




Current Status and Determinants of Fatigue in Chinese Older Adults Receiving Maintenance Hemodialysis: A Multicentre Cross-Sectional Study

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Background: Fatigue is highly prevalent in older adults receiving maintenance hemodialysis and seriously affects quality of life. However, evidence on the current status of fatigue and its determinants in this population remains scarce, especially in the unique socio-cultural context of China.

Aim: A multicenter cross-sectional study to investigate the current status of fatigue and analyze associated factors in Chinese older adults receiving maintenance hemodialysis to provide information for targeted interventions.

Methods: This multicenter cross-sectional study was conducted between July 2024 and February 2025. A convenience sampling method was used to recruit 279 older adults receiving maintenance hemodialysis from two tertiary hospitals in Wuxi City. The Revised Piper Fatigue Scale, the Self-Efficacy in Chronic Disease Scale, the Index of Family Caring Scale, the Medical Coping Scale, the Anxiety Self-Rating Scale, and the Depression Self-Rating Scale were used to assess fatigue and related factors. Influential factors were analyzed by *t*-test, Pearson correlation, and multiple linear regression.

Results: The prevalence of fatigue was 80.3%, and multiple linear regression showed: dialysis vintage ≥ 5 years ($\beta=0.092$, $P<0.05$), self-efficacy ($\beta=-0.309$, $P<0.001$), family care ($\beta=-0.212$, $P<0.001$), confrontation coping style ($\beta=-0.194$, $P<0.001$), avoidance coping style ($\beta=0.090$, $P<0.01$), depression ($\beta=0.104$, $P<0.05$), hemoglobin ($\beta=-0.083$, $P<0.05$), and serum albumin ($\beta=-0.075$, $P<0.05$) were independent determinants on fatigue.

Conclusion: Fatigue is a prominent and serious problem in Chinese older adults receiving maintenance hemodialysis, which is influenced by a combination of physical, psychological, and social factors. Based on the determinants identified, targeted interventions should prioritize enhancing self-efficacy through structured education and skill-building programs, strengthening family support systems via family empowerment models, and promoting adaptive coping strategies through cognitive-behavioral techniques. There is an urgent need to incorporate fatigue into routine clinical monitoring and implement such individualized management to improve quality of life and prognosis.

Keywords: hemodialysis, older adults, fatigue, self-efficacy, family functioning

Introduction

Chronic kidney disease (CKD) has become a major global public health challenge, with a prevalence exceeding 10%.¹ End-stage renal disease (ESRD), the terminal stage of CKD, is characterized by irreversible loss of kidney function and necessitates renal replacement therapy. As populations age, the incidence of ESRD continues to rise.² The global annual incidence is approximately 146 cases per million population, and China has the largest number of affected individuals.³ The expanding ESRD population has resulted in a global renal resource supply that is insufficient to meet demand,

making hemodialysis the primary treatment method for ESRD patients.⁴ Notably, an increasing proportion of patients receiving maintenance hemodialysis (MHD) are older adults. The mean age of incident patients with MHD in Europe is 65.5 years;⁵ in China, 61.2% of newly initiated dialysis patients are ≥ 60 years,⁶ indicating that older adults now constitute the majority of the MHD population.

Although MHD prolongs survival, patients experience high hospitalization and mortality rates and substantial declines in quality of life, imposing considerable psychological and financial burdens on patients and families.⁷ Among the myriad physical symptoms exacerbated by the disease and its treatment, fatigue is one of the most prevalent and debilitating complications, affecting 20–86% of patients with MHD,⁸ with most reporting moderate to severe intensity. Recognized for its clinical significance, fatigue has been designated by the Standardised Outcomes in Nephrology–Haemodialysis (SONG-HD) initiative as a core outcome measure for patients with MHD, alongside vascular access complications, cardiovascular events, and mortality, and recommends its routine assessment in clinical studies.⁹

Fatigue is a multidimensional symptom, defined as a pervasive, subjective sense of exhaustion that diminishes functional capacity and impedes engagement in daily activities, encompassing physical, mental, cognitive, emotional, and motivational fatigue.¹⁰ In patients with MHD, fatigue is closely associated with poorer quality of life, sleep disturbance, and physical discomfort. Evidence indicates that patients transitioning from a non-fatigued to a fatigued state have a 2.18-fold higher mortality risk, and each one-point increase in fatigue score corresponds to a 6% rise in mortality risk.¹¹ Furthermore, fatigue is significantly linked to an increased risk of cardiovascular disease and suicidal ideation.¹² Older adults receiving MHD are particularly susceptible to fatigue due to the compounding effects of aging and comorbidities,⁷ severely undermining their physical health and overall well-being. The World Health Organization's Global Report on Ageing and Health underscores that healthy aging entails not only preservation of physical function but also improvement in overall quality of life and well-being. Addressing fatigue in this population is therefore a clinical priority.

Existing studies have identified multiple correlates of fatigue in MHD, including age,¹³ educational attainment,¹⁴ sleep quality,¹⁵ psychological status,¹⁶ and social support.⁸ However, within China's unique cultural and socioeconomic context, research specifically targeting fatigue in older adults on MHD remains limited, and tailored interventions are scarce. The Chinese sociocultural environment, deeply influenced by Confucian values such as filial piety and collectivism, places strong emphasis on family centrality within social support systems. Within this context, familial involvement becomes a cornerstone of health management, wherein family members frequently assume intensive caregiving roles and provide substantial emotional and instrumental support. This culturally embedded, family-oriented ecosystem may uniquely shape the fatigue experience among older adults receiving MHD. For example, prior research has shown that family support is associated with fatigue in patients with hepatocellular carcinoma,¹⁷ suggesting its potential relevance in other chronic conditions. Nevertheless, the specific role and influence of family support on fatigue in older adults undergoing MHD within China's distinct sociocultural context have not been sufficiently explored and warrant focused investigation. Psychological factors such as anxiety and depression are also influential in MHD,¹⁸ yet their specific relationship with fatigue in older adults is not well defined. In addition, low self-efficacy is common in MHD and has been associated with adverse outcomes.¹⁹ Given the multidimensional and complex nature of fatigue, a systematic examination of its determinants in older adults receiving MHD is warranted.

Therefore, this study aimed to describe the current status of fatigue in Chinese older adults receiving MHD and to analyze its determinants, providing empirical evidence to elucidate its multifactorial underpinnings and to inform the development and implementation of culturally appropriate fatigue-intervention strategies.

Research Hypotheses:

H1. Fatigue prevalence is high among Chinese older adults receiving MHD, with a substantial proportion at moderate-to-severe levels.

H2. Fatigue severity is associated with multidomain characteristics, including psychosocial factors (eg, self-efficacy, family functioning, depressive symptoms), physiological factors (eg, hemoglobin, serum albumin), dialysis-related factors (eg, dialysis vintage), and demographic factors (eg, age, education).

Methods

Aim

The study aimed to investigate the current status of fatigue in Chinese older adults receiving MHD and to analyze its determinants.

Design

This study adopted a multicentre cross-sectional research design. Our study was reported based on the Report of Observational Studies in Epidemiology (STROBE) Cross-sectional Research Inventory.

Participants

This cross-sectional study was conducted at the hemodialysis centers of two tertiary-level hospitals in Wuxi City. Data collection took place from July 2024 to February 2025. During this period, older adults receiving MHD treatment who met the inclusion criteria were consecutively enrolled using a convenience sampling method. The inclusion criteria were as follows:

Inclusion criteria: (1) aged ≥ 60 years; (2) diagnosed with ESRD,²⁰ undergoing regular hemodialysis for ≥ 3 months, and in a relatively stable condition (stable vital signs, absence of acute complications); (3) no cognitive dysfunction, and possessing normal reading comprehension and communication skills; (4) informed consent and voluntary participation in this study.

Exclusion criteria: (1) diagnosed with severe mental illnesses; (2) presence of chronic infections, such as known or suspected active tuberculosis, current anti-tuberculosis therapy, or TB-related symptoms (eg, persistent cough, fever, night sweats, unintended weight loss); (3) having malignant neoplasms or other critical life-threatening conditions.

Sample size was determined a priori using G*Power 3.1 (*F*-tests: linear multiple regression, fixed model, R^2 deviation from zero). Assuming a medium effect size ($f^2=0.15$), $\alpha=0.05$, power $(1-\beta)=0.90$, and 19 planned predictors, the required sample size was $N=187$. To allow for potential invalid responses to questionnaires, we inflated the target by 20% to $N=224$. Ultimately, 279 patients undergoing MHD completed the survey.

Measures

General Information Questionnaire

Socio-demographic information and clinical indicators were collected by reviewing the patient's electronic medical record system, including gender, age, marital status, place of residence, education level, per capita monthly household income, primary disease, dialysis vintage, inter-dialytic weight gain percentage (IDWG%, $IDWG\% = [(inter-dialytic\ weight\ gain / dry\ weight) \times 100\%]$), Kt/V, serum albumin, and hemoglobin.

The Revised Piper Fatigue Scale (RPFS)

The scale was revised by Piper equal to 1998.²¹ The scale consists of 22 items and is scored on a 0–10 point scale, with the final score being the average of all the item scores, which is used to assess the severity of fatigue: 0–3 for mild fatigue, 4–6 for moderate fatigue, and ≥ 7 for severe fatigue. This scale has been widely applied in studies of patients undergoing MHD.^{22,23} The Chinese version of the RPFS has demonstrated excellent psychometric properties in previous studies. It showed high internal consistency with a Cronbach's alpha of 0.97.

Self-Efficacy for Chronic Disease Scale (SECD)

This scale was developed by Lorig et al²⁴ and is suitable for assessing the confidence level of chronic disease patients in the task of self-management of their disease. The scale contains six entries, with higher scores indicating greater self-efficacy. The scale has established reliability and validity across diverse cultural contexts.^{25,26} In this study, it exhibited high internal consistency with a Cronbach's alpha of 0.929.

Family APGAR Index (APGAR)

This scale was developed by Smilkstein et al²⁷ in 1978 to assess family functioning. The total score of the scale ranges from 0–10, with 0–3 indicating severe impairment of family functioning, 4–6 indicating moderate impairment, and 7–10

indicating good family functioning. APGAR has been widely used in the Chinese family, with great reliability and validity.²⁸ In this study, it exhibited acceptable internal consistency with a Cronbach's alpha of 0.752.

Medical Coping Mode Questionnaire (MCMQ)

This scale was developed by Feifel et al²⁹ in 1987 to assess the coping strategies adopted by patients in disease situations, comprising three dimensions: confrontation, avoidance, and submission. The questionnaire is scored on a Likert scale of 4; the higher the score of the dimension, the more the patient tends to adopt this kind of coping. This questionnaire demonstrates good reliability and validity, with a Cronbach's alpha coefficient of the scale at 0.796.

Self-Rating Anxiety Scale (SAS)

This scale was developed by Zung³⁰ in 1971. It is based on a 4-point Likert scale, with a standard score of <50 as no anxiety, 50–59 as mild anxiety, 60–69 as moderate anxiety, and ≥ 70 as severe anxiety. This scale has been widely adopted in international clinical practice and research as a reliable assessment tool. In this study, its internal consistency was good, with a Cronbach's alpha of 0.814.

Self-Rating Depression Scale (SDS)

This scale was developed by Zung³¹ in 1965 to assess the severity of depressive symptoms. It is based on a 4-point Likert scale, with a standard score of <50 classified as no depression, 50–60 classified as mild depression, 60–70 classified as moderate depression, and >70 classified as severe depression. This scale has been widely adopted in international clinical practice and research as a reliable assessment tool. In this study, the Cronbach's alpha coefficient for the scale was 0.856.

Data Collection

The researcher and two uniformly trained investigators conducted an on-site survey utilizing a paper-based questionnaire. Before the survey, participants were thoroughly informed about the study's objective and relevance, the procedure for completing the questionnaire, and the principle of confidentiality. Aside from the clinical indicators, which were examined by the researcher in the medical record, the remaining scales were completed by the patients themselves. For patients experiencing reading or writing challenges, the investigator inquired about each item and completed the questionnaire on their behalf based on their responses. All questionnaires were gathered on-site and confirmed for completeness.

This study circulated 283 questionnaires, recovering 279 valid responses, resulting in a valid recovery percentage of 98.59%.

Statistical Analysis

Data entry and analysis were done using SPSS 26.0 software, and the recovered surveys were numbered. Missing data were handled using mean imputation for continuous variables. Measurement data conforming to normal distribution were expressed as mean \pm standard deviation (Mean \pm SD); count data were described as frequency and percentage (n, %). Differences in fatigue scores among patients with different demographic and clinical characteristics were compared using independent samples *t*-tests and one-way analysis of variance (ANOVA). Pearson correlation analysis was used to explore the correlation between the scale scores, physiological indicators, and fatigue scores. The fatigue score was used as the dependent variable, and variables that were statistically significant in one-way analyses were subjected to multiple linear regression analyses. $P < 0.05$ was considered a statistically significant difference. All selected variables were entered simultaneously into a multivariate linear regression model using the forced entry method to assess their independent association with fatigue.

Regression assumptions. Model assumptions were checked using standard diagnostics: linearity with partial regression (added-variable) plots; residual normality with the histogram and P–P plot; homoscedasticity with residual-versus-fitted plots; multicollinearity with variance inflation factors (VIF); and independence of errors with the Durbin–Watson statistic.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Jiangnan University (Approval No. JUN202412RB029) and the Ethics Committee of Jiangnan University Affiliated Center Hospital (Approval No. (2024) Y-245). Written informed consent was obtained from all participants before their inclusion in the study.

Results

General Information on Older Adults Receiving MHD

A total of 279 older adults receiving MHD were included in this study. Of these, 158 (56.6%) were male and 121 (43.4%) were female. The majority of participants were 60–74 years old (85.3%), were married (84.2%), and resided in urban areas (76.7%). Detailed demographic and clinical characteristics are presented in [Table 1](#).

Fatigue Status of Older Adults Receiving MHD

Among 279 older adults receiving MHD, the mean patient fatigue score was (4.46 ± 2.93) . 55 (19.7%) patients had no fatigue, and 224 (80.3%) patients reported the presence of fatigue. Of these, 56 (20.1%) were mildly fatigued, 102 (36.6%) were moderately fatigued, and 66 (23.7%) were severely fatigued, indicating that the proportion of patients with moderate fatigue was the highest. The distribution of fatigue severity is detailed in [Table 2](#).

Table 1 General Information on Older Adults Receiving MHD

Variables	Categories	Frequency (n)	Percent (%)
Gender	Male	158	56.6
	Female	121	43.4
Age (years)	60-74	238	85.3
	≥75	41	14.7
Marital status	Married	235	84.2
	Unmarried/Divorced/widowed	44	15.8
Residence	Rural	65	23.3
	Urban	214	76.7
Education level	Primary and below	117	41.9
	Middle School	122	43.7
	High School and above	40	14.3
Monthly income (yuan)	≤3000	97	34.8
	3001–5000	136	48.7
	≥5001	46	16.5
Primary Disease	Glomerulonephropathy	101	36.2
	Diabetic nephropathy	77	27.6
	Hypertensive nephropathy	61	21.9
	Other	40	14.3
Dialysis vintage (years)	≤1	67	24.0
	1–5	107	38.4
	≥5	105	37.6

Table 2 Severity of Fatigue

Level	Frequency (n)	Percent (%)
No fatigue	55	19.7
Mild fatigue	56	20.1
Moderate fatigue	102	36.6
Severe fatigue	66	23.7

One-Way Analysis of Fatigue Scores

Given that continuous variables were tested to be basically in line with normal distribution, two independent samples *t*-test or one-way analysis of variance (ANOVA) was used to examine the differences in fatigue scores of patients with different demographic characteristics.

The results showed that the effects of age, marital status, place of residence, education level, per capita monthly household income, and dialysis vintage on the fatigue scores of older adults receiving MHD were statistically significant ($p < 0.05$). See Table 3 for details.

Correlation Analysis Between Fatigue Scores and Related Variables

Pearson correlation analysis was used to explore the correlation between scale scores, physiological indicators, and total fatigue scores (the data conformed to normal distribution). The results showed that the total fatigue score was significantly and negatively correlated with self-efficacy ($r = -0.746, p < 0.01$), family caring ($r = -0.668, p < 0.01$), confrontation coping style ($r = -0.656, p < 0.01$), hemoglobin level ($r = -0.490, p < 0.01$), and serum albumin level ($r = -0.432, p < 0.01$). The total fatigue score was significantly and positively correlated with avoidance coping style ($r = 0.357, p < 0.01$), submission coping style ($r = 0.580, p < 0.01$), anxiety score ($r = 0.275, p < 0.01$), depression score ($r = 0.292, p < 0.01$), and the inter-dialytic weight gain percentage ($r = 0.292, p < 0.01$). Detailed results are shown in Table 4.

Table 3 Results of Univariate Analysis of Total Fatigue Score in Older Adults Receiving MHD (n=279)

Variables	Frequency	Fatigue Score ($\bar{x} \pm s$)	t/F	P
Gender			-0.338 ^a	0.735
Male	158	4.40±2.85		
Female	121	4.52±3.05		
Age (years)			-3.057 ^a	0.002
60–74	238	4.24±2.91		
≥75	41	5.73±2.79		
Marital status			-5.258 ^a	<0.001
Married	235	4.07±2.80		
Unmarried/Divorced/widowed	44	6.49±2.82		
Residence			2.961 ^a	0.003
Rural	65	5.39±2.74		
Urban	214	4.17±2.94		
Education level			10.497 ^b	<0.001
Primary and below	117	5.32±2.67		
Middle School	122	4.03±2.98		
High School and above	40	3.23±2.86		
Monthly income (yuan)			14.117 ^b	<0.001
≤3000	97	5.67±2.62		
3001–5000	136	3.75±2.90		
≥5001	46	3.99±2.90		
Primary Disease			1.526 ^b	0.208
Glomerulonephropathy	101	4.28±2.99		
Diabetic nephropathy	77	4.63±2.88		
Hypertensive nephropathy	61	4.96±2.80		
Other	40	3.79±3.03		
Dialysis vintage (years)			17.232 ^b	<0.001
≤1	67	3.07±2.65		
1–5	107	4.23±2.49		
≥5	105	5.57±3.10		

Notes: ^a *t*-test, ^b ANOVA.

Table 4 Results of Correlation Analyses Between Scales and Physiological Indicator Variables

Variables	Fatigue	Self-Efficacy	Family Care	Confrontation	Avoidance	Submission	Anxiety	Depression	KT/V	IDWG%	Hb	ALB
Fatigue	I											
Self-efficacy	-0.746**	I										
Family care	-0.668**	0.530**	I									
Confrontation	-0.656**	0.536**	0.473**	I								
Avoidance	0.357**	-0.234**	-0.204**	-0.260**	I							
Submission	0.580**	-0.495**	-0.497**	-0.455**	0.177**	I						
Anxiety	0.275**	-0.210**	-0.233**	-0.186**	0.047	0.218**	I					
Depression	0.626**	-0.517**	-0.519**	-0.489**	0.242**	0.493**	0.256**	I				
KT/V	-0.028	0.033	0.087	0.066	0.097	-0.028	-0.001	-0.014	I			
IDWG%	0.292**	-0.287**	-0.231**	-0.191**	0.098	0.162**	0.012	0.173**	0.084	I		
Hb	-0.490**	0.397**	0.377**	0.347**	-0.235**	-0.380**	-0.104	-0.350**	0.041	-0.287**	I	
ALB	-0.432**	0.351**	0.260**	0.322**	-0.177**	-0.295**	-0.154*	-0.350**	0.070	-0.265**	0.286**	I

Notes: The numbers in the table represent the correlation coefficients *r*; * denotes $P < 0.05$; ** denotes $P < 0.01$; "IDWG%" represents inter-dialytic weight gain percentage; "Hb" represents hemoglobin; "ALB" represents albumin.

Multivariate Linear Analysis of Factors Affecting Fatigue

The total fatigue score was used as the dependent variable, and the univariate analyses (age, marital status, place of residence, education, per capita monthly household income, dialysis vintage) and Pearson correlation analyses (self-efficacy, family care, confrontation coping style, avoidance coping style, submission coping style, anxiety scores, depression scores, and inter-dialytic weight gain percentage, hemoglobin, serum albumin) with $p < 0.05$ were included in the regression model as independent variables. Categorical variables have been treated as dummy variables (see Table 5 for the assignment scheme).

The multiple linear regression analysis (Table 6) identified dialysis vintage ≥ 5 years, self-efficacy, family care, confrontation coping style, avoidance coping style, depressive symptoms, serum albumin, and hemoglobin as independent determinants of the total fatigue score among older adults receiving MHD ($p < 0.05$). The model exhibited excellent fit ($F=47.245, p < 0.001; R^2=0.776; \text{adjusted } R^2=0.760$) and met all statistical assumptions: residuals were approximately normal and homoscedastic, relationships were linear, multicollinearity was low (VIF 1.17–2.06; all < 3), and errors were independent (Durbin–Watson = 1.85). Beyond statistical significance, we interpreted the standardized coefficients (β) alongside unstandardized estimates (B) and 95% confidence intervals to assess clinical relevance. This analysis revealed that self-efficacy demonstrated a moderate inverse association with fatigue ($\beta = -0.309; B = -0.680, 95\% \text{ CI } -0.863 \text{ to } -0.497$), suggesting its role as a clinically relevant predictor. In contrast, avoidance coping, although statistically significant, exhibited a small effect size ($\beta = 0.090; B = 0.120, 95\% \text{ CI } 0.036 \text{ to } 0.205$), indicating a limited practical impact on fatigue in this population.

Table 5 Assignment of Values to Categorical Variables

Variables	Assignment of Value
Age (years)	60–75 = 0; $\geq 75 = 1$
Marital status	Married = 0; Unmarried / Divorced / widowed = 1
Residence	Rural =0; Urban =1
Education level	With primary school or below as the baseline Middle School: Middle School = 1; otherwise = 0 High school and above: High school and above = 1; otherwise = 0
Monthly income (yuan)	With ≤ 3000 as the baseline 3001–5000: 3001–5000= 1; otherwise = 0 $\geq 5001: \geq 5001= 1; \text{ otherwise } = 0$
Dialysis vintage (years)	With ≤ 1 as the baseline 1–5:1–5 = 1; otherwise = 0 $\geq 5: \geq 5 = 1; \text{ otherwise } = 0$

Table 6 Results of Multifactorial Analysis of Fatigue in Older Adults Receiving MHD (n=279)

Variables	B	SE	β	t	P	95% CI for B		VIF
						Lower Limit	Upper Limit	
Constant	11.615	2.151		5.401	<0.001**	7.380	15.850	
Dialysis vintage (years) (Baseline:≤1)	–	–	–	–	–	–	–	–
≥5	0.552	0.242	0.092	2.278	0.024*	0.075	1.029	1.866
Self-efficacy	–0.680	0.093	–0.309	–7.326	<0.001**	–0.863	–0.497	2.061
Family care	–0.373	0.071	–0.212	–5.259	<0.001**	–0.513	–0.233	1.883
Confrontation	–0.129	0.026	–0.194	–5.048	<0.001**	–0.179	–0.079	1.707
Avoidance	0.120	0.043	0.090	2.816	0.005**	0.036	0.205	1.174
Depression	0.035	0.014	0.104	2.570	0.011*	0.008	0.062	1.905
Hemoglobin	–0.015	0.007	–0.083	–2.272	0.024*	–0.029	–0.002	1.542
Albumin	–0.057	0.027	–0.075	–2.148	0.033*	–0.110	–0.005	1.414

Note: $R^2=0.776$, adjusted $R^2=0.760$; $F=47.245$, $P<0.001$. * denotes $P < 0.05$; ** denotes $P < 0.01$.

To further examine the interplay among predictors, we conducted univariable regression analyses. The corresponding coefficients differed from those in the multivariable model, indicating potential interrelationships among predictors. Detailed results are provided in [Supplementary Table 1](#).

Discussion

In this study, the prevalence of fatigue was as high as 80.3% in 279 older adults receiving MHD investigated and more than 60.3% of the patients reported moderate or severe fatigue. This outcome indicates that fatigue is widespread and intense in this demographic, imposing a significant burden on patients and their families. Jhamb et al³² reported that the incidence of fatigue in patients with MHD ranged from 65–97%, aligning with the findings of the current investigation. Some scholars analyzed the probability of fatigue in Chinese patients with MHD, and the results showed that the incidence of fatigue ranged from 70.8% to 72.2%,²³ which is lower than the findings of the current study. In contrast, a survey of patients with MHD over 65 years of age found high levels of fatigue in older adults receiving MHD, with an MHD patient score of (5.09 ± 1.22) and a moderate-to-severe fatigue incidence of 76.67%,³³ surpassing the findings of the current study. This disparity may be attributed to the characteristics of the study sample (eg, age distribution), geographical differences, and different fatigue assessment tools used. This suggests that future studies need to focus on developing or validating standardized fatigue assessment tools that apply to MHD populations with good sensitivity and specificity to improve the accuracy of fatigue identification. This study and previous literature consistently show that fatigue is prominent and severe in older adults receiving MHD and requires urgent clinical attention. Fatigue screening and assessment should be strengthened, and individualized intervention strategies should be developed and implemented based on the results of the assessment, to effectively reduce the degree of fatigue and improve the quality of life of patients.

In this study, we found that dialysis vintage was an independent influence on fatigue in older adults receiving MHD. This result is similar to the findings of Gobbi et al.³⁴ Prolonged dialysis may exacerbate issues such as uremic toxin accumulation, calcium and phosphorus metabolism disorders, and immune dysfunction, resulting in complications like pruritus, malnutrition, and other conditions that elevate the body's burden, thereby inducing or worsening fatigue. Research indicates that the heightened burden of complications may diminish patients' trust in treatment, elevate psychological stress, and further intensify fatigue.³⁵ Patients with a longer dialysis vintage are associated with higher rates of treatment failure and mortality as well as a poorer prognosis.³⁶ Therefore, healthcare professionals should devote more attention to patients with longer dialysis vintage, regularly assess their fatigue status and needs, promptly adjust treatment regimens, and enhance nutritional support and psychological counseling to reduce their fatigue symptoms, which is crucial for improving patients' health outcomes and quality of life.

Self-efficacy, a fundamental element of Bandura's social cognitive theory,³⁷ serves as a significant predictor of individual motivation, behavioral performance, and persistence, profoundly influencing the domains of education,

healthcare, and personal development. In this study, correlation analysis showed that self-efficacy was significantly negatively associated with fatigue in older adults receiving MHD, and multifactorial analysis further established self-efficacy as an independent factor influencing their fatigue. Although studies specifically exploring the relationship between fatigue and self-efficacy in older adults receiving MHD are limited, studies in patients with other chronic diseases, such as esophageal cancer³⁸ and rheumatoid arthritis,³⁹ support that self-efficacy is an important influence on fatigue, and that the lower the level of self-efficacy, the greater the degree of fatigue in patients. Studies have shown that individuals with high self-efficacy tend to demonstrate better self-management abilities and health literacy, which in turn affects the quality of life of patients with chronic diseases.^{40,41} Decreased self-efficacy predicts decreased quality of life, which highlights the importance of improving self-efficacy in older adults receiving MHD. Consequently, healthcare professionals should fully recognize the significance of self-efficacy and develop interventions, such as targeted health education and counseling programs, to stimulate the internal motivation and self-efficacy of patients with MHD through the use of self-efficacy theoretical models, such as Bandura's self-efficacy theory, to help patients cope with the challenges of the disease, alleviate the fatigue level, and improve the quality of life.

Family functioning reflects a family's ability to maintain cohesion, fulfill roles, resolve domestic issues, adapt to stressors, and communicate effectively. It helps create an environment that supports members' physiological, psychological, and social well-being, and serves as a predictor of mental health and subjective well-being.⁴² In this study, both correlation and multivariate analyses indicated that higher family functioning is significantly and independently associated with lower levels of fatigue. This result is consistent with prior research on fatigue in patients recovering from stroke.⁴³ Social support, particularly from family, plays a beneficial role in self-management behaviors among individuals receiving MHD, serving as a vital source of both emotional and practical support.⁴⁴ This reliance on family can be interpreted within China's distinct socio-cultural background. Influenced by Confucian values, the traditional norm of children supporting aging parents remains strongly upheld. Thus, the family often forms the central living and support environment for older adults. This is especially pertinent for those undergoing MHD, who commonly rely on family members for daily assistance. As a result, the quality of family support considerably influences their overall quality of life. Similar observations have been noted in studies of Chinese patients with hematological malignancies, where stronger family support is correlated with improved well-being.⁴⁵ Evidence supports the value of family-centered empowerment models in enhancing family functioning, self-efficacy, and quality of life among adults with chronic conditions.⁴⁶ Consistent with these insights, the current study identifies family functioning as an important determinant of fatigue among older adults receiving MHD. It is thus recommended that healthcare providers implement targeted interventions, such as structured programs that involve family members in care and improved social assistance resources, to enhance family functioning. Such strategies could help reduce symptom burden and enhance overall well-being in this population.

Coping refers to the cognitive and behavioral strategies that an individual adopts to maintain psychological equilibrium in the face of stress or distress.⁴⁷ Medical coping, ie, medical coping strategy, is a response to stressful events exhibited by patients when facing stress or adversity and is characterized by active adjustment of cognition and the need to adapt to the environment. In this study, correlation analysis indicated that confrontation coping styles were negatively associated with fatigue, whereas avoidance and submission coping styles were positively correlated with fatigue. Multivariate analysis further identified both confrontation and avoidance coping styles as independent determinants of fatigue. This aligns with observations in post-stroke patients, in which maladaptive coping strategies have been associated with higher fatigue levels.⁴⁸

It is noteworthy that coping strategies do not operate in isolation but are closely interrelated with emotional states. Previous research in MHD populations indicates that confrontational coping tends to correlate negatively with symptoms of anxiety and depression, whereas avoidant and resigned coping styles often exhibit positive associations with these psychological symptoms.⁴⁹ Although longitudinal studies in other chronic conditions suggest that preexisting psychological factors such as depression history are among the strongest predictors of persistent fatigue, and that the beneficial effect of adaptive coping may be reduced when prominent depressive symptoms are present,⁵⁰ the current findings still support the clinical relevance of coping behaviors. These results suggest that coping represents a modifiable target for interventional efforts, even if its effects may be partially mediated through emotional pathways. Therefore, healthcare providers should consider evaluating coping behaviors in clinical practice and promoting more adaptive strategies, for

instance, through cognitive-behavioral interventions. Such approaches may not only directly alleviate fatigue but also mitigate negative emotional states that can contribute to fatigue severity. Nevertheless, it is important to acknowledge the cross-sectional design of this study, which precludes definitive causal inferences regarding whether coping directly influences fatigue or arises in response to it. Future longitudinal studies are necessary to elucidate the temporal and mechanistic relationships between coping styles and fatigue in MHD patients, which would facilitate the development of more precisely targeted interventions.

Negative emotions are prevalent in patients with MHD. Correlation analyses in this study showed positive correlations between anxiety and depression levels and fatigue levels; multifactorial analyses further confirmed that depression was an independent influence on fatigue in older adults receiving MHD. However, findings on the relationship between depression and dialysis-related fatigue are not fully consistent. For example, the study by Letchmi et al⁵¹ showed no significant relationship between depression and fatigue in patients with MHD, whereas the findings of Farragher et al¹⁶ reported a significant positive association between depression and fatigue in patients with MHD. This inconsistency may be related to differences in the characteristics of the study population and the assessment tools used. The emergence of depressed mood as an independent influence on fatigue may be due to the overlap between the core symptoms of depression (eg, lack of motivation, cognitive delays) and the physiological depletion of fatigue at the biological level, especially in older age groups. Neurotransmitter imbalances and chronic inflammatory states may directly inhibit energy metabolism and induce “pathological behavior”,^{52,53} while depression may lead to decreased treatment adherence, which in turn may lead to problems such as inadequate dialysis and malnutrition, further exacerbating fatigue. Therefore, it is recommended that a dynamic assessment system be established to regularly assess the emotional status of older adults receiving MHD, and that psychoeducation be conducted to help patients learn ways to adjust their negative emotions to improve their overall physical condition.

Patients with MHD are often accompanied by multiple complications during treatment. In this study, hemoglobin and serum albumin levels were found to be influential factors for fatigue in older adults receiving MHD. This is similar to the findings of previous studies,³³ in which a decrease in hemoglobin led to an inadequate supply of blood oxygen, which may affect the normal functioning of the body’s organs, thus inducing a feeling of fatigue in patients. Albumin levels and hemoglobin levels were also reported as factors affecting patient fatigue in a study of leukemia patients.⁵⁴ However, the relationship between such biomarkers and fatigue is complex and not universally consistent across patient populations. For instance, in conditions like myelodysplastic syndromes, the link between hemoglobin and fatigue can be weak or absent, suggesting that a better understanding of fatigue etiology may require exploring factors beyond anemia.⁵⁵ Furthermore, a cross-sectional study in multiple myeloma patients found that the inflammatory marker C-reactive protein was significantly correlated with fatigue and quality of life, and that after controlling for C-reactive protein in regression analysis, hemoglobin was no longer a significant predictor.⁵⁶ The significant association found in our MHD cohort may be attributed to its unique context: while major physiological abnormalities are routinely managed, subclinical variations in biomarkers within the managed range may still significantly impact the subjective fatigue experience in this group.

The role of nutritional status as a fatigue mediator in older adults and its underlying mechanisms are mainly related to changes in food intake (loss of appetite), changes in body composition (malnutrition, sarcopenia), and mitochondrial dysfunction,⁵⁷ where nutritional interventions may be beneficial in improving fatigue. Therefore, notwithstanding the complexities highlighted above, our findings reinforce the clinical imperative for vigilant monitoring and personalized management. An individualized nutritional support program should be developed for the patient, prioritizing the implementation of home dietary management in conjunction with the family, and integrating exercise rehabilitation and psychological support. At the same time, health education for patients and caregivers should be strengthened to enhance their knowledge of the association between fatigue and nutritional management, and a comprehensive family-centered intervention pathway should be established to improve nutritional status, alleviate fatigue, and improve quality of life.

Limitations

This study has several limitations. First, the data relied on patient self-report, which may be subject to recall and social desirability biases. Second, as a cross-sectional study, the design precludes causal inference and does not establish the

temporal order or directionality between fatigue and its correlates. Third, several variables assessed in this study are dynamic and can fluctuate over time; because they were captured at a single time point, the observed relationships represent cross-sectional associations and should not be interpreted as causal effects. Fourth, while our study focused primarily on patient-level determinants, such as psychosocial and clinical factors, we did not systematically examine dialysis center-level characteristics (eg, staff attitudes, physical environment, and distance from residence), which may also represent important determinants of fatigue. Future research should therefore employ longitudinal designs to track temporal relationships and dynamic trajectories of patient-level variables and adopt a more comprehensive socio-ecological framework to investigate potential interactions between patient-level and center-level factors in contributing to fatigue, which is essential for building a robust evidence base for effective interventions.

Relevance for Clinical Practice

Although exploratory given the cross-sectional design, this study provides practice-oriented insights. It is among the first to systematically characterize fatigue and its multidimensional correlates in Chinese older adults receiving MHD, addressing a gap in the literature. The findings document the high prevalence and severity of fatigue and identify independent correlates in multivariable analyses, including self-efficacy, family functioning, coping styles, depressive symptoms, and hemoglobin and serum albumin levels. On this basis, clinicians may incorporate routine fatigue assessment into dialysis care for older adults and use assessment results to inform risk-stratified management. A multidisciplinary collaborative approach may be used to develop individualized care pathways that integrate physiological optimization, psychological support, and family support, with the aim of reducing symptom burden and improving quality of life.

Conclusion

This multicenter study revealed a high prevalence of moderate-to-severe fatigue among older Chinese adults receiving MHD, highlighting an urgent need for effective symptom management. The findings demonstrated that fatigue severity was independently associated with dialysis vintage, self-efficacy, family functioning, coping styles, depressive symptoms, hemoglobin, and serum albumin levels, indicating multifactorial associations. To address this complex symptom burden, we recommend integrating structured self-efficacy education into routine care, implementing family-centered support interventions, and adopting standardized fatigue assessment in clinical practice. Future research should focus on longitudinal studies to clarify causal relationships and develop culturally adapted, multifaceted management strategies tailored to this population.

Abbreviations

CKD, Chronic Kidney Disease; ESRD, End-stage renal disease; MHD, Maintenance hemodialysis.

Data Sharing Statement

The datasets generated and/or analyzed during the present study are available from the corresponding author, Prof. Fengping Liu, upon reasonable request.

Ethics Approval and Informed Consent

This study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Jiangnan University (Approval No. JUN202412RB029) and the Ethics Committee of Jiangnan University Affiliated Center Hospital (Approval No. (2024) Y-245). Written informed consent was obtained from all participants before their inclusion in the study.

Consent for Publication

We agree that we can publish details of any images, videos, audio recordings, etc., and have shown those who agree to publish the content of the article to be published.

Acknowledgments

We would like to express our heartfelt thanks to all the patients and members of the nephrology teams at the recruiting hospitals for their invaluable support.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

Open Fund of Gansu Provincial Key Laboratory of Functional Genomics and Molecular Diagnosis (Grant Nos. 2021BYGT-006).

Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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