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Duc Manh Nguyen, Minh Hoang Nguyen, Le Thuan Nguyen

Determinants of nutritional risk assessed by the geriatric nutritional risk index in Vietnamese maintenance hemodialysis patients: A cross-sectional study

Internal Medicine Department, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Viet Nam

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Abstract. *Malnutrition is prevalent and strongly predicts adverse outcomes in maintenance hemodialysis (MHD) patients. The Geriatric Nutritional Risk Index (GNRI) is a validated nutritional risk screening tool for this population. This study determined the prevalence of nutritional risk and identified independent factors associated with GNRI scores in Vietnamese MHD patients.*

Methods. A cross-sectional study enrolled 125 end-stage kidney disease (ESKD) patients on MHD for ≥ 3 months at the Dialysis Unit of the Rehabilitation and Occupational Disease Hospital, Ho Chi Minh City, Vietnam, from January to June 2025. Nutritional risk was assessed using the GNRI, calculated from serum albumin, actual body weight, and ideal body weight, and classified into four categories (no risk: GNRI > 98; low risk: 92–98; moderate risk: 82–<92; major risk: < 82). For binary prevalence reporting, patients were dichotomised as at any nutritional risk (GNRI ≤ 98) versus no risk (GNRI > 98), consistent with the original Bouillanne classification. Univariate analysis used Spearman's correlation and the Mann–Whitney U test. Multivariable linear regression with backward elimination identified independent factors associated with GNRI scores.

Results. The mean GNRI score was 94.74 ± 6.75. Overall, 77 patients (61.6%) had any nutritional risk (GNRI ≤ 98), including 38 (30.4%) with low risk, 32 (25.6%) with moderate risk, and 7 (5.6%) with major risk. Multivariable regression identified five independent associated factors of lower GNRI scores: advanced age (B = –0.142; 95% CI: –0.216, –0.069; p < 0.001), diabetes mellitus (B = –2.229; 95% CI: –4.714, –0.085; p = 0.042), active hepatitis C virus (HCV) infection (B = –3.055; 95% CI: –5.847, –0.263; p = 0.032), higher epoetin alfa dose (B = –0.020; 95% CI: –0.033, –0.006; p = 0.005), and elevated parathyroid hormone (PTH) levels (B = –0.002; 95% CI: –0.003, –0.0001; p = 0.027). The final model explained 32.4% of the variance (adjusted R^2 = 0.324).

Conclusions. Nutritional risk is prevalent in Vietnamese MHD patients, affecting 61.6% of the cohort. Malnutrition severity is independently associated with advanced age, diabetes mellitus, active HCV infection, ESA hyporesponsiveness, and secondary hyperparathyroidism. Targeted interventions, including HCV treatment, optimisation of anaemia management, and mineral-bone disorder control, are essential to improve nutritional outcomes in this population.

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Correspondence should be addressed to Minh Hoang Nguyen: hoangnguyencv@gmail.com

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Дук Мань Нгуєн, Мінь Хоанг Нгуєн, Ле Тхуан Нгуєн

Детермінанти нутритивного ризику, оціненого за геріатричним індексом нутритивного ризику, у в'єтнамських пацієнтів, які лікуються гемодіалізом: поперечне когортне дослідження

Кафедра внутрішньої медицини, Медичний університет Фам Нгок Тхать, Хошимін, В'єтнам

Резюме. *Мальнутриція є поширеним ускладненням та відомим предиктором несприятливих наслідків у пацієнтів, які лікуються гемодіалізом (ГД),. Геріатричний індекс нутритивного ризику (GNRI) є валідованим інструментом скринінгу нутритивного ризику в цій популяції. Метою цього дослідження було визначити поширеність нутритивного ризику та ідентифікувати незалежні фактори, асоційовані з GNRI у в'єтнамських ГД пацієнтів.*

Методи. До поперечного когортного дослідження було включено 125 пацієнтів, які лікувались методом ГД понад 3 місяці у відділенні діалізу лікарні реабілітації та професійних захворювань, Хошимін, В'єтнам, у період із січня до червня 2025 року. Нутритивний ризик оцінювали за допомогою GNRI, який розраховували на основі рівня сироваткового альбуміну, фактичної маси тіла та ідеальної маси тіла, і класифікували за чотирма категоріями: відсутність ризику (GNRI > 98); низький ризик (92–98); помірний ризик (82–<92); високий ризик (< 82). Для бінарного представлення поширеності мальнутриції, пацієнтів поділяли на тих, хто мав будь-який нутритивний ризик (GNRI ≤ 98), і тих, хто не мав ризику (GNRI > 98), відповідно до оригінальної класифікації Bouillanne. В однофакторному аналізі використовували кореляцію Спірмена та U-критерій Манна–Вітні. Багатофакторну лінійну регресію з покроковим виключенням змінних застосовували для визначення незалежних факторів, асоційованих із показниками GNRI.

Результати. Середній показник GNRI становив 94,74 ± 6,75. Загалом 77 пацієнтів (61,6%) мали будь-який нутритивний ризик (GNRI ≤ 98). Зокрема, 38 (30,4%) хворих мали низький ризик, 32 (25,6%) – помірний ризик і 7 (5,6%) – високий ризик. Багатофакторна регресія визначила п'ять незалежних факторів, асоційованих з нижчими показниками GNRI: старший вік (B = –0,142; 95% ДІ: –0,216, –0,069; p < 0,001), цукровий діабет (B = –2,229; 95% ДІ: –4,714, –0,085; p = 0,042), активна інфекція вірусу гепатиту C (HCV) (B = –3,055; 95% ДІ: –5,847, –0,263; p = 0,032), вища доза епоетину альфа (B = –0,020; 95% ДІ: –0,033, –0,006; p = 0,005) та підвищений рівень паратиреоїдного гормону (PTH) (B = –0,002; 95% ДІ: –0,003, –0,0001; p = 0,027). Фінальна модель пояснювала 32,4% варіабельності показника (скоригований R^2 = 0,324).

Висновки. Нутритивний ризик визначено у 61,6% пацієнтів. Тяжкість мальнутриції незалежно асоціювалась зі старшим віком, цукровим діабетом, активною HCV-інфекцією, резистентністю до еритропоез-стимулювальних засобів і вторинним гіперпаратиреозом. Цільові втручання, зокрема лікування HCV-інфекції, оптимізація менеджменту анемії та контроль порушень мінерального і кісткового обміну, є необхідними для покращення нутритивних наслідків у цій популяції.

Ключові слова: *хронічна хвороба нирок, гемодіаліз, геріатричний індекс нутритивного ризику, мальнутриція, білково-енергетична недостатність.*

Introduction. Chronic kidney disease (CKD) affects approximately 650 million people worldwide and is a leading cause of death globally [1]with both prevalence and incidence rates on the rise globally. Therefore, the study employed the Global Burden of Disease (GBD. End-stage renal disease (ESRD) requires renal replacement therapy (RRT), of which hemodialysis remains the predominant modality [2].

Protein-energy wasting (PEW) and malnutrition affect 20–75% of patients on maintenance hemodialysis (MHD), driven by uremic anorexia, dialysis-related nutrient losses, systemic inflammation, metabolic acidosis, hormonal derangements, and comorbidities such as diabetes mellitus and chronic viral hepatitis [3]. Nutritional status independently predicts cardiovascular events, hospitalisation, and mortality in MHD patients.

Minh Hoang Nguyen
hoangnguyencv@gmail.com

The Geriatric Nutritional Risk Index (GNRI), developed by Bouillanne et al. [4], uses serum albumin, actual body weight, and ideal body weight to screen nutritional risk. The formula is: GNRI = (1.489 × albumin [g/L]) + (41.7 × [actual body weight / ideal body weight]). Four risk categories are defined: major risk (GNRI <82), moderate risk (82–<92), low risk (92–98), and no risk (GNRI > 98). Lower scores indicate more severe malnutrition and predict increased cardiovascular events and mortality [5, 6]. Each 1-point

GNRI increment has been associated with approximately 5% mortality reduction in MHD patients [5].

Despite the clinical utility of the GNRI, data on Vietnamese MHD patients remain scarce. The existing Vietnamese studies on malnutrition in hemodialysis have employed different assessment tools: Lan et al. used the DMS (Dialysis Malnutrition Score), while a study of Le et al used SGA-DMS (Subjective Global Assessment – Dialysis Malnutrition Score) [6, 7]. Only the study of Tran et al surveyed GNRI combined with PNI (Prognostic Nutritional Index), CONUT (Controlling Nutritional Status), mGPS (modified Glasgow Prognostic Score), and SII (Systemic Immune-Inflammation Index) but has not yet stratified nutritional risk and identified risk factors predicting nutritional status based on GNRI [8]. No Vietnamese study has yet used multivariable regression to identify independent factors associated with GNRI scores. This gap is clinically important because GNRI has important practical advantages over subjective tools such as the Subjective Global Assessment or the Malnutrition – Inflammation Score, which require trained dietitians and are time-consuming. The GNRI relies solely on serum albumin and body weight, both routinely measured in hemodialysis units. This makes it particularly suited for resource-limited settings such as Vietnam, where many local dialysis centres lack dedicated nutrition professionals. However, while the GNRI has been used descriptively in Vietnamese MHD populations, no study has yet identified the independent clinical and biochemical factors associated with GNRI scores using multivariable analysis.

This study aimed to: (1) describe the prevalence and distribution of malnutrition risk classified by the GNRI in Vietnamese MHD patients; and (2) identify independent clinical and biochemical factors associated with GNRI scores. We hypothesised that, in addition to age and diabetes mellitus, HCV infection and CKD-related complications, including anaemia and secondary hyperparathyroidism, would be independently associated with poorer nutritional status.

Patients and methods. _Study design and setting_. A single-centre cross-sectional study was conducted at the Dialysis Unit of the Rehabilitation and Professional Disease Hospital, Ho Chi Minh City, Vietnam, from January to June 2025. The unit provides outpatient MHD three times weekly using standard bicarbonate haemodialysis with high-flux membranes, targeting a single-pool Kt/V of ≥ 1.2 per session. The study was approved by the Institutional Review Board of the Rehabilitation and Occupational Disease Hospital, Ho Chi Minh City (Approval No. 15/HĐĐĐ-BVPHCN-ĐTBNN). All participants provided written informed consent prior to enrolment. Patient data were anonymised and used solely for research purposes, in accordance with the Declaration of Helsinki.

Participants. Inclusion criteria: (1) Age ≥18 years; (2) diagnosis of ESRD undergoing outpatient MHD for ≥3 consecutive months; (3) clinically stable, defined as absence of acute illness, hospitalisation, trauma, or surgery within the preceding 4 weeks; (4) provision of voluntary written informed consent.

Exclusion criteria: (1) Incomplete laboratory data or essential anthropometric measurements; (2) pregnancy; (3) active malignancy or other conditions causing acute, unintentional weight change.

Sample size. Sample size was estimated using a minimum of 10 subjects per predictor variable. Based on 8 – 10 anticipated candidate variables, at least 80 – 100 patients were required. Accounting for 20% potential incomplete data, a target of ≥100 patients was set. All eligible patients during the study period were consecutively enrolled, yielding a final sample of 125.

Data collection. Clinical and demographic data included age, sex, dialysis vintage (years), history of diabetes mellitus (DM), hepatitis B virus (HBV) infection (HBsAg seropositivity), and hepatitis C virus (HCV) infection (anti-HCV seropositivity with detectable HCV RNA), collected from structured interviews and medical records.

Anthropometric measurements included dry body weight (post-dialysis target weight) and height. Ideal body weight (IBW) was calculated using the Lorentz formula.

Epoetin alfa dose was recorded as the mean weekly dose (IU/kg/week) averaged over the preceding 3 months.

Venous blood samples were collected from the arteriovenous fistula before mid-week dialysis after an overnight fast of ≥ 8 hours. Parameters measured included haemoglobin (g/dL), lymphocyte count (K/mm^3), serum albumin (g/L, bromocresol green method), total cholesterol (mmol/L), HDL-cholesterol (mmol/L), LDL-cholesterol (mmol/L), triglycerides (mmol/L), serum phosphate (mmol/L), and intact PTH (iPTH, pg/mL, chemiluminescent immunoassay). Dialysis adequacy was assessed by single-pool Kt/V (Daugirdas second-generation formula).

Nutritional assessment. Nutritional risk was assessed using the GNRI formula [4]:

GNRI = (1.489 × Albumin [g/L]) + (41.7 × [Dry Weight / Ideal Body Weight (kg)])

When actual body weight exceeded IBW, the ratio was capped at 1.0. Patients were classified into four nutritional risk categories according to established GNRI cut-off values (Table 1).

Table 1

Nutritional risk categories

GNRI range	Risk category
GNRI > 98	No nutritional risk
92 ≤ GNRI ≤ 98	Low nutritional risk
82 ≤ GNRI < 92	Moderate nutritional risk
GNRI < 82	Major nutritional risk (severe)
GNRI ≤ 98	Any risk (combined)

GNRI: Geriatric Nutritional Risk Index

For binary prevalence reporting, patients were dichotomised as at-risk (GNRI ≤ 98) versus no risk (GNRI > 98), consistent with the original Bouillanne classification [4]. For regression analysis, GNRI was treated as a continuous outcome variable.

Statistical analysis. Analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± SD or median (IQR: 25th – 75th percentile). Categorical variables are reported as frequencies and percentages. Normality was assessed using the Kolmogorov–Smirnov test.

For univariate analysis, Spearman's rank correlation was used for continuous variables. The Mann-Whitney U test compared GNRI scores between groups for binary categorical variables (sex, DM, HBV, HCV), with effect size r, calculated as r = Z/ . All variables with univariate $p < 0.25$ were entered into the multivariable model [9].

Multivariable linear regression with backward elimination (removal threshold: $p > 0.10$) identified independent predictors of GNRI. Assumptions verified included linearity (partial regression plots), independence of residuals (Durbin-Watson statistic), homoscedasticity (Breusch-Pagan test), normality of residuals (Shapiro-Wilk test), and absence of multicollinearity (VIF < 5). Results are presented as unstandardised B coefficients with 95% confidence intervals (CI). Statistical significance was set at $p < 0.05$ (two-tailed).

Results. Baseline characteristics. Of 125 enrolled patients, the mean age was 56.89 ± 15.47 years (49.60% male). The most prevalent comorbidity was diabetes mellitus (43.20%), followed by active HCV infection (16.80%). Notably, mean serum albumin was below the recommended target (37.13 ± 3.31 g/L; target ≥ 40 g/L), haemoglobin reflected suboptimal anaemia control (10.16 ± 1.59 g/dL), and median iPTH was markedly elevated at 514.70 pg/mL (IQR: 289.05–946.50), indicating widespread secondary hyperparathyroidism. Dialysis adequacy was satisfactory (mean Kt/V: 1.38 ± 0.18). Full details are presented in Table 2.

Table 2

Baseline characteristics of the study population (n = 125)

Variable	Value
Demographic and clinical characteristic	
Age (years), mean ± SD	56.89 ± 15.47
Male sex, n (%)	62 (49.60%)
History of Diabetes Mellitus, n (%)	54 (43.20%)
Active HBV infection (HBsAg+), n (%)	7 (5.60%)
Active HCV infection (anti-HCV+ /HCV RNA+), n (%)	21 (16.80%)
Dialysis vintage, median years (IQR)	2.50 (1.50 – 4.00)
Epoetin alfa dose (IU/kg/week), mean ± SD	155.84 ± 80.76
Kt/V (single-pool), mean ± SD	1.38 ± 0.18
Laboratory characteristic	
Haemoglobin (g/dL), mean ± SD	10.16 ± 1.59
Lymphocyte count (K/mm^3), median (IQR)	1.52 (1.20 – 2.02)
Serum albumin (g/L), mean ± SD	37.13 ± 3.31
Total Cholesterol (mmol/L), median (IQR)	3.22 (2.77 – 3.84)
HDL-cholesterol (mmol/L), median (IQR)	0.91 (0.77 – 1.12)
LDL-cholesterol (mmol/L), median (IQR)	1.48 (1.14 – 1.94)
Triglycerides (mmol/L), median (IQR)	1.34 (0.98 – 2.30)
Serum phosphate (mmol/L), median (IQR)	1.72 (1.47 – 2.20)
iPTH (pg/mL), median (IQR)	514.70 (289.05 – 946.50)

HBV: Hepatitis B Virus; HCV: Hepatitis C Virus; HDL: High-density lipoprotein; IQR: Interquartile Range; iPTH: Intact parathyroid hormone; LDL: Low-density lipoprotein; SD: Standard Deviation.

GNRI scores and nutritional risk classification. The mean GNRI was 94.74 ± 6.75. Using the four-tier Bouillanne classification (Table 1), 48 patients (38.40%) had no risk (GNRI > 98), 38 (30.40%) low risk, 32 (25.60%) moderate risk, and 7 (5.60%) major risk. Overall, 77 patients (61.60%) had GNRI ≤ 98, indicating any degree of nutritional risk. Of these, 39 patients (31.20%) had moderate to major risk (GNRI < 92), representing clinically significant malnutrition.

<u>*Univariate analysis*</u>. Table 3 presents univariate associations between clinical and laboratory variables and GNRI scores. Variables significantly associated with lower GNRI scores were advanced age ($p < 0.001$), female sex ($p = 0.013$), higher epoetin alfa dose ($p = 0.002$), lower haemoglobin ($p = 0.013$), lower lymphocyte count ($p = 0.011$), and higher serum phosphate ($p < 0.001$). History of DM ($p = 0.059$) and HCV infection ($p = 0.054$). All variables with $p < 0.25$ were entered into the multivariable model.

Table 3

Univariate analysis of associations between clinical variables and GNRI scores

Variable	Test	r	p-value
Age (years)	Spearman	−0.353	< 0.001
Female sex	Mann–Whitney U	−0.222	0.013
History of diabetes mellitus	Mann–Whitney U	−0.170	0.059
Active HBV infection	Mann–Whitney U	−0.064	0.477
Active HCV infection	Mann–Whitney U	−0.173	0.054
Dialysis vintage (years)	Spearman	0.042	0.640
Epoetin alfa dose (IU/kg/week)	Spearman	−0.277	0.002
Haemoglobin (g/dL)	Spearman	0.222	0.013
Lymphocyte count (K/mm^3)	Spearman	0.227	0.011
Total cholesterol (mmol/L)	Spearman	−0.057	0.526
HDL-cholesterol (mmol/L)	Spearman	−0.164	0.067
LDL-cholesterol (mmol/L)	Spearman	−0.134	0.139
Triglycerides (mmol/L)	Spearman	0.105	0.248
Serum phosphate (mmol/L)	Spearman	0.316	< 0.001
iPTH (pg/mL)	Spearman	0.104	0.249

Note: *For continuous variables, Spearman's rank correlation coefficient (r) was reported as the measure of association and effect size. For binary categorical variables (sex, DM, HBV, HCV), the Mann–Whitney U test was used to compare GNRI score between groups.*

DM: *diabetes mellitus; HBV: hepatitis B virus; HCV: hepatitis C virus; iPTH: intact parathyroid hormone; r: correlation coefficient and effect size (Mann–Whitney U test)*

<u>*Multivariable linear regression.*</u> Twelve candidate variables with $p < 0.25$ at univariate analysis were entered into the model: age, sex, diabetes mellitus, active HCV infection, epoetin alfa dose, haemoglobin, lymphocyte count, HDL-cholesterol, LDL-cholesterol, triglycerides, serum phosphate, and iPTH.

All regression assumptions were satisfied. No first – order autocorrelation of residuals was detected (Durbin – Watson = 1.97, close to the ideal value of 2.0). Residuals were approximately normally distributed (Shapiro – Wilk $p = 0.14$, failing to reject the null hypothesis of normality). Homoscedasticity was validated (Breusch – Pagan $p = 0.21$, indicating no significant heteroscedasticity). Multicollinearity was absent: all VIF values were < 2.5 (well below the threshold of 5), indicating that the independent variables were sufficiently independent of one another and that coefficient estimates were stable. Linearity was visually assessed via partial regression plots and found acceptable. After backward elimination, five independent associated factors of GNRI scores remained (Table 4). The model explained 32.4% of the variance in GNRI scores ($R^2 = 0.352$; adjusted $R^2 = 0.324$; F-statistic $p < 0.001$).

Table 4

Multivariable linear regression model for independent associated factors of GNRI score

Variable	B	95% CI	p-value	VIF
Age (years)	−0.142	−0.216; −0.069	< 0.001	1.23
History of diabetes mellitus	−2.229	−4.714; −0.085	0.042	1.18
Active HCV infection	−3.055	−5.847; −0.263	0.032	1.09
Epoetin alfa dose (IU/kg/week)	−0.020	−0.033; −0.006	0.005	1.41
iPTH (pg/mL)	−0.002	−0.003; −0.0001	0.027	1.37

$R^2 = 0.352$; Adjusted $R^2 = 0.324$; F-statistic $p < 0.001$. Variables removed by backward elimination ($p > 0.10$): haemoglobin, lymphocyte count, female sex, serum phosphate, HDL-cholesterol, LDL-cholesterol, and triglycerides.

B: unstandardised regression coefficient; CI: confidence interval; HCV: hepatitis C virus; iPTH: intact parathyroid hormone; VIF: variance inflation factor.

Age was the strongest associated factor: each additional year was associated with a 0.142-point decrease in GNRI (B = –0.142; 95% CI: –0.216, –0.069; $p < 0.001$). Patients with DM had GNRI scores 2.229 points lower than non-diabetic patients (B = –2.229; 95% CI: –4.714, –0.085; p = 0.042). Active HCV infection was associated with a 3.055-point reduction (B = –3.055; 95% CI: –5.847, –0.263; p = 0.032), the largest effect among comorbidities. Each 1 IU/kg/week increase in epoetin alfa dose was associated with a 0.020-point decrease (B = –0.020; 95% CI: –0.033, –0.006; p = 0.005). Each 1 pg/mL increase in iPTH was associated with a 0.002-point decrease (B = –0.002; 95% CI: –0.003, –0.0001; p = 0.027).

Discussion. This study demonstrated a high prevalence of nutritional risk among Vietnamese MHD patients: 61.60% had GNRI ≤ 98, and 31.20% had moderate to major risk (GNRI < 92), including 25.60% with moderate risk and 5.60% with major risk. The mean GNRI of 94.74 ± 6.75 places this population in the low to moderate risk range. Five independent factors were independently correlated with lower GNRI scores: advanced age, diabetes mellitus, active HCV infection, higher epoetin alfa dose, and elevated iPTH. These findings highlight several clinically modifiable targets for nutritional intervention.

While associations between malnutrition and factors such as age or diabetes have been reported in other MHD populations, this study offers distinct contributions beyond geographic replication. Previous Vietnamese studies on malnutrition in hemodialysis used either the Dialysis Malnutrition Score, SGA-DMS or GNRI combined with other indices, and none employed multivariable regression to identify independent clinical and biochemical associated factors of GNRI scores.[6–8] This study addresses that gap directly. First, it is the first to evaluate HCV infection as an independent associated factor of GNRI within a multivariable framework. HCV showed the largest effect among comorbidities, identifying a potent and modifiable determinant of nutritional status. Second, the simultaneous evaluation of metabolic (diabetes, secondary hyperparathyroidism), infectious (HCV), and haematological (ESA dose) determinants in a single model provides an integrated view of the multifactorial causes of malnutrition in this population. Third, the identification of modifiable factors, including HCV (treatable with direct-acting antivirals), secondary hyperparathyroidism (manageable with phosphate binders and calcimimetics), and ESA hyporesponsiveness (amenable to iron optimisation), has direct implications for targeted nutritional interventions in Vietnamese dialysis practice.

The prevalence of any nutritional risk in our cohort (61.60%) is consistent with published data from Asian MHD populations. Study at two hospitals in Ho Chi Minh City of Lan et al. 2024 and Linh et al, 2025 found 76.3% and 72,26% of hemodialysis patients had mild to severe malnutrition assessed by the DMS and SGA-DMS, respectively [6,7]. The difference across studies likely reflects the use of different assessment tools and cut-off thresholds, as well as differences in patient demographics and dialysis practices. These findings collectively suggest that malnutrition affects the majority of MHD patients across diverse Asian settings. The relatively high proportion of moderate and major risk patients in our cohort likely reflects the elevated burden of diabetes (43.2%) and chronic viral hepatitis (16.8% HCV), both of which impair nutritional status through distinct pathophysiological mechanisms.

Age was the strongest independent correlated factor (B = –0.142 per year; $p < 0.001$), consistent with Takahashi et al. and Tran et al. [8,10]. Malnutrition in older MHD patients results from physiological anorexia of ageing, sarcopenia, polypharmacy, cognitive decline, and social isolation, compounded by uraemic anorexia and dialysis-related nutrient losses. A multidisciplinary approach integrating dietitian support, physical rehabilitation, and medication review is essential for this subgroup [11].

Diabetic patients had GNRI scores 2.229 points lower than non-diabetic patients (p = 0.042). Diabetes contributes to malnutrition through insulin resistance, impairing skeletal muscle amino acid uptake, advanced glycation end-products promoting chronic inflammation and catabolism, and diabetic gastroparesis, reducing dietary intake [12]. These findings are consistent with reports from Asian MHD cohorts [13].

Active HCV infection showed the largest reduction in GNRI among comorbidities (B = –3.055; p = 0.032), while HBV infection showed no significant association (p = 0.477). This asymmetry is biologically plausible: 60–80% of acute HCV infections progress to chronicity compared with only 5 – 10% of adult HBV infections [14]. Chronic HCV drives hepatic fibrosis and impairs albumin synthesis, directly lowering GNRI scores. Chronic HCV also promotes systemic inflammation, insulin resistance, and mitochondrial dysfunction, all of which potentiate PEW. The availability of direct-acting antiviral (DAA) therapies with > 95% sustained virological response rates offers a modifiable intervention to improve nutritional status in HCV-infected MHD patients.

Higher epoetin alfa dose requirements were independently associated with lower GNRI scores (B = –0.020 per IU/kg/week; p = 0.005). Importantly, the erythropoiesis resistance index (ERI = weekly ESA dose/body weight/haemoglobin) was not calculated. Epoetin alfa dose served only as a surrogate for ESA hyporesponsiveness and does not account for the achieved haemoglobin level. Patients receiving higher doses while maintaining adequate haemoglobin may be misclassified. This association should therefore be interpreted with caution, as it may reflect true hyporesponsiveness, inadequate dosing relative to anaemia severity, or greater overall comorbidity burden. In MHD patients, reduced ESA responsiveness often reflects underlying chronic inflammation, iron deficiency, or uraemic inhibition of erythropoiesis. Inflammatory cytokines (notably IL-6 and TNF-α) simultaneously impair erythropoiesis through hepcidin-mediated iron sequestration and promote protein catabolism, creating a bidirectional relationship between anaemia management difficulty and nutritional deterioration. These findings are consistent with those of Tsai et al., who demonstrated that lower GNRI scores were significantly associated with erythropoietin resistance in dialysis patients [**15**]. Future studies should incorporate ERI for a more precise assessment.

Median iPTH was elevated markedly in our cohorts (514.7 pg/mL). High iPTH was independently associated with lower GNRI scores (B = –0.002 per pg/mL; p = 0.027). Notably, iPTH was not significant at the univariate level (r = 0.104, p = 0.249) but emerged as significant in the multivariable model. This is consistent with statistical suppression: serum phosphate was positively correlated with both iPTH and GNRI at the univariate level (r = 0.316, p < 0.001). When phosphate was included in the model and subsequently removed during backward elimination (p = 0.183), the shared variance between phosphate and iPTH was partitioned out, unmasking the independent negative effect of iPTH on GNRI. This inverse association is consistent with Yoshida et al., who reported that elevated iPTH was independently associated with lower odds of adequate nutritional status (OR = 0.68 for males and 0.83 for females) in a multicentre cohort of 1342 Japanese hemodialysis patients [**16**] their association has not been clarified. The aim of our study was to clarify the association between the geriatric nutritional risk index (GNRI. High PTH levels correlated with low muscle mass in the study of Liu et al. [**17**]. These findings show a negative effect of iPTH on nutritional status rather than a statistical artefact. Proposed mechanisms include PTH-mediated increases in resting energy expenditure through protein and lipid catabolism, and stimulation of brown adipose tissue thermogenesis [**18, 19**]. In the context of dietary restrictions inherent to MHD, chronically elevated energy expenditure may accelerate PEW.

Our study has several limitations. First, the cross-sectional design precludes causal inference. Second, this was a single-centre study. Regional variations in dialysis practices, comorbidity profiles (particularly the prevalence of diabetes and viral hepatitis between Northern and Southern Vietnam), dietary patterns, socioeconomic factors, and medication access may all influence GNRI scores. Our urban centre in Ho Chi Minh City may serve a population differing from rural or Northern Vietnamese dialysis units, or from international cohorts. Multicentre studies across diverse Vietnamese regions are needed to determine generalisability. Third, the sample size (n = 125), while meeting the subjects-per-variable criterion, may limit power for smaller effects to detect factors with marginally non-significant. Fourth, serum albumin, the primary biochemical component of the GNRI, is a negative acute-phase reactant reduced by systemic inflammation, fluid overload, and hepatic dysfunction independently of nutritional intake. Without inflammatory markers such as CRP or IL-6, we cannot distinguish true protein-energy malnutrition from inflammation-driven hypoalbuminaemia. This is especially relevant given the prevalence of the malnutrition-inflammation complex syndrome (MICS) in MHD populations. The associations with epoetin alfa dose and iPTH, both influenced by inflammatory status, may partly reflect inflammatory burden rather than nutrition per se. Future studies incorporating inflammatory markers alongside the GNRI would improve model explanatory power (current adjusted $R^2 = 0.324$) and enable separation of nutritional from inflammatory components. Fifth, ERI was not directly calculated. As discussed, the epoetin alfa dose as a proxy for ESA hyporesponsiveness does not account for achieved haemoglobin, and the observed association should be interpreted accordingly. Sixth, dietary intake data were not collected. Future longitudinal, multicentre studies incorporating dietary assessment, inflammatory profiling, and direct ERI measurement are warranted.

Conclusions. Nutritional risk is prevalent in Vietnamese MHD patients, with 61.6% classified as at-risk (GNRI ≤ 98) and 31.2% having moderate-to-major risk (GNRI < 92). Advanced age, diabetes, active HCV infection, higher ESA dose, and elevated iPTH were independently associated with poorer nutritional status. Active HCV infection showed the largest effect among comorbidities, identifying a key modifiable target. Routine GNRI screening, aggressive HCV treatment, and optimisation of anaemia and mineral-bone disorder management should be integrated into standard MHD care.

Competing interests. The authors have no conflicts of interest to declare.

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Ethics approval and consent to participate. The study was approved by the Institutional Review Board of the Rehabilitation and Occupational Disease Hospital, Ho Chi Minh City (Approval No. 15/HĐĐĐ-BVPHCN-ĐTBNN). All participants provided written informed consent prior to enrolment. Patient data were anonymised and used solely for research purposes, in accordance with the Declaration of Helsinki.

Data availability statement. The data supporting the findings of this study are available from the corresponding author upon reasonable request but are not publicly accessible due to ethical and patient confidentiality restrictions, in accordance with the IRB approval of the Rehabilitation and Occupational Disease Hospital, Ho Chi Minh City, Vietnam (No. 15/HĐĐĐ-BVPHCN-ĐTBNN)

Author contributions.

Duc Manh Nguyen: conceptualisation, methodology, formal analysis;

Hoang Minh Nguyen: data curation, investigation and writing original draft;

Le Thuan Nguyen: supervision, writing, review and editing.

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