# Association between malnutrition-inflammation score (MIS) and quality of life in elderly hemodyalisis patients

## Associação entre o escore de desnutrição-inflamação (MIS) e qualidade de vida em pacientes idosos em hemodiálise

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## ABSTRACT

**Introduction:** The malnutrition-inflammation process is one of the main causes of morbidity and mortality in patients with chronic kidney disease (CKD), influencing quality of life. The aim of this study was to identify the inflammatory and nutritional status of elderly hemodialysis (HD) and its association with quality of life. **Methods:** This study was carried out in health services in three different cities. The Malnutrition-Inflammation Score (MIS) was used to assess the inflammatory and nutritional status, with anthropometric measurements, protein status, lean mass and function. The quality of life was assessed using KDQOL-SF™. Data were analyzed using multivariate analysis and the Poisson model to evaluate the factors that increased the risk of developing malnutrition and inflammation. **Results:** The MIS identified a 52.2% prevalence of malnutrition and inflammation in the population. In univariate analysis, most KDQOL-SF™ domains presented higher scores for nourished elderly. Anthropometric measures associated with muscle mass and functionality were lower in the malnourished elderly. Multivariate modeling revealed a higher nutritional risk of 50.6% for women and older age, since with each additional year of life the risk of malnutrition increased by 2.4% and by 0.4% with each additional month on HD. Greater arm muscle circumference (AMC) and higher serum albumin were factors for reducing malnutrition by 4.6% and 34.7%, respectively. **Conclusion:** Higher serum albumin and preserved AMC have been shown to be good indicators of better nutritional status. Higher MIS was associated with poorer quality of life, older age, lower income and education, longer time on dialysis, and presence of comorbidities.

**Keywords:** Malnutrition; Dialysis; Chronic Kidney Insufficiency; Elderly; Quality of Life.

## RESUMO

**Introdução:** O processo de desnutrição-inflamação é uma das principais causas de morbimortalidade em pacientes com DRC, influenciando a qualidade de vida. O objetivo deste estudo foi identificar o estado inflamatório e nutricional de idosos em hemodiálise (HD) e sua associação com qualidade de vida. **Métodos:** Estudo realizado em serviços de saúde de três cidades diferentes. O Escore de Desnutrição-Inflamação (MIS, por sua sigla em inglês) foi utilizado para avaliar estado inflamatório e nutricional, com medidas antropométricas, estado proteico, massa magra e funcionalidade. A qualidade de vida foi avaliada com KDQOL-SF™. Os dados foram analisados utilizando análise multivariada e modelo de Poisson para avaliar fatores que aumentaram o risco de desenvolver desnutrição e inflamação. **Resultados:** O MIS identificou prevalência de 52,2% de desnutrição e inflamação na população. Na análise univariada, a maioria dos domínios do KDQOL-SF™ apresentou escores maiores para idosos nutridos. Medidas antropométricas associadas à massa muscular e funcionalidade foram menores em idosos desnutridos. A modelagem multivariada revelou maior risco nutricional de 50,6% para mulheres e idosos pois o risco de desnutrição aumentou em 2,4% para cada ano adicional de vida e em 0,4% para cada mês adicional de HD. Maior circunferência muscular do braço (CMB) e maior albumina sérica foram fatores de redução da desnutrição em 4,6% e 34,7%, respectivamente. **Conclusão:** Demonstrou-se que albumina sérica mais elevada e CMB preservada são bons indicadores de melhor estado nutricional. Maior MIS foi associado a pior qualidade de vida, idade mais avançada, menor renda e escolaridade, maior tempo em diálise e presença de comorbidades.

**Descritores:** Desnutrição; Diálise; Insuficiência Renal Crônica; Idosos; Qualidade de Vida.

## Introduction

The number of people with chronic kidney disease (CKD) on maintenance hemodialysis (HD) has increased significantly in recent decades, mainly due to the aging of the population and the increase in the prevalence of hypertension and diabetes. On the other hand, dialysis therapy has improved, increasing the survival of patients in chronic dialysis programs[1,2]. The latest census by the Brazilian Society of Nephrology showed a total number of 153,831 patients on dialysis[3].

Although dialysis techniques have continuously advanced, the mortality rate among patients with CKD remains high. The malnutrition-inflammation process is one of the main causes of morbidity and mortality in patients with CKD. This finding is illustrated by the inverse association between mortality rates and markers of adequate nutritional status[4]. Protein-energy wasting (PEW) is a condition of malnutrition, inflammation, anorexia and wasting of body reserves due to inflammatory and non-inflammatory conditions in CKD patients[5,6].

The nutritional assessment of individuals on HD remains a significant challenge since there is no single method capable of accurately diagnosing the nutritional status of these patients[7]. The Malnutrition-Inflammation Score (MIS) is a practical and reproducible measure that can be used in both HD and peritoneal dialysis patients. Studies have shown that the MIS is associated with inflammation, anemia, quality of life and mortality. Higher MIS values are independently associated with a higher risk of hospitalization[8,9].

While the association between quality of life (QoL) and MIS in CKD has been addressed in a number of studies, there is a lack of studies regarding this association in older patients. It should be highlighted that health-related QoL is a strong and independent predictor of hospitalization and death in patients undergoing dialysis[10], and regular assessment of QoL is recommended as one of the parameters for adequacy of treatment by the Kidney Disease Outcomes Quality Initiative (K/DOQI)[11,12].

The aim of this study was to identify the inflammatory and nutritional status of elderly hemodialysis patients and the association between this and their quality of life.

## Methods

This was a cross-sectional study conducted at three hemodialysis clinics in the metropolitan region of Recife in northeastern Brazil. The procedures complied with the ethical standards of the responsible committee on human experimentation and the Helsinki Declaration of 1975, as revised in 2013, and the protocol was approved by the Ethics Committee (CAAE 64859716.5.0000.5207). The informed consent form was signed by all participants. The sample consisted of all patients from the three nephrology clinics, recruited from March to December 2017, of both sexes, aged ≥ 60 years, who had undergone hemodialysis three times a week for at least six months. Elderly patients were excluded if they presented neoplasms, positive serology for human immunodeficiency virus (HIV), viral hepatitis, Alzheimer's disease, cognitive impairment, amputated limb and/or wheelchair-bound, Parkinson's disease and stroke sequelae.

The sample selection protocol is described in Figure 1. Initially, a screening test for cognitive impairment, the Mini-Mental State Examination (MMSE), was carried out to identify which elderly people were eligible to take part in the study, with cut-off points of 18 and 23, depending on the participants' level of schooling[13].

Clinical, sociodemographic, and dialysis data were collected from clinical records and patients were questioned.

To assess patient perception of QoL, the KDQOL-SF™ questionnaire was used[14].

Anthropometric measurements were performed after the HD session by three researchers all previously trained in nutrition tracking tools. Weight was measured on a Marte® electronic scale. Height was measured with a portable Sanny® stadiometer. To calculate the body mass index (BMI)[15], the current weight (kg) was divided by the squared height (m), with the result expressed in kg/m$^2$.

The arm circumference (AC) was measured on the non-vascular access arm using a Cescorf® inelastic tape measure. The measurement was recorded in centimeters[16].

To obtain the arm muscle circumference (AMC), measurements of the triceps skinfold (TS) on the non-vascular access arm and AC were entered into the Frisancho equation[16].

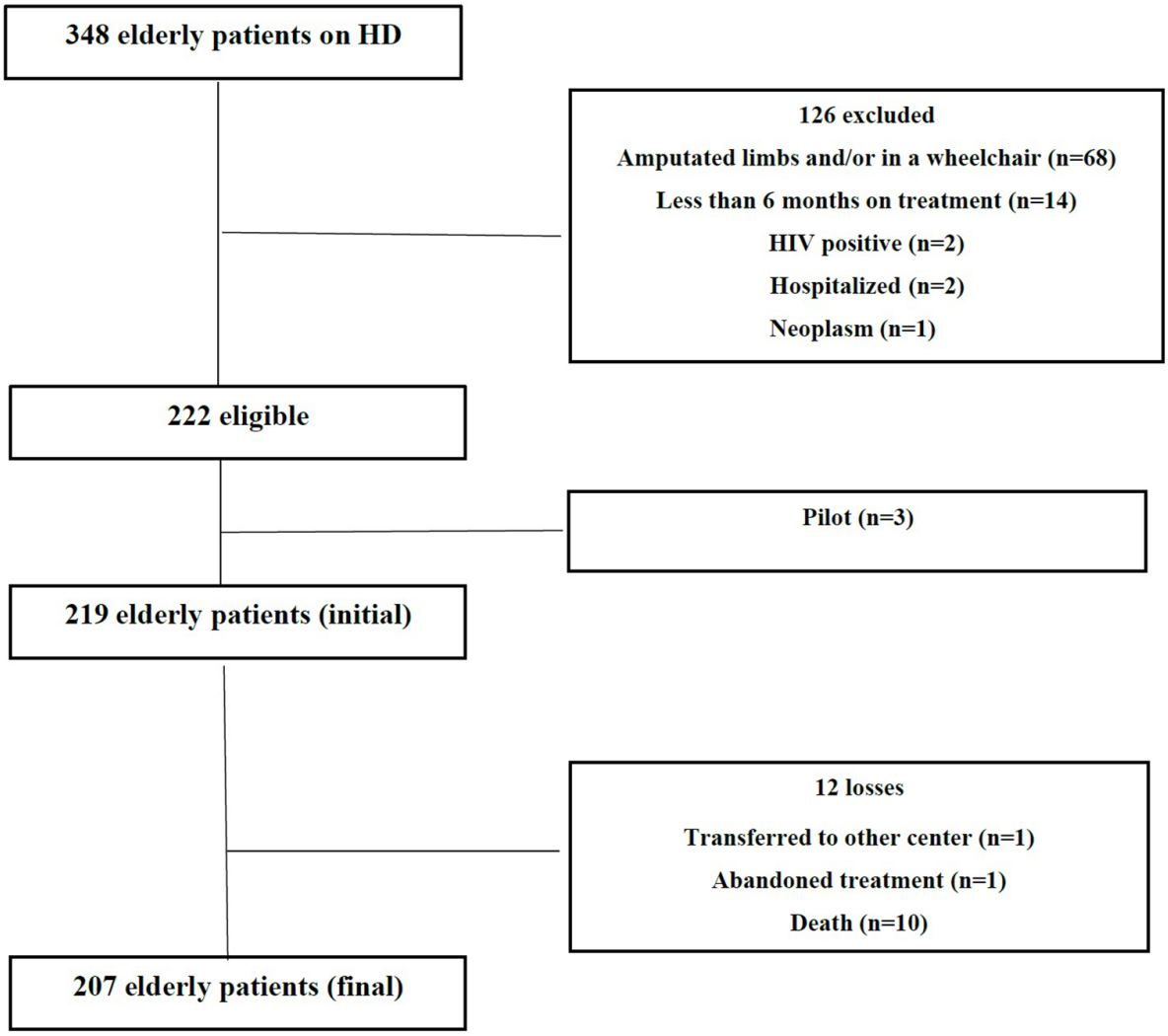


**Figure 1.** Sample selection protocol.

To measure the TS, a Cescorf® adipometer was used. The adequacy of the AMC was obtained through the 50th percentile value (Frisancho[17]) and calculated by the Blackburn et al.[18] equation, whereby a reduction of >10% was classified as being malnourished[19].

Calf circumference (CC) was assessed on the left leg at the widest point and classified as malnourished with a CC <31 cm[20].

A handgrip strength (HGS) test was performed on the patient's hand with no arteriovenous fistula and was obtained using a Saehan® hand dynamometer with a malnutrition cut-off of <23.3 kg specific to the hemodialysis population[21].

Malnutrition-inflammation was assessed by the MIS, as recommended by Kalantar-Zadeh et al.[22], and patients were classified as nourished when they scored less than 6 and malnourished with scores higher than or equal to 6[23].

KDQOL – SF™ according to the MIS score comprise specific and generic domains. The specific domains are List of symptoms/problems, Effects of kidney disease, Burden of kidney disease, Professional role, Cognitive Function, Quality of Social Interaction, Sexual Function, Sleep, Social support, Stimulation from dialysis team, and Patient Satisfaction. The generic domains are Physical Functioning, Role-Physical, Pain, General Health, Emotional well-being, Role-Emotional, Social Function, Energy/Fatigue[22].

Laboratory parameters were collected from medical records according to the patient's routine follow-up, during which a blood sample is

collected before the hemodialysis session. The study considered the levels of phosphorus, calcium, parathyroid hormone, vitamin D, hemoglobin, and serum albumin.

Data were analyzed using SPSS. The sample description was performed by absolute and relative frequencies, means and standard deviations or medians and interquartile ranges of the assessed variables. For the bivariate analysis, the Chi-square association test, Student's t test or Mann-Whitney test were used. In cases where the Chi-square test assumptions were not met, Fisher's exact test was applied.

The multivariate analysis included factors with a significance of up to 20% in the bivariate analysis. The Poisson model with a robust variance was applied to assess the factors that increase the risk of developing malnutrition in the studied elderly patients. Factors with a significance level of 5% were maintained in the model. Moreover, the confidence intervals for the prevalence ratio and the Wald test were calculated to compare the risks between the levels of the assessed factors. All conclusions were drawn based on a significance level of 5%.

## Results

This study included 207 individuals, of which 131 were males (63.3%), aged between 60 and 94 (68.23 ± 6.68). Clinical and nutritional characteristics are described in Table 1, with results stratified by the MIS as nourished and malnourished.

The malnutrition-inflammation prevalence was 52.2% based on the MIS, and the average QoL score was 65.06 in the population studied based on the KDQOL-SF™.

MIS was associated with age, female gender, and not having a partner. Most of the elderly patients had low schooling, a monthly income between 1 and 5 minimum wages, and their therapy was funded by the Brazilian Public Healthcare System (SUS). However, there was no difference in these characteristics between MIS categories.

In terms of the nutritional parameters, the mean BMI, AC, AMC, CC, HGS, and serum albumin were significantly lower in patients classified as malnourished by the MIS. There was a prevalence of malnutrition ranging from 54.1% by the HGS to 30.9% by the CC (Table 2). The comorbidities were similar between the groups.

The dialysis parameters revealed that most of the elderly had an arteriovenous fistula (AVF)/prosthesis (74.4%) as a vascular access for hemodialysis and had 4-hour dialysis sessions (96.1%). The dialysis dose, determined by the Kt/V, presented better mean values in the malnourished group (1.64 ± 0.38 versus 1.52 ± 0.32, p = 0.014). The elderly who were most affected by the malnutrition-inflammation process were those who had been on dialysis for longer (43 versus 59 months, p = 0.041).

Table 3 describes the 19 domains of the KDQOL-SF™ questionnaire. Most domains presented higher scores for the nourished elderly patients. In the specific domains List of Symptoms/ Problems (p < 0. 001), Effects of kidney disease (p = 0.004), Burden of kidney disease (p = 0.004), Cognitive function (p = 0.001), Sleep (p = 0.002), Patient social support (p = 0.045), and satisfaction (p = 0.005), the QoL of the malnourished patients was significantly lower than those who were nourished.

The generic QoL domains Physical functioning, Physical function, Pain, Emotional well-being, Emotional function, and Social function were also significantly different in nourished and malnourished elderly.

Table 4 presents the Poisson model adjustment for malnutrition and inflammation. After the bivariate analysis to assess the individual influence of factors on the development of malnutrition and inflammation, the combined analysis resulted in the following significant factors: gender, age, AMC measurement, serum albumin level, and time on HD. It was also observed that the female group presented a 50.6% greater risk of developing higher (worse) malnutrition-inflammation scores compared to the male group. For age, it was observed that with an increase of one year of life, there was a 2.4% increase in the risk of developing higher malnutrition-inflammation scores. For the AMC and albumin, there was a reduction of 4.6% and 34.7%, respectively, in the risk of developing malnutrition-inflammation with an increase of 1 cm in the AMC and of 1 g/dL in albumin. In terms of time on HD, for each month that the patient underwent treatment, this risk increased by 0.4%.

## Discussion

Assessing the nutritional status of HD patients is critical, since malnutrition, especially PEW

**Table 1** Clinical and nutritional characteristics according to the malnutrition-inflammation score (MIS) of older patients undergoing hemodialysis in northeastern Brazil, (N = 207)

| Characteristics | Total* | Malnutrition-inflammation score (MIS) | | p-value |
|---|---|---|---|---|
| | | Nourished (MIS < 6)* | Malnourished (MIS ≥ 6)* | |
| | (n = 207) | (n = 99) | (n = 108) | |
| **Age** (years)** | 68.23 ± 6.68 | 66.80 ± 4.96 | 69.55 ± 7.72 | **0. 002**[1] |
| Sex | | | | |
| Female | 76 (36.7) | 24 (31.6) | 52 (68.4) | **< 0. 001**[3] |
| Schooling | | | | |
| < 9 years (low schooling) | 113 (54.6) | 55 (48.7) | 58 (51.3) | 0.789[3] |
| Civil status (with partner) | | | | |
| No partner | 73 (35.3) | 28 (38.4) | 45 (61.6) | **0.044**[3] |
| **Family income** | | | | |
| < 1 minimum wage | 4 (1.9) | 2 (50) | 2 (50) | |
| 1–5 minimum wages | 188 (90.8) | 89 (47.3) | 99 (52.7) | 0.921[3] |
| > 5 minimum wages | 15 (7.2) | 8 (53.3) | 7(46.7) | |
| **Nutritional Parameters** | | | | |
| BMI (kg/m$^2$)** | 24.29 ± 4.21 | 25.22 ± 3.94 | 23.43 ± 4.28 | **0.002**[1] |
| AC (cm)** | 28.10 ± 3.82 | 29 ± 3.32 | 27.29 ± 4.07 | **0.001**[1] |
| AMC (cm)** | 23.82 ± 2.91 | 24.66 ± 2.47 | 23.04 ± 3.08 | **< 0.001**[1] |
| CC (cm)** | 32.47 ± 3.38 | 33.43 ± 3.13 | 31.59 ± 3.38 | **< 0.001**[1] |
| HGS (kg)** | 24.29 ± 8.73 | 27.10 ± 8.82 | 21.71 ± 7.85 | **<0.001**[1] |
| Serum albumin (g/dL)** | 3.8 ± 0.33 | 3.86 ± 0.30 | 3.74 ± 0.34 | **0.008**[1] |
| **Comorbidities** | | | | |
| Diabetes mellitus | 100 (48.3) | 47 (47) | 53 (53) | 0.818[3] |
| Systemic arterial hypertension | 180 (87) | 84 (46.7) | 96 (53.3) | 0.389[3] |
| Anemia | 97 (46.9) | 41 (42.3) | 56 (57.7) | 0.163[3] |
| **Dialysis Parameters** | | | | |
| Dialysis dose (Kt/V)** | 1.58 ± 0.36 | 1.52 ± 0.32 | 1.64 ± 0.38 | **0.014**[1] |
| Phosphorous (mg/dL)** | 4.84 ± 1.11 | 4.91 ± 1.08 | 4.77 ± 1.15 | 0.373[1] |
| Calcium (mg/dL)** | 8.87 ± 0.66 | 8.93 ± 0.68 | 8.82 ± 0.63 | 0.246[1] |
| Calcium-phosphorus product (mg$^2$/dL$^2$)** | 42.29 ± 10.89 | 43.27 ± 10.57 | 41.39 ± 11.14 | 0.214[1] |
| PTH (pg/ mL)*** | 311.30 (168; 493) | 338.10 (173; 519) | 298.25 (165.25; 460) | 0.454[2] |
| Vitamin D (ng/mL)** | 31.88 ± 12.35 | 33.20 ± 13.11 | 30.68 ± 11.53 | 0.144[1] |
| Hemoglobin (g/100 ml)** | 10.98 ± 1.4 | 11.09 ± 1.45 | 10.87 ± 1.45 | 0.271[1] |
| Time on HD (months)*** | 51 (22; 88) | 43 (21; 78) | 59 (24.50; 97.5) | **0.041**[2] |
| Vascular access for HD | | | | |
| *AVF or prosthetic* | 154 (74.4) | 74 (48.1) | 80 (51.9) | 0.912[3] |
| *Permcath or DLC* | 53 (25.6) | 25 (47.2) | 28 (52.8) | |
| Length of HD session | | | | |
| *3 to 3.5 hours* | 8 (3.9) | 4 (50) | 4 (50) | 1.000[4] |
| *4 hours* | 199 (96.1) | 99 (47.8) | 108 (52.2) | |

Abbreviations: BMI, body mass index; AC, arm circumference; AMC, arm muscle circumference; CC, calf circumference; HGS, handgrip strength; PTH, parathyroid hormone; HD, hemodialysis; AVF, arteriovenous fistula; DLC, double lumen catheter.
Notes: *Absolute and relative frequency for categorical variables; **Mean ± SD; ***Median and interquartile range; [1]p-value of Student's t-test; [2]p-value of Mann-Whitney test; [3]p-value of Chi-square test; [4]p-value of Fisher's exact test.

**Table 2** Prevalence of malnutrition according to each nutritional indicator in elderly patients undergoing hemodialysis in northeastern Brazil (N = 207)

| Nutritional indicator | Prevalence of malnutrition (%) |
|---|---|
| MIS (≥ 6) | 52.2 |
| Serum albumin (< 3.8 g/dL) | 38.2 |
| Reduced AMC (> 10%) | 39.1 |
| HGS (< 23.3 kg) | 54.1 |
| CC (< 31 cm) | 30.9 |

Abbreviations: MIS, Malnutrition-inflammation score; AMC, arm muscle circumference; HGS, handgrip strength; CC, calf circumference.

**Table 4** Poisson model adjustment for a higher malnutrition-inflammation score (MIS)

| Assessed factor | PR | 95%CI | p-value |
|---|---|---|---|
| Sex | | | |
| *Male* | 1.000 | – | – |
| *Female* | 1.506 | 1.154 – 1.965 | 0.003 |
| Age | 1.024 | 1.009 – 1.040 | 0.002 |
| AMC | 0.954 | 0.913 – 0.998 | 0.042 |
| Albumin | 0.653 | 0.452 – 0.943 | 0.023 |
| Time on HD (months) | 1.004 | 1.002 – 1.006 | <0.001 |

Abbreviations: AMC, arm muscle circumference; HD, hemodialysis; PR, Prevalence Ratio; CI, Confidence Interval.

**Table 3** Scores of the KDQOL-SF™ domains according to malnutrition-inflammation score (MIS) of elderly patients undergoing hemodialysis in northeastern Brazil (n = 207)

| | | Malnutrition-Inflammation Score (MIS) | | |
|---|---|---|---|---|
| Assessed dominion | Total** | Nourished (MIS < 6)** | Malnourished (MIS ≥ 6)** | p-value |
| Specifics | (n = 207) | (n = 99) | (n = 108) | |
| List of symptoms/problems | 79.22 ± 15.14 | 83.69 ± 13.62 | 75.13 ± 15.36 | **< 0. 001**[1] |
| Effects of kidney disease | 69.38 ± 17.85 | 73.13 ± 16.40 | 65.94 ± 18.50 | **0.004**[1] |
| Burden of kidney disease*** | 50 (37.5; 75) | 50 (43.75; 75) | 50 (25; 62.5) | **0.004**[2] |
| Professional role*** | 0 (0; 50) | 0 (0; 50) | 0 (0; 50) | 0.413[2] |
| Cognitive Function | 85.31 ± 17.08 | 89.56 ± 16.11 | 81.41 ± 17.07 | **0.001**[1] |
| Quality of Social Interaction | 80.97 ± 17.38 | 83.29 ± 17.85 | 78.82 ± 16.72 | 0.064[1] |
| Sexual Function* | 86.17 ± 22.31 | 91.53 ± 15.60 | 75.78 ± 29.39 | 0.059[1] |
| Sleep | 69.24 ± 21.32 | 73.98 ± 20.39 | 64.88 ± 21.30 | **0.002**[1] |
| Social support | 80.27 ± 28.23 | 84.34 ± 24.49 | 76.54 ± 30.91 | **0.045**[1] |
| Stimulation from dialysis team | 72.89 ± 27.72 | 76.13 ± 26.06 | 69.90 ± 28.95 | 0.106[1] |
| Patient Satisfaction | 64.65 ± 22.46 | 69.19 ± 21.86 | 60.49 ± 22.27 | **0.005**[1] |
| **Generic (SF)** | | | | |
| Physical Functioning*** | 45 (25; 75) | 60 (35; 85) | 35(20; 58.75) | **<0.001**[2] |
| Role-Physical*** | 50 (25; 100) | 75 (50; 100) | 25 (0; 75) | **<0.001**[2] |
| Pain*** | 77.50 (42.50; 100) | 80 (45; 100) | 75.0 (32; 50) | **0.004**[2] |
| General Health*** | 50(40; 70) | 55 (45; 70) | 50 (35; 65) | 0.070[2] |
| Emotional well-being | 72.37 ± 22.74 | 76.52 ± 23.27 | 68.55 ± 21.65 | **0.011**[1] |
| Role-Emotional*** | 66.67 (0; 100) | 100 (33.33; 100) | 66.7 (0; 100) | **0.002**[2] |
| Social Function | 74.52 ± 23.94 | 80.05 ± 22.44 | 69.44 ± 24.24 | **0.001**[1] |
| Energy/Fatigue | 62.08 ± 22.62 | 64.54 ± 23.86 | 59.81 ± 21.27 | 0.133[1] |

Notes: *(n = 47); **Mean ± SD; ***Median and interquartile range; [1]p-value of Student's t-test; [2]p-value of the Mann-Whitney test. In the dimensions of the KDQOL-SF™ the value 0 reflects the lowest QoL and the value 100 reflects the highest QoL.

syndrome, is highly prevalent and contributes to increased morbidity and mortality in patients on chronic HD[5,24]. The MIS is considered a sensitive parameter for assessing malnutrition and inflammation in HD patients, and a predictor of mortality[22], but its use in the elderly population has been poorly documented.

According to the MIS, the prevalence of malnutrition-inflammation in the studied population was 52.2%. A more advanced age was associated

with higher MIS levels, a result also found in other studies[25]. Aging is a risk factor for malnutrition, with an increase of 2.4% in risk for each year of life in the multivariate model for this population. Physiological changes take place in old age, resulting from reduced energy needs and expenditure, referred to as the anorexia of aging. This physiological anorexia increases the risk of weight loss and malnutrition when an older person develops a physical or psychological illness[26].

For older people, food stands for family, union, and quality of life. The fact that patients live with a partner and reside with their family may increase their care at home. The most malnourished elderly patients were those who did not have a partner (61.6%). CKD causes functional losses that compromise independence and autonomy, which occurs more often with older patients[27].

Women are usually less prevalent in CKD studies. The true protective effects of female hormones on the progression of kidney disease remain unknown. On the other hand, when on dialysis, women present poorer clinical parameters, including anemia, nutrition, and quality of life[28]. In this study, while 36.7% of the sample were women, 68.4% were malnourished and at a 50.6% increased risk of developing higher MIS scores than men.

The anthropometric and dialysis parameters were worse in the malnourished patients, which reinforces the importance of gaining body weight, especially lean mass. This is because weight gain reflects in better functional and immunological conditions, greater independence, and lower morbidity and mortality related to malnutrition[29].

Serum albumin is an important nutritional parameter in patients undergoing renal replacement therapy, with a level of 3.8 g/dL considered normal. The elderly patients in this study were able to achieve this goal. Pereira et al.[30] in a large study of 1,679 patients investigated the impact of albumin on mortality after two years of hemodialysis and found that mortality was significantly higher in the albumin group below 3.8 g/dL. Szuck et al.[8], who verified the ability of nutritional indicators to predict the risk of hospitalization in hemodialysis patients, found that only serum albumin was able to predict this risk, and that patients with <3.8g/dL presented a 2.47 times higher incidence than those with higher albumin levels.

For the population of this study, the AMC was a protective factor for malnutrition-inflammation in the multivariate model, as with a one-centimeter increase in the AMC there was a 4.6% reduction in the risk of a higher MIS.

Regarding the adequacy of dialysis assessed by the measurement of Kt/V, the current European recommendation is a Kt/V equal to or greater than 1.2[31]. Kt/V is very important in the assessment of nutritional status, since inadequate dialysis results in a uremic state, progressing to nausea, vomiting, and anorexia, with consequent impairment in food intake. The results of this study demonstrate that dialysis was appropriate for these elderly patients, with a mean Kt/V of 1.58. The malnourished elderly patients presented the highest Kt/V levels, demonstrating that malnutrition can occur even when dialysis is efficient. Malnutrition reduces body volume, making the elderly more susceptible to an increase in Kt/V. The literature indicates that longer periods on HD are associated with poor nutritional status and inflammation[32]. In the sample studied, the risk of malnutrition-inflammation increased 0.4% for each month of dialysis therapy.

With increased access to new dialysis therapies, such as high-volume hemodiafiltration (HDF), and improvements in dialysis quality, the nutritional status of elderly patients on chronic dialysis may improve. In the study by Maduell et al.[33], patients were randomized to continuous dialysis or HDF. The results showed that the normalized protein catabolic rate, which is a parameter of nutritional status, was higher in patients randomized to HDF.

The negative association between the nutritional condition/protein-energy wasting (PEW) and QoL has been demonstrated and its importance highlighted by several studies, since dialysis treatment, despite prolonging survival, has a great impact on various aspects of patients' lives[34–36]. To date, there is no single method, such as a gold standard, capable of diagnose PEW, so the use of various nutritional markers is recommended[36]. Importantly, an ideal nutritional indicator should be able to predict clinical outcomes and identify patients who are in need of receiving nutritional interventions[37]. Despite dialysis therapy, PEW is common in dialysis patients and is related to inflammation, associated comorbidities, a hypercatabolic state, and decreased intake and anorexia[38].

This study observed a negative association between MIS and several domains of the KDQOL-SF™, suggesting that the occurrence of malnutrition-inflammation may have negatively affected the QoL of the elderly patients in this hemodialysis population. A systematic review demonstrated that malnourished older adults were more likely to have a poorer quality of life ($p < 0.001$; OR 2.85; CI 2.20–3.70). The authors also noted that when considering the effect of nutritional support in intervention studies, there is a significant improvement in the QoL of these individuals in both physical and mental aspects[39].

In terms of the KDQOL-SF™, the domain that obtained the highest score was sexual function, although it was not statistically associated statistically associated with the MIS.. This domain assesses whether patients have engaged in sexual activity over the last four weeks and the extent to which there have been problems with sexual arousal and satisfaction. This result should be carefully analyzed as part of the sample reported having an active sex life. However, erectile dysfunction is very common in patients with chronic kidney failure due to hormonal, physical, neurological, and psychological changes[40].

Other high-scoring domains (better QoL) associated with MIS were cognitive function and social support. The social support domain verifies the support received from family and friends, and the domain of quality of social interaction assesses the family and social relationships with the patient. These aspects can be highly valued by elderly patients, as they are highly dependent on the care that hemodialysis requires from family members. It is important to involve the family in the treatment by encouraging their participation and guiding them to cooperate with the healthcare team[10]. When elderly people on renal replacement therapy are in an environment with supportive family and social relationships, they generally accept their treatment and are motivated and grateful[41].

The item cognitive function assesses the participant's perception of difficulties in concentrating and thinking, the presence of mental confusion, and the delay in reacting to phenomena that have happened or have been spoken of. Patients with CKD are at risk of cognitive decline. Cognitive impairment may be present at any stage of kidney disease and is associated with an increased risk of death and lower adherence to treatment. Although the mechanisms leading to loss of cognitive function in CKD are not completely clear, the literature demonstrates that clinical conditions, such as the elimination rate of uremic toxins, may induce neuronal lesions[41]. Oliveira et al.[10] reported a significant inverse correlation between QoL and number of missed treatments, revealing that the lower the QoL in this aspect, the higher the number of missed treatments, thereby representing a lower adherence to treatment.

Sleep was one of the domains with the lowest score, and malnutrition-inflammation was significantly associated, since in this population, nourished patients slept better than those who were malnourished. Poor sleep quality is not uncommon in hemodialysis patients, with a prevalence ranging from 41% to 83%. It is most commonly associated with women, older age, the presence of depression, cardiovascular disease, poor quality of dialysis therapy and a compromised health-related quality of life[42].

The low QoL score as an effect of kidney disease demonstrates how the limitations of dialysis, such as a restricted fluid intake and diet, travel difficulties, dependence on health staff, personal appearance and other limitations, are an inconvenience to elderly patients. The low QoL reflects the disruption that kidney disease brings to the lives of these patients, particularly because of the time they spend on treatment[41]. The results observed for the professional role score are related to the fact that almost all older people are no longer of productive age and those who are still working at the start of dialysis therapy often retire.

With regard to the generic domains (SF-36), the elderly patients in this study presented higher scores in the domains involving mental aspects, and lower scores in the domains involving physical aspects. With the aging process, the limitations caused by hemodialysis treatment tend to increase, especially the physical limitations. However, the emotional side becomes stronger with increasing age. Older people are psychologically better able to cope with the demands of treatment, their expectations are more realistic and they are more able to adapt to their state of health[10,32].

The limitations of the study are related to the cross-sectional design, in which the group was only assessed

once. Therefore, causal relationships cannot be established, i.e. whether malnutrition-inflammation causes impaired QoL, or if impaired QoL causes a decrease in appetite, and thus malnutrition. Cross-sectional studies with elderly people are subject to survival bias, as the most serious participants may have died, i.e. the results observed were from a population of senior survivors. In addition, the lack of analysis of fat-free mass loss and food intake made a more accurate assessment of nutrition in elderly patients impossible.

In summary, the results showed that the malnutrition-inflammation score was associated with poorer QoL for elderly hemodialysis patients. Serum albumin and AMC were found to be protective factors for high MIS.

Furthermore, elderly people with longer periods of renal replacement therapy, more years of life and women are at greater risk of developing malnutrition-inflammation.

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## Data Avaliability

The data underlying this article are available in the article and in its online supplementary material.

## Authors' Contributions

KCRL and ANMG contributed with study idea and design; KCRL and ACOS responsible for data acquisition; ANMG and ACOS analyzed the results; KCRL, ANMG, TOCS, NFLV and ACOS responsible for article drafting and manuscript edition, including tables and figures; KCRL, ANMG, TOCS, NFLV and ACOS revised critically, read, and approved the manuscript.

## Conflict of Interest

The authors declare no conflict of interest.

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