly hemodialysis populations [20–22]. The absence of a statistically significant association in our study may be related to the relatively modest sample size, limited age distribution, and inclusion of patients undergoing two different dialysis modalities.

Recorded dialysis duration was expressed in months, not hospital-stay days, and did not differ significantly between deceased patients and survivors. BMI also did not differ significantly in the overall cohort. Previous studies have discussed dialysis initiation strategies and the association of nutritional status with mortality [23,24]. In the peritoneal dialysis subgroup, BMI was lower among deceased patients ($p = 0.040$). This result should be considered exploratory because multiple subgroup comparisons were performed and chance findings are possible.

The reported comorbidity table included malnutrition in 43 patients (34.7%), atherosclerotic cardiovascular disease in 35 (28.2%), hypertension in 32 (25.8%), and diabetes mellitus in 17 (13.7%). Stroke was recorded in only one patient (0.8%) and was not a frequent condition. Comorbidity categories were not mutually exclusive.

The principal finding of this study was the consistent association between lower serum albumin levels and mortality across dialysis modalities. Deceased patients had significantly lower serum albumin levels than survivors in the overall cohort and in both the peritoneal dialysis and hemodialysis groups. Hypoalbuminemia was associated with 3.03-fold higher odds of mortality. These findings are consistent with previous studies demonstrating an association between lower serum albumin levels and increased mortality among patients undergoing hemodialysis or peritoneal dialysis [22,25–27]. The consistency of this association across modalities suggests that serum albumin may be a useful cross-modality marker of adverse clinical outcomes in dialysis patients.

The association between serum albumin and mortality is biologically plausible because serum albumin reflects several interrelated processes, including nutritional status, systemic inflammation, protein losses, and physiological reserve. In patients with chronic kidney disease, chronic inflammation may suppress hepatic albumin synthesis while increasing protein catabolism and vascular permeability [9,14–16]. Persistent uremic inflammation, characterized by increased concentrations of inflammatory mediators such as interleukin-6, tumor necrosis factor-α, and interleukin-1, may further contribute to hypoalbuminemia and adverse cardiovascular outcomes [15,16,28]. Therefore, low serum albumin should not be interpreted solely as a marker of inadequate nutritional intake but rather as an integrated indicator of nutritional and inflammatory disturbances.

Serum albumin discriminated between deceased patients and survivors with a recalculated AUC of 0.712 (95% CI, 0.605–0.820) in the overall cohort. The exploratory, sample-derived cut-off of 3.15 g/dL yielded 70.4% sensitivity and 66.0% specificity. These findings describe discrimination within the present sample and do not establish validated prognostic prediction. Threshold selection and performance assessment used the same dataset, so the apparent performance may be optimistic. Independent validation is required before clinical application. Previous studies have also examined albumin and mortality in dialysis populations [20,27,29].

This study has several strengths. First, it included patients undergoing both peritoneal dialysis and hemodialysis, allowing the association between serum albumin and mortality to be evaluated across dialysis modalities. Second, the study combined group comparisons, measures of association, and ROC analysis to provide complementary assessments of the relationship between serum albumin and mortality status.

Several limitations should be acknowledged. This retrospective single-center study evaluated recorded mortality status without a uniform follow-up interval. Individual index dates, death dates, and complete observation times were unavailable in the extracted dataset; the analyses therefore did not account for unequal observation time. No multivariable adjustment was performed, and residual confounding by age, dialysis modality, comorbidities, and other factors cannot be excluded. Only 11 deaths occurred in the peritoneal dialysis group and 16 in the hemodialysis group, limiting precision; modality-specific analyses are exploratory and do not demonstrate effect modification without a formal interaction test. The small number of events also limits the complexity of adjusted models. C-reactive protein, dialysis adequacy, residual kidney function, vascular access, and formal nutritional assessments were incompletely characterized. Albumin was measured once. ROC discrimination and threshold performance were estimated in the same sample without validation. Mortality coding and the provenance of some comorbidity categories require reconciliation with the original records.

Lower serum albumin was associated with documented mortality status in this cohort. These findings support further investigation of serum albumin as an

accessible marker of adverse outcomes, while the independent prognostic value and clinical utility remain unestablished.

## 5. Conclusion

Lower serum albumin levels were associated with recorded mortality in unadjusted analyses of patients receiving hemodialysis or peritoneal dialysis. Hypoalbuminemia was associated with higher crude odds of mortality (OR, 3.03; 95% CI, 1.12–8.16). Serum albumin showed moderate sample discrimination (AUC, 0.712; 95% CI, 0.605–0.820). The 3.15 g/dL threshold is exploratory and requires independent validation. Studies with clearly defined observation times, adjustment for confounders, and validated outcome coding are needed before prognostic or clinical recommendations can be made.

## Declarations

***Author Contributions***

Conceptualization: Ronald Winardi Kartika, Stepani Haringka Pitri, Yohanes Firmansyah, and Tena Djuartina; methodology: Stepani Haringka Pitri and Yohanes Firmansyah; data collection: Stepani Haringka Pitri and Yohanes Firmansyah; formal analysis: Ronald Winardi Kartika and Stepani Haringka Pitri; interpretation of results: all authors; writing original draft preparation: Tena Djuartina; writing review and editing: all authors. All authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

***Data Availability Statement***

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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***Institutional Review Board Statement***

This retrospective study was conducted using data obtained from medical records. Ethical approval was granted by the Medical and Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Krida Wacana Christian University (UKRIDA) (Approval No. 1998/SLKE/IM/UKKW/FKIK/KEPK/VII/2025). The requirement for informed consent was waived by the ethics committee because of the retrospective study design and the use of anonymized data.

***Conflicts of Interest***

The authors declare that they have no conflicts of interest.

***Clinical Trial Statement***

Not applicable. This was a retrospective observational study and did not involve any interventional procedures; therefore, clinical trial registration was not required.

***Consent for Publication***

Not applicable. All data were anonymized, and no identifiable personal information or images are included in this manuscript

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