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# Factors associated with the prevalence of malnutrition among adult hemodialytic patients
## A two-center study in the Jeddah region, Saudi Arabia

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**Abstract**

Chronic kidney disease, one of the most common diseases in the world, is characterized by irreversible impairment of the kidney's metabolic, excretory, and endocrine functions. During end-stage renal disease, patients require renal replacement therapy, such as hemodialysis (HD). Protein-energy wasting is a common health problem among HD patients. This study aims to assess the nutritional status of HD patients at two HD centers in Jeddah, Saudi Arabia, and to determine its associated factors. A cross-sectional study was conducted at two different dialysis centers in Jeddah, Saudi Arabia; 211 female and male HD patients. Malnutrition was recognized using the modified-subjective global assessment (M-SGA) comprising two parts: medical history and physical examination. Sociodemographic and health status for all patients were also determined. Patients were classified based on their M-SGA score into two groups: normal and malnourished. Overall, 54.5% of the participants showed malnutrition. Unemployment, low muscle strength and mass, high level of medication use, and high dialysis vintage were positively ($P < .05$) associated with malnutrition. In conclusion, the M-SGA score indicates a high prevalence of malnutrition among HD patients. These results show the importance of regular assessment and follow-ups for HD patients ensuring better health and nutritional status.

**Abbreviations:** 95% CI = 95% confidence intervals, BMI = body mass index, GI = gastrointestinal, HD = hemodialysis, MOH = Ministry of Health, M-SGA = modified-subjective global assessment, nPCR = normalized protein catabolic rate, NS = not significant, PEW = protein-energy wasting, OR = odds ratio, SAR = Saudi riyal, SGA = subjective global assessment, USD = US dollar.

**Keywords:** chronic kidney disease, modified-subjective global assessment, protein-energy wasting

## 1. Introduction

Chronic kidney disease is a worldwide public health concern. It is defined as an irreversible impairment of kidney functioning, which may promote end-stage renal disease and require renal replacement therapy.[1] Renal replacement therapies, which include peritoneal dialysis, hemodialysis (HD), and kidney transplants, were globally established in the 1960s.[2] In 2018, the total number of chronic HD patients in Saudi Arabia was 19,033, including 6419 patients in the Western region, an increase of 58.6% from the number of cases in the 2011 (around 12,000 cases). Saudi Arabia has 271 HD

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centers, most working under the supervision of the Saudi Ministry of Health (MOH), except several government non-MOH hospitals.[3]

Protein-energy wasting (PEW) is a common problem among HD patients. There are many causes of PEW, including increased nutrient requirements, anorexia, altered taste sensation, emotional distress, gastrointestinal (GI) symptoms, catabolic metabolism, and nutrient loss during HD sessions. In addition, the proportions of glucose, amino acids (approximately 4–12 grams) and water-soluble vitamins are lost while crossing the dialyzer membrane. The last PEW pathway is associated with inflammation and co-morbidities, such as infections, sepsis, and cardiovascular disease.[4] The malnutrition caused by HD negatively affects quality of life and can increase the hospitalization period, morbidity, and mortality rate.[4,5]

Using nutrition assessments to measure nutrition status involves anthropometric, biochemical, clinical, and dietary data. These data are collected by nutrition specialists, with the subjective global assessment (SGA) being one of the most valuable healthcare provider tool. The SGA is an inexpensive and rapid assessment tool recommended for HD patients by the National Kidney Foundation's Kidney Disease/Dialysis Outcomes and Quality Initiative. This tool assesses nutrition status and supports prediction of nutritionally associated clinical outcomes based on medical history and physical examinations.[6] A patient's medical history includes functional capacity, gastrointestinal symptoms, weight loss, co-morbidities, and dietary intake. Physical examinations assess muscle loss and subcutaneous fat.[6] Biochemical evaluations measure hemoglobin, albumin, and the normalized protein catabolic rate (nPCR) to provide valid measurements for PEW detection. Albumin is the most common malnutrition indicator because its synthesis decreases during malnutrition, and it is affected by food intake. Thus, albumin is a good indicator of nutrition status among HD patients.[4] Furthermore, albumin levels are significantly related to the nPCR.[2,7] Finally, bioelectrical impedance analysis is a noninvasive and inexpensive method for assessing body composition in clinical conditions in terms of lean body mass, fat percent, and fluid volume. Different factors can affect bioelectrical impedance measurements, including age, sex, and ethnicity.[8]

Studies regarding malnutrition in HD in Saudi Arabia are scarce. A cross-sectional study conducted in 2012[7] showed that 48.7% HD patients in Jeddah were moderately malnourished and 6.3% were severely malnourished. Most of these malnourished patients were female and of older age. Another recent study conducted in Jeddah included 71 HD patients; it reported that 43.7% were malnourished, and risk factors for malnutrition were associated with a poor appetite score and low hemoglobin level.[9] The most common risk factors related to malnutrition for HD patients were aging, underweight, living alone, longer dialysis duration, chronic disease(s) and intake of medication(s), poor educational level, unemployment, and transplantation history.[1,9,10] Therefore, socioeconomic, anthropometric, clinical, and health status were highly associated with malnutrition for HD patients. Accordingly, our study aims to assess the nutrition status among adult HD patients at two HD centers in Jeddah, Saudi Arabia, and to determine the associated factors related to malnutrition.

## 2. Methods

### 2.1. Study design and settings

This cross-sectional study was conducted at two branches of Diaverum HD in Jeddah, Saudi Arabia: the Prince Abdulmajeed Dialysis Center, the largest dialysis center in Saudi Arabia, and the North Jeddah Dialysis Center. The data were collected between August and September 2020. The data were collected after the study was approved by the MOH Ethical Committee

(H-02-K-076-0620-305) in accordance with the tenets of the Declaration of Helsinki.

### 2.2. Subjects

There were 6419 HD patients in the Western region of Saudi Arabia in the year 2018, according to reports issued by the Saudi Center for Organ Transplantation and MOH.[3] Therefore, Epi Info™ software was used (https://www.cdc.gov/epiinfo/index.html), to ensure the minimum sample-size requirement of 161 participants, specified to achieve study power of 80%, was fulfilled. The total number of patients in both dialysis centers was 612.

Before the study, the participants were asked to participate and informed written consent forms were obtained. The patient inclusion criteria were as follows: adults aged between 18 and 65 years old; undergoing HD three times per week for at least 3 hours per session; hemodialyzed for at least 6 months; the absence of nutritional support (enteral and parenteral feeding); and the ability to stand. The exclusion criteria were as follows: any physical, mental, or psychiatric disease(s); patients with amputations; presence of infectious diseases, specifically HIV and hepatitis; communication disability; newly diagnosed patients.[1,10] Additionally, 74 (12.1%) and 17 (2.8%) HD patients refused and did not come to the clinic, respectively. Based on these criteria, 211 HD patients were recruited, and Figure 1 displays the flow chart for the selection of eligible participants. The participation rate was 34.5%.

### 2.3. Data collection

The data were collected using a questionnaire with four sections. The first section considered sociodemographic and health status information. The second section was the SGA. The third section included data about biochemical parameters; these data were obtained via computerized documentation or by face-to-face interviews. The final section was the bioelectrical impedance analysis, which evaluated body composition. The four sections of the used questionnaire were as follows:

**2.3.1. Sociodemographic and health status.** This component produced data about each patient's age, sex, education level, employment status, marital status, residency, household income, living status, HD vintage, HD duration, HD time per week, tobacco use, body mass index (BMI), medications, and co-morbidities.[1,10] According to the previous studies, the BMI groups for HD patients were: underweight ($<18.5\,kg/m^2$), normal weight ($18.5–<25\,kg/m^2$), overweight ($25–<30\,kg/m^2$), and obese ($>30\,kg/m^2$).

**2.3.2. Subjective global assessment.** Patients were screened using a modified-subjective global assessment (M-SGA).[6] In brief, this M-SGA was divided into two sections: medical history and physical examination. Medical history included five parameters, with each measured on a five-point scale. The first measurement was anthropometric assessment (weight change over the previous 6 mo). The second measurement was dietary intake. Gastrointestinal symptoms, the third evaluative measurement, were divided into five categories: no symptoms, nausea, vomiting, diarrhea, and severe anorexia. Functional capacity, which is only related to nutrition, evaluated the patient's activity level. The final parameter considered co-morbidity, which was measured by estimating and evaluating HD vintage and co-morbidity levels. Co-morbidity levels included the number of comorbid diseases and the number of medications being taken. Any patient estimated to have a moderate or severe scale score in 1 to 3 area(s) was categorized as having moderate malnutrition, while severe malnutrition was defined when a
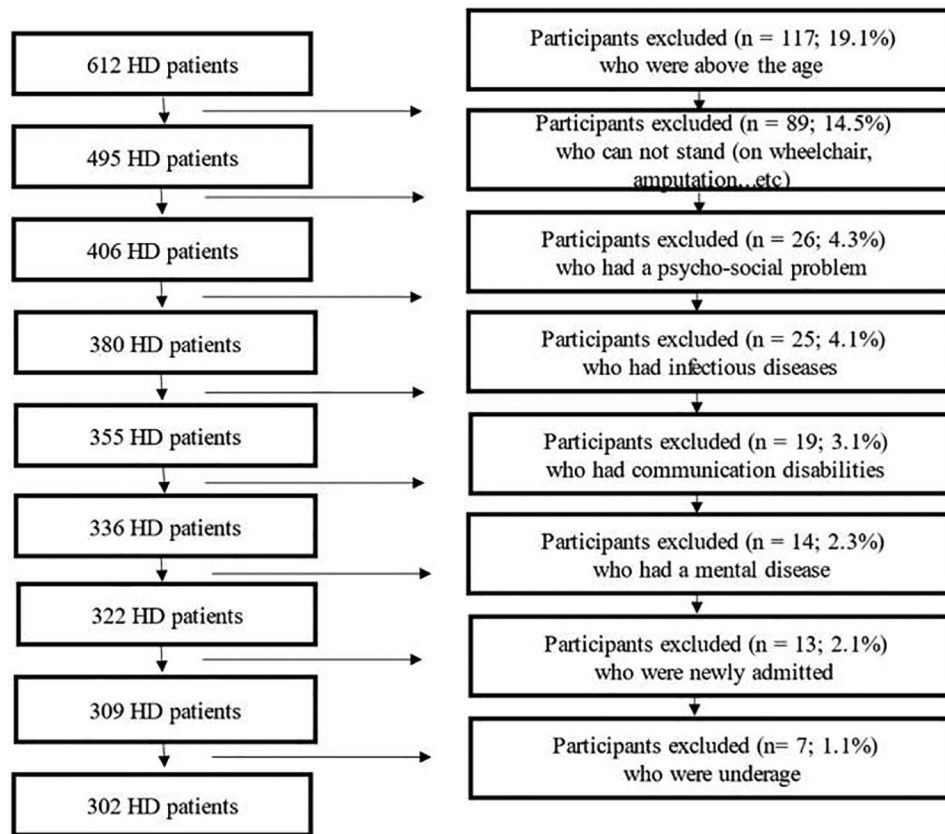
**Figure 1.** Recruitment of participants.

patient was categorized as severe in a minimum of 3 areas of the scale.[6]

The physical examination section of the SGA comprises two parts, and the results of each part were divided into three levels. First, fat stores were estimated using bioimpedance and clinical examination. Second, muscle wasting was evaluated using a Handgrip instrument (GRIPX Digital Hand Dynamometer Grip Strength Measurement, Shanghai, China).[6,11] Three readings from the same instrument were averaged to obtain the final handgrip results.[11] The M-SGA comprises 7 components, and was conducted by researchers who are certificated by the Saudi Commission of Health Specialties and have experience with HD patients. At each component of the M-SGA, there was a rate from 1 (normal) to 5 (severe malnutrition). For each patient, the values for all components were added together, creating a score which ranged from 7 to 35; HD patients were considered well-nourished when the total value was 7, and patients were considered malnourished if the sum of the components was more than 7.

***2.3.3. Biochemical assessment.*** The biochemical assessment measured hemoglobin, albumin, and nPCR. These measurements were conducted pre-dialysis for patients by blood drawing at the beginning of each month. The values were obtained from participants' electronic documentation and compared with the normal ranges.[2]

***2.3.4. Bioimpedance analysis.*** The bioimpedance instrument (Tanita, BC 418, Japan) was used to evaluate the lean body mass, fat mass, and body water content of each participant. The patient removed their shoes and any metallic accessories and stood on the machine in the correct position to produce these measurements. Among the study population, 29 patients refused to participate in this analysis, whereas 182 HD patients (101 males and 81 females) completed the body composition measurements. The body composition analyses for HD patients were performed 15 to 60 minutes post dialysis, which in turn reflected their dry weight and minimized the potential impact of fluid retention. Therefore, the anthropometric measurements were completed according to dry weight.

### 2.4. Statistical analysis

Statistical analysis was conducted using IBM-SPSS statistics (Statistic Package for Social Sciences; Armonk, NY) version 23, with *P* values <.05 considered statistically significant. Continuous variables were expressed as mean ± standard deviation. The frequencies of categorical variables were compared using a Chi-squared test. The Mann–Whitney *U* test was used to compare mean ranks between two groups with non-normal distribution. To assess the risk factors related to malnutrition, the odds ratio (OR) and 95% confidence intervals (95% CI) were determined using univariate binary logistic regression.

## 3. Results

### 3.1. Sociodemographic and anthropometric characteristics for HD patients

Table 1 describes the sociodemographic and anthropometric characteristics that are predictors of malnutrition in HD patients. The average M-SGA score for well-nourished and malnourished participants was 8.7 ± 1.4 and 14.6 ± 1.8, respectively. The mean age was 46.4 years ± 11.6. Most of the participants were between 30 and 49 years (46.4%), 9.1% were between 18 and 29 years, and 44.5% of the participants were 50 years old or more. Overall, 122 were males (57.8%),

**Table 1**

Sociodemographic and anthropometric characteristics as predictors for malnutrition in HD patients.

| | Frequency (%) or mean ± SD | | | | |
| | | Malnutrition | | | |
| Variable | Total | No (n = 96) | Yes (n = 115) | P value | OR (95% CI) |
|---|---|---|---|---|---|
| Age | 46.4 ± 11.6 | 45.7 ± 11.8 | 47.1 ± 11.6 | .394 | NS |
| Age category (n = 211) | | | | | |
| 18–29 | 19 (9.1%) | 11 (11.5%) | 8 (7%) | .52 | NS |
| 30–49 | 98 (46.4%) | 43 (44.8%) | 55 (47.8%) | | |
| 50–65 | 94 (44.5%) | 42 (43.8%) | 52 (45.2%) | | |
| Sex (n = 211) | | | | | |
| Male | 122 (57.8%) | 59 (61.5%) | 63 (54.8%) | .201 | NS |
| Female | 89 (42.2%) | 37 (38.5%) | 52 (45.2%) | | |
| Living arrangements (n = 211) | | | | | |
| Alone | 15 (7.1%) | 7 (7.3%) | 9 (7%) | .566 | NS |
| With family | 196 (92.9%) | 89 (92.7%) | 107 (93%) | | |
| Number of family members (n = 211) | 5.1 ± 2.9 | 5.1 ± 2.9 | 5.1 ± 2.9 | .819 | NS |
| <3 | 64 (30.3%) | 27 (28.1%) | 37 (32.2%) | .816 | NS |
| 4–6 | 96 (45.5%) | 45 (46.9%) | 51 (44.3%) | | |
| >6 | 51 (24.2%) | 24 (25%) | 27 (23.5%) | | |
| Marital status (n = 211) | | | | | |
| Single | 52 (24.6%) | 25 (26%) | 27 (23.5%) | .956 | NS |
| Married | 128 (60.7%) | 58 (60.4%) | 70 (60.9%) | | |
| Divorced | 21 (10%) | 9 (9.4%) | 12 (10.4%) | | |
| Widow | 10 (4.7%) | 4 (4.2%) | 6 (5.2%) | | |
| Income category (SAR†; n = 211) | | | | | NS |
| <3000 | 40 (19%) | 13 (13.5%) | 27 (23.5%) | .267 | |
| 3001–5000 | 48 (22.7%) | 22 (22.9%) | 26 (22.6%) | | |
| 5001–10,000 | 70 (33.2%) | 33 (34.4%) | 37 (32.2%) | | |
| >10,000 | 53 (25.1%) | 28 (29.2%) | 25 (21.7%) | | |
| Education level (n = 211) | | | | | |
| Illiterate | 16 (7.6%) | 8 (8.3%) | 8 (7%) | .382 | NS |
| Primary | 20 (9.5%) | 8 (8.3%) | 12 (10.4%) | | |
| Intermediate | 28 (13.3%) | 9 (9.4%) | 19 (16.5%) | | |
| Secondary | 80 (37.9%) | 34 (35.4%) | 46 (40%) | | |
| University | 62 (29.4%) | 34 (35.4%) | 28 (24.3%) | | |
| Higher education | 5 (2.4%) | 3 (3.1%) | 2 (1.7%) | | |
| Employment status (n = 211) | | | | | 1 |
| Employment | 73 (34.6%) | 40 (41.7%) | 33 (28.7%) | **.038** | **2.257 (1.184–4.302)*** |
| Unemployment | 83 (39.3%) | 29 (30.2%) | 54 (47%) | | 1.257 (0.623–2.535) |
| Retired | 55 (26.1%) | 27 (28.1%) | 28 (24.3%) | | |
| Weight (kg; n = 211) | 74.2 ± 20.9 | 76.3 ± 17 | 72.5 ± 23.6 | .075 | NS |
| Height (cm; n = 211) | 161.3 ± 9.2 | 162.2 ± 7.5 | 160.5 ± 10.3 | .318 | NS |
| BMI (kg/m²; n = 211) | 28.5 ± 6.8 | 29 ± 6.1 | 28.1 ± 7.3 | .199 | NS |
| BMI category | | | | | |
| Underweight | 11 (5.2%) | 1 (1%) | 10 (8.7%) | .94 | NS |
| Normal weight | 57 (27%) | 26 (27.1%) | 31 (27%) | | |
| Overweight | 68 (32.2%) | 32 (33.3%) | 36 (31.3%) | | |
| Obese | 75 (35.5%) | 37 (38.5%) | 38 (33%) | | |
| Handgrip (n = 211) | 19.8 ± 12.2 | 21.5 ± 11.9 | 18.3 ± 12.3 | **.011** | **0.978 (0.955–0.998)*** |
| Fat free mass (kg; n = 182) | 47.6 ± 10.8 | 49.5 ± 10.5 | 45.9 ± 10.8 | **.018** | **0.969 (0.942–0.996)*** |
| Body fat (%; n = 182) | 32.1 ± 10.8 | 32.1 ± 10.8 | 32.1 ± 10.9 | .975 | NS |
| Fat weight (kg; n = 182) | 24.5 ± 13 | 25 ± 12.1 | 24.1 ± 13.7 | .395 | NS |
| Total body water (kg; n = 182) | 35.1 ± 7.9 | 36.5 ± 7.7 | 34 ± 7.9 | .12 | NS |

Bold results are considered statistically significant at *P < 0.05 and **P ≤ 0.001. Univariate binary logistic regression was performed to determine ORs and 95% CIs. P values were determined by Chi-squared (χ²) test for categorical variables and by Mann–Whitney U test for continuous variables.
SAR = Saudi riyals, NS = not significant, 95% CI = 95% confidence intervals, BMI = body mass index, OR = odds ratio.
†1 SAR equals 0.27 American Dollar.

and the remainder were females. Only 7.1% of the participants were living alone, with 92.9% living with family. The mean number of family members in the household was 5.1 ± 2.9. Around 30% (n = 64) of the patients had three or fewer family members at home, 45.5% (n = 96) had between four and six, and 24.2% (n = 51) had more than six. About 60% of the patients were married, with the remaining being single (24.6%), divorced (10%), or widowed (4.7%). Regarding monthly income, 19% of participants received ≤Saudi riyal (SAR) 3000 (~US dollar (USD) 810), approximately 23% received between

3001 and 5000 SR (~USD 1350), approximately 33% received between SAR 5001 and 10,000 (~USD 2700), and 25.1% received more than SAR 10000. Regarding education level, most patients had a secondary education (37.9%) and 29.4% had a university education. The approximate percentages of employed (34.6%) and unemployed (39.3%) participants were similar, while the remainder of participants (26.1%) were retired. The result showed a significant difference (P = .038) in employment status between well-nutrition and malnutrition participants. The mean BMI was 28.5 kg/m² ± 6.8, indicating

that 11 participants (5.2%) were underweight, 57 were normal weight (27%), 68 were overweight (32.2%), and 75 were obese (35.5%). The mean handgrip score was 19.8 ± 12.2. The mean handgrip results indicated a significant association ($P = .011$) to the degree of malnutrition, with well-nourished patients producing higher handgrip scores than those with malnutrition. Overall, the Tanita device showed that the mean fat-free mass, body fat percent, fat weight, and total body water weight were 47.6 kg ± 10.8, 32.1% ± 10.8, 24.5 kg ± 13, and 35.1 kg ± 7.9, respectively. The average fat-free mass demonstrated a significant difference ($P = .018$) between well-nourished and malnourished participants, whereas the other Tanita device measurements did not reveal any significant differences ($P > .05$) between the groups. Table 1 also presents the sociodemographic and anthropometric predictors potentially related to malnutrition in HD patients. Following previous results, significant ($P < .05$) effects were observed for unemployment (OR = 2.257, 95% CI = 1.184–4.302), handgrip (OR = 0.978, 95% CI = 0.955–0.998), and fat free mass (OR = 0.969, 95% CI = 0.942–0.996).

### 3.2. Biochemical and health status for HD patients

Table 2 presents biochemical and health statuses as predictors of malnutrition in HD patients. Regarding tobacco use, 122 patients (57.8%) were nonsmokers, 42 were smokers (19.9%), and 47 were previously smokers (22.3%). Most patients (n = 176; 83.4%) had not received a kidney transplant; 35 had received a kidney transplant. The mean HD duration was 5.8 years ± 5.5. The results demonstrated a highly significant difference ($P < .001$) in the HD duration between well-nourished and malnutrition participants (3.4 yr vs 7.9 yr, respectively). Additionally, there was a highly significant difference

($P < .001$) in nutritional status between participants with less than four years and participants with 4 years or more of HD treatment. The average number of chronic diseases was 2.1 ± 1.1, and the average number of medications for chronic diseases was 4.3 ± 2.8. The average number of medications for chronic disease was significantly ($P = .001$) associated with nutritional status. Furthermore, significant correlations ($P < .001$) were found between well-nutrition and malnutrition groups ($P < .001$) and the number of medications used to treat chronic disease—fewer than four medications, or four medications or more. Most patients had normal hemoglobin (94.3%), albumin (99.5%), and nPCR levels (60.7%). The averages of the hemoglobin serum level, albumin serum level, and nPCR were not significant ($P > .05$) in either group. Table 2 shows the potential health status predictors related to malnutrition, with HD vintage (continuous results; OR = 1.299, 95% CI = 1.176–1.435, discontinuous results; OR = 11.36, 95% CI = 5.958–21.661) and the number of medications (continuous results; OR = 1.203, 95% CI = 1.067–1.355; discontinuous results; OR = 3.063, 95% CI = 1.732–5.417) being the only significant ($P < .05$) results.

## 4. Discussion

The study aimed to assess the nutritional status and factors related to malnutrition in HD patients in Jeddah, Saudi Arabia, where only two studies have discussed the prevalence of malnutrition among such patients.[7,8] This study used the M-SGA, handgrip, and body composition analysis tools to assess patient nutrition status. The five-point scale parameters M-SGA chosen included medical history (weight change, dietary intake, GI symptoms, functional capacity, and co-morbidities) and physical examinations (measuring fat stores,

### Table 2
**Biochemical and health status as predictors for malnutrition in HD patients (n = 211).**

| | Frequency (%) or mean ± SD | | | | |
| | | Malnutrition | | | |
| Variable | Total (n = 211) | No (n = 96) | Yes (n = 115) | P value | OR (95% CI) |
|---|---|---|---|---|---|
| Tobacco use | | | | .6 | NS |
| Yes | 42 (19.9%) | 22 (22.9%) | 20 (17.4%) | | |
| Ex-smoker | 47 (22.3%) | 21 (21.9%) | 26 (22.6%) | | |
| No | 122 (57.8%) | 53 (55.2%) | 69 (60%) | | |
| Previous kidney transplant | | | | .184 | NS |
| Yes | 35 (16.6%) | 13 (13.5%) | 22 (19.1%) | | |
| No | 176 (83.4%) | 83 (86.5%) | 93 (80.9%) | | |
| Dialysis vintage (yr) | 5.8 ± 5.5 | 3.4 ± 3.5 | 7.9 ± 6 | **<.001** | **1.299 (1.176–1.435)\*\*** |
| <4 yr | 94 (44.5%) | 71 (74%) | 23 (20%) | **<.001** | 1 |
| >4 yr | 117 (55.5%) | 25 (26%) | 92 (80%) | | **11.36 (5.958–21.661)\*\*** |
| Comorbidities | 2.1 ± 1.1 | 2.1 ± 1.1 | 2.1 ± 1.1 | .753 | NS |
| <3 chronic diseases | 138 (65.4%) | 62 (64.6%) | 76 (66.1%) | .466 | NS |
| >3 chronic diseases | 73 (34.6%) | 34 (35.4%) | 39 (33.9%) | | |
| Number of medications for chronic diseases | 4.3 ± 2.8 | 3.7 ± 2.6 | 4.9 ± 2.8 | **.001** | **1.203 (1.067–1.355)\*** |
| <4 Medications | 86 (40.8%) | 53 (55.2%) | 33 (28.7%) | **<.001** | 1 |
| >4 Medications | 125 (59.2%) | 43 (44.8%) | 52 (71.3%) | | **3.063 (1.732–5.417)\*\*** |
| Hemoglobin (g/dL) | 11.3 ± 0.9 | 11.4 ± 0.8 | 11.2 ± 1 | .258 | NS |
| Deficient | 12 (5.7) | 5 (5.2%) | 7 (6.1%) | .923 | NS |
| Normal | 199 (94.3%) | 91 (94.8%) | 108 (93.9%) | | |
| Albumin (g/L) | 38.6 ± 2.8 | 38.7 ± 2.7 | 38.5 ± 2.8 | .881 | NS |
| Deficient | 1 (0.5%) | 0 | 1 (0.9%) | .545 | NS |
| Normal | 210 (99.5%) | 96 (100%) | 114 (99.1%) | | |
| nPCR (g/kg/day) | 1.1 ± 0.3 | 1.1 ± 0.3 | 1.1 ± 0.3 | .503 | NS |
| Deficient | 83 (39.3%) | 37 (38.5%) | 46 (40%) | .471 | NS |
| Normal | 128 (60.7%) | 59 (61.5%) | 69 (60%) | | |

Bold results are considered statistically significant at \*$P < 0.05$ and \*\*$P ≤ 0.001$. Normal biochemical serum level: Hemoglobin: 10 to 12g/dL; Albumin: >35 g/L; nPCR: >1.0 g/kg/day. Univariate binary logistic regression was performed to determine ORs and 95% CIs. $P$ values were determined by Chi-squared ($\chi^2$) test for categorical variables and by Mann–Whitney $U$ test for continuous variables.
95% CI = 95% confidence intervals, nPCR = normalized protein catabolic rate, NS = not significant, OR = odds ratio.

subcutaneous fat, and muscle status). The body composition analysis tool was used to support the results derived from the M-SGA. The results of this study indicated that factors significantly ($P < .05$) related to malnutrition were unemployment, handgrip, fat-free mass, medication consumption, and the number of years of HD.

The worldwide prevalence of malnutrition among HD patients varies. Comparable results for the prevalence of malnutrition among HD patients have been found in Lithuania (42.4%),[12] Australia (46%),[13] and Brazil (47%).[14] A higher percentage (54.4%) was observed in Malaysia,[15] while the lowest percentage (27.3%) was observed in Iran.[16] In the Arab region, a recent cross-sectional study in Palestine focused on evaluating the nutrition status of 174 HD patients using inexpensive nutritional assessment equipment. That study showed that most HD patients (65%) experienced moderate malnutrition.[1]

Of this study's participants, 45.5% were well-nourished, 51.7% demonstrated moderate malnutrition, and 2.8% showed severe malnutrition. These results were similar to the previous studies conducted in Jeddah, where the percentages of malnourished participants were 54.3%[7] and 43.7%.[9] This consistent malnutrition prevalence in the current study can be explained by the fact that the patients of all the studies were living in the same city and may have similar medical care. Therefore, identifying the prevalence of malnutrition and associated risk factors for HD patients is noteworthy to improve further nutritional and medical interventions and reduce its prevalence.

In contrast, the proportion of moderately malnourished patients in the present study was smaller than that reported by the study in Palestine (65%). Additionally, there were more severely malnourished patients in our study than in the Palestine study,[1] and lower proportions of moderately malnourished patients were reported in studies conducted in Iran (18.8%) and Australia (40%), but levels of severe malnutrition were higher in both countries (10.9 and 6%, respectively).[13,16] The differences between our study and other studies could be caused by different risk factors, socioeconomic levels, facilities, and population factors. Furthermore, malnutrition in HD patients could be shown in differing degrees by changing some physiological factors, including reduced appetite, diminished taste sensitivity, chewing and ingestion difficulties, increased co-morbidities, diminished cognitive abilities, and obstacles to purchasing and preparing food.[1,17]

The length of dialysis treatment also had a direct relationship with undernutrition. Patients who had experienced 4 years or more of HD were at a higher risk of severe malnutrition than patients with fewer than 4 years of HD. This might be explained by studies which have found that HD duration increases the risk of other diseases and further complications. Moreover, increased HD duration can promote weight loss.[18] HD is a highly catabolic process, leading patients to lose essential nutrients, such as proteins, amino acids, glucose, and vitamins. It has been reported that patients undergoing dialysis three times a week may lose 2 kg of lean body mass every year.[1] However, some studies have indicated that there is no significant link between HD duration and malnutrition,[7,13] potentially because some patients were on a path toward transplant surgery or death.[18]

Regarding the association between HD patients taking a lower number of medications and avoiding malnutrition, the results of this study matched those that were found by the study in Palestine.[1] This result could be related to the effect of medications on nutrient absorption, food intake, and appetite, which may, in turn, promote GI symptoms. Moreover, increasing the number of medications has been associated with increased numbers of diseases and catabolic states.[1] In contrast, the study in Brazil observed the inverse phenomenon.[17]

This study found a significant association between handgrip and malnutrition. This is consistent with a previous study which showed an inverse relationship between handgrip and malnutrition.[19] The handgrip is an inexpensive, simple, fast, and reliable method for evaluating muscle strength and malnutrition, and this measurement was incorporated with anthropometric and laboratory measurements. Additionally, the handgrip results indicate early nutrition status deterioration, which facilitates prompt and early intervention.[19] Our findings showed that the malnourished HD patients recorded lower handgrip values ($P = .011$) compared to the well-nourished HD patients ($18.3 \pm 12$ and $21.5 \pm 11.9$, respectively). This observation could be attributed to potential muscle weakness in response to malnutrition.[19] It is well known that muscle mass, as measured by fat-free mass, is higher in well-nourished HD patients than in malnourished patients.[20] This is in agreement with our findings, where the impact of malnutrition yielded comparable results by reducing both muscle mass and handgrip values. Accordingly, it could be assumed that these factors are correlated and could be used as predictive factors for malnutrition.

In the present study, unemployment was the only socioeconomic factor related to malnutrition; hence, unemployed HD patients were about 2.3 times more likely to be malnourished than employed HD patients. This could be because unemployment is linked to low income, which leads to shortages of food sources, delayed medical treatment, and low healthcare allowance. Furthermore, employed individuals could have better physical and mental health than unemployed individuals, because of their higher mobility and increased contact with others.[4] The employment rate for HD patients varies in different countries; in general, and the number of malnourished patients gradually decreased as employment figures increased.[21]

Several of the predictive factors that were significantly associated with malnutrition in previous studies were not significant in our study. For example, a study conducted in Iran in 2020 indicated that the prevalence of malnutrition was significantly greater among female HD patients than male HD patients, and demonstrated a positive relationship between serum albumin and malnutrition, as well as older age and malnutrition.[15] Meanwhile, the previously mentioned study in Brazil indicated strong associations between malnutrition in HD patients and low incomes, illiteracy, retirement, the presence of hypertension, hospitalization frequency, and depression.[16] Additionally, in the Omari study, malnutrition was positively associated with patients living alone,[1] and the Alharbi study showed strong relationships between nutrition status and sex, hemoglobin, and albumin.[7] The differences between the aforementioned variables and the present study could be due to differences in study population size, recruited age, data collection methods, socioeconomic status, patients' dietary habits, and medical intervention(s).

This study provides updated findings on the prevalence and the risk factors of malnutrition among HD patients in Jeddah City. Furthermore, the study used a combination of questionnaire, clinical and physical examinations, and some laboratory data to highlight important conclusions. There are some limitations of our study. The use of convenience sampling to recruit participants could affect the results or produce biases in the results. The authors did not provide measures of dialysis adequacy (%URR or Kt/V). In addition, because the data were collected from one city the results cannot be generalized for Saudi Arabia. Finally, inflammatory biomarkers and some biochemical parameters, such as phosphorous, potassium, and calcium, as well as interdialytic weight gain that could affect the nutritional status assessment were not considered.

## 5. Conclusions

According to the SGA, malnutrition was highly prevalent among HD patients. The percentage of moderately malnourished patients was 51.7%, severely malnourished was 2.8%, and the remaining patients were well-nourished (45.5%). This high prevalence was significantly associated with unemployment, low muscle strength and muscle mass, increased medications consumption, and length

of HD treatment. These findings indicate the need for healthcare providers to implement regular nutritional assessment, education, counseling, and follow-up consultations with HD patients, as well as being aware of which patients are at risk of malnutrition, preventing nutritional deterioration. Further studies in different regions and with larger sample sizes are recommended to increase the generalizability of the results.

## Acknowledgments

## Author contributions

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