Research article

Trajectories and influencing factors of psychological resilience among Chinese patients with maintenance hemodialysis

Yao Zhang [a,1], Yingying Huang [a,1], Yuan Qiu [b,1], Yiwen Hu [a], Jingrui Tao [a], Qiongying Xu [a], Liping Zhang [c], Chaoqun Dong [a,*]

[a] School of Nursing, Wenzhou Medical University, Wenzhou, China
[b] Zhoushan Tourism &Health College, Zhoushan, China
[c] The Second Affiliated Hospital of Wenzhou Medical University, Wenzhou, China

A R T I C L E   I N F O

A B S T R A C T

Objective: To identify distinct trajectories of psychological resilience among Chinese patients with maintenance hemodialysis, explore influencing factors and inform the formulation of corresponding interventions.

Methods: This was a multi-center longitudinal study with a 6-month follow-up. With convenience sampling, a total of 231 patients with maintenance hemodialysis were recruited between September 2020 and July 2021. Patients' characteristics, including sociodemographic information, social support and family resilience was collected through structured questionnaires as potential baseline influencing factors of psychological resilience trajectories. Psychological resilience was evaluated using the 25-item Chinese version of the Conner and Davidson resilience scale. Latent class growth modeling was conducted to identify homogeneous subgroups with distinct trajectories of psychological resilience. Univariable and multinomial logistic regression analysis were used to examine whether baseline influencing factors were associated with trajectories in patients with maintenance hemodialysis.

Results: Five distinct psychological resilience trajectory groups were identified: declining group (n = 20, 8.7 %), rising group (n = 17, 7.4 %), moderate-stable group (n = 128, 55.4 %), high-stable group (n = 7, 3.0 %) and low-stable group (n = 59, 25.5 %). High-stable group and moderate-stable group were combined into the well-psychological resilience group for multinomial logistic regression analysis. The multinomial logistic regression analysis showed that influencing factors associated with trajectories of psychological resilience were age, religion, monthly household income per capita, and baseline family resilience.

Conclusions: The results highlight the heterogeneity in the development of psychological resilience among Chinese patients with maintenance hemodialysis. There is a need for healthcare professionals to screen for trajectories of psychological resilience in Chinese maintenance hemodialysis patients and prepare individual mental healthcare interventions.

* Corresponding author
 E-mail address: dcq1208@163.com (C. Dong).
[1] These authors contributed equally to this work.

1. Introduction

End-stage renal disease (ESRD), the last stage of chronic kidney disease, is life-threatening and irreversible [1]. It not only increases global morbidity and mortality but also raises an enormous economic burden [2]. With the current technological improvements, maintenance hemodialysis (MHD) has been a commonly used method of renal replacement therapy for end-stage renal disease in many countries [3]. Kidney disease patients with regular dialysis treatment for more than 3 months, and more than 2 times a week is known as maintenance hemodialysis treatment [4,5]. The number of people receiving maintenance hemodialysis treatment worldwide exceeded 2.5 million and is expected to more than double to 5.4 million by 2030 [1]. According to the China Kidney Disease Network Data Report, the prevalence of ESRD is rapidly increasing in China, with around 402.18 per million people undergoing maintenance hemodialysis therapy [6]. By 2021, there are about 750,000 hemodialysis patients in China [7].

Maintenance hemodialysis treatment significantly prolongs the survival of patients with ESRD; however, long-term maintenance hemodialysis treatment may increase the risk of psychological problems [8,9]. Patients with ESRD may experience significant psychological stress with the challenge of medical complications, physical deterioration, family role conflict, and economic burden [10, 11]. It has been reported that almost every patient with ESRD experienced depression or anxiety during treatment [12].

Despite the significant psychological distress associated with ESRD and maintenance hemodialysis, some patients demonstrated remarkable resilience in the face of treatment-related crises and challenges. Psychological resilience is the dynamic process of encompassing positive adaptation and effective coping strategies within the context of adversity [13]. Previously, scholars have systematically discussed the relationships between stress, psychological resilience, and immune system function [14], proposing that psychological resilience may play a role in regulating the stress and promoting a better prognosis in patients experiencing stress due to their diseases. Furthermore, it was found that psychological resilience changes over time after adversity [15]. Individuals who do not experience the same level of change in psychological resilience when they experience catastrophic events, will undermine their ability to cope with adverse events [16]. Therefore, gaining knowledge about the psychological resilience's trajectory and contributing elements may help patients with ESRD maintain their psychological well-being.

A recent systematic review proposed four resilience trajectories following potential trauma, that is resilience, recovery, chronicity, and delayed onset [17]. For patients with ESRD, hemodialysis treatment has been recognized as a traumatic event [18]. While hemodialysis treatment increases the pain and stress of patients, it also enables them to undergo positive psychological adjustments and helps them cope with traumatic events [19]. However, few empirical studies longitudinally explored the trajectory of psychological resilience in ESRD patients.

Previously, most studies defined homogeneous groups as a unity and used research methods that analyzed the population as a whole with the presupposition that the distribution of the effects of adverse events on different individuals over time is homogeneous. This, in turn, contradicts individual heterogeneity and makes it difficult to capture the potential variation in individuals after experiencing adverse events [20]. The latent class growth model (LCGM) can accommodate group heterogeneity to analyze individuals' trajectories over time, by assuming that there are different categories within a homogeneous group [21]. It paints a more refined portrait of changing trends [22]. By identifying distinct trajectory groups using LCGM, we may capture the heterogeneity of the dynamics of psychological resilience in Chinese maintenance hemodialysis patients.

Most of the existing studies tried to explore the factors associated with psychological resilience through cross-sectional studies or literature analysis [10,23]. Socio-demographic variables such as higher education level and family incomes, being married and employed were found to be associated with psychological resilience [10,24,25]. The ecological model of resilience also proposed that sociocultural resources (e.g., social support) and contextual resources (e.g., family resources) played important roles in the development of psychological resilience [26]. The positive correlation between social support and psychological resilience has been examined in many cross-sectional studies. Meanwhile, family resilience, as one of the most important indicators of family resources, was also found to be positively associated with psychological resilience. However, the relationship between sociodemographic variables, social support and family resilience of maintenance hemodialysis patients and their trajectory of change in psychological resilience remains unclear. This may result in poorly targeted and ineffective psychological interventions. With limited resources, it is essential to maximize the targeting and effectiveness of interventions to promote sustainable development in global health [27].

Therefore, we tried to investigate the trajectory of psychological resilience in patients with ESRD and to identify the factors that influence it, in order to provide a reference for the design of targeted intervention programs. The specific objectives of the study were as follows: (1) To identify the trajectories of psychological resilience among maintenance hemodialysis patients. (2) To examine the sociodemographic variables, social support, and family resilience as factors influence different trajectory groups.

2. Materials and methods

2.1. Participants

This multi-center longitudinal study describes the 6-month trajectories of psychological resilience among maintenance hemodialysis patients. Considering the identification accuracy of the latent class growth model, the sample size was suggested to be no less than 200 [28]. With a 20 % loss rate, the required sample size was estimated to be 220. The inclusion criteria were: (1) age ≥18 years old; (2) receiving hemodialysis treatment ≥3 months; (3) the treatment frequency at least two times per week; and (4) with normal cognitive ability and can communicate verbally or in writing. The exclusion criteria were: (1) physician-diagnosed psychiatric or mental disorders based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, TR), such as schizophrenia, bipolar disorder, and depression; (2) neurological disorders or cognitive impairments (e.g. delirium, dementia); and (3) inability to

communicate verbally or complete the questionnaires.

2.2. Data collection

From September 2020 to July 2021, a total of 280 eligible patients with maintenance hemodialysis were enrolled using a convenience sampling strategy from the hemodialysis centers of three comprehensive hospitals in Zhejiang Province, China. Participants were followed for six months and received follow-up questionnaires every three months (T0 = baseline, T1 = 3 months after, T2 = 6 months after), measuring socio-demographics, social support, family resilience, and psychological resilience. The period of follow-up was decided by combining the experience of previous studies [29,30] and the time and feasibility of the study. Fig. 1 shows the timeline of the study. Well-trained graduate nursing students performed the measurement at the hemodialysis centers before the participants' hemodialysis treatment. Researchers instructed the patients to fill out the questionnaire completely. Each participant took about 20–30 min to complete the questionnaires. Patients with low quality of responses, such as short response time (less than 10 min) or responses that showed a clear pattern, were excluded. To be included in the present study, the participants had to complete all three assessment moments. The study obtained written informed consent from all participants prior to their participation. Following completion of the questionnaire, participants were provided with small gifts as compensation. The study was approved by the Ethics Committee of the First Affiliated Hospital of the Wenzhou Medical University (No. 2020198) and conducted following the Declaration of Helsinki.

2.3. Measures

Socio-demographic information concerning age, gender, marital status, religion, monthly household income per capita, education level, medical insurance, duration of the disease, comorbidities and primary caregivers were collected with a self-developed questionnaire.

Social support was assessed with the Chinese version of the Medical Outcomes Study-Social Support Survey (MOS-SSS) [31]. The 19-item MOS-SSS assesses four types of social support, including informational/emotional support, tangible support, positive social interactive support, and affectionate support. Participants rated each item on a five-point scale ranging from "none" (1) to "all of the time" (5). The total score ranges from 19 to 95, with higher scores indicating higher levels of social support. The Cronbach's α was 0.944 for the total score in the present sample, indicating good internal reliability.

Family resilience was assessed with the 44-item Chinese version of the Family Resilience Assessment Scale (C-FRAS) [32], which captures four subscales of family resilience: family communication and problem-solving (FCPS), utilizing social and economic resources (USER), maintaining a positive outlook (MPO), and ability to make meaning of adversity (AMMA). Participants rated each item on a four-point scale ranging from "strongly disagree" (1) to "strongly agree" (4). A total score was created by summing the scores from all four subscales, with total scores ranging from 44 to 176. Higher scores indicate greater family resilience. The Cronbach's α was 0.968 for the total score in the present sample.

Psychological resilience was collected using the 25-item Chinese version of the Conner and Davidson resilience scale (CD-RISC) [33]. Three subscales evaluate participants' levels of tenacity, strength, and optimism. Participants rated each item on a five-point scale ranging from "not true at all" (0) to "true all" (4). Total scores range from 0 to 100, with higher scores indicative of high psychological resilience. The Cronbach's α was 0.927 for the total score in the present sample.

MPlus™ Version 8.3 [34] and SPSS Version 26.0 (IBM Corp., Armonk, NY, USA) were used for data analysis. Trajectories of psychological resilience three time-point were identified using LCGM. To identify the model that best represented the data, the Bayesian information criterion (BIC), sample-size-adjusted BIC (aBIC), Akaike information criterion (AIC), entropy, parametric bootstrapped LRT (BLRT), and Lo-Mendell-Rubin Adjusted Likelihood Ratio test (LMRT), and bootstrap likelihood ratio test (BLRT) were used. The BIC, the aBIC, and the AIC with lower values indicate a better fit model [35]. The entropy value ≥ 0.70 indicates adequate classification precision. The LMRT and BLRT were examined to evaluate the absolute fit between a k-1 class model and a k-class model [36]. The characteristics of trajectory groups were compared using the Chi-squared test for socio-demographic and clinical variables, as well as the Kruskal-Wallis test for social support and family resilience. The independence test was used to assess the existence of association or dependence between categorical variables. The multicollinearity test was used to determine whether
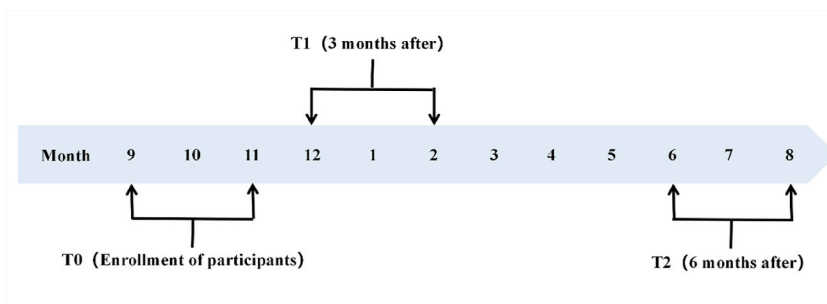

Fig. 1. The timeline of the study.

there was multicollinearity in the variables. As the dependent variable (well-psychological resilience group) was non-ranked, the multinomial logistic regression analysis was used to examine the factors influencing psychological resilience trajectories. The goodness-of-fit of the multinomial logistic regression model was evaluated using the likelihood ratio test. All categorical variables included as influencing factors are independent of each other. None of our variables had any concerns with multicollinearity. All variables associated with $p < 0.10$ in the univariate analysis were then selected as independent variables and incorporated into the multinomial logistic regression models. Statistical significance was set at $p < 0.05$. The results of multinomial logistic regression are interpreted in relation to odds ratio (OR), the 95 % confidence interval (CI) and p-value. Sensitivity analysis was performed after mean imputation for missing data to test model robustness.

3. Results

3.1. Demographic characteristics

Of 280 maintenance hemodialysis patients recruited, 22 declined to participate in the study at the baseline survey stage (T0) due to lack of interest or fatigue (participation rate = 92 %). At 3 months after the survey stage (T1), 1 withdrew from the study due to renal transplantation and 4 refused to continue participation. At 6 months after the survey (T2) stage, 1 person died and 21 people responded with poor quality, such as short response time and regularity of responses. Finally, 231 patients of the 258 baseline responders (participation rate = 89.5 %) were included in this analysis. Fig. 2 displays an enrollment flowchart. The participants' ages ranged from 44 to 71 years, with a mean age of 57.40 (SD 13.559). The majority of participants were male (67.5 %, n = 156), with religion (50.6 %), medical insurance (97.8 %, n = 226), married/cohabitating (88.3 %, n = 204), and with an education level of middle school and below (64.5 %, n = 149). Regarding the household income per capita, 33 (14.3 %) participants reported a household income per capita less than 2000 RMB (Chinese Currency), 150 (64.9 %) participants reported a household income per capita between 2000 RMB and 6000 RMB, and 48 (20.8 %) participants reported the household income per capita more than 6000RMB. Regarding the duration of the disease, 57 (24.7 %) participants had been diagnosed with the disease for less than 5 years, 139 (21.2 %) for 5–10 years (not including 5 years), and 125 (54.1 %) for more than 10 years. Of the sample, 164 (71.0 %) had one or more comorbidities.

3.2. Trajectories of psychological resilience

Fit indices for latent class growth models of psychological resilience are presented in Table 1. Evaluating fit, theory and the existing evidence, the AIC and aBIC for the 5-class were lower than the AIC and aBIC for the 4-class. The entropy value for the 5-class was 0.729, demonstrating that the 5-class model provided a clear classification. And the LMRT and BLRT for the 5-class were significant, indicating that the 5-class accounted for data more than 4-class. Moreover, even though the entropy value for the 6-class was greater than that of the 5-class, the LMRT and BLRT for the 6-class were not significant, suggesting that too many classes had been extracted. Accordingly, a latent class growth model with 5 classes was found to be the best fit.

Table 2 and Fig. 3 illustrate that five different trajectory groups were identified. Class 1, which accounted for 8.66 % (n = 20) was named the "declining group" because it started with the second-highest psychological resilience but declined over time to the lowest psychological resilience at the end, declining from 85.20 to 49.95. Class 2, which accounted for 7.36 % (n = 17) was named the "rising
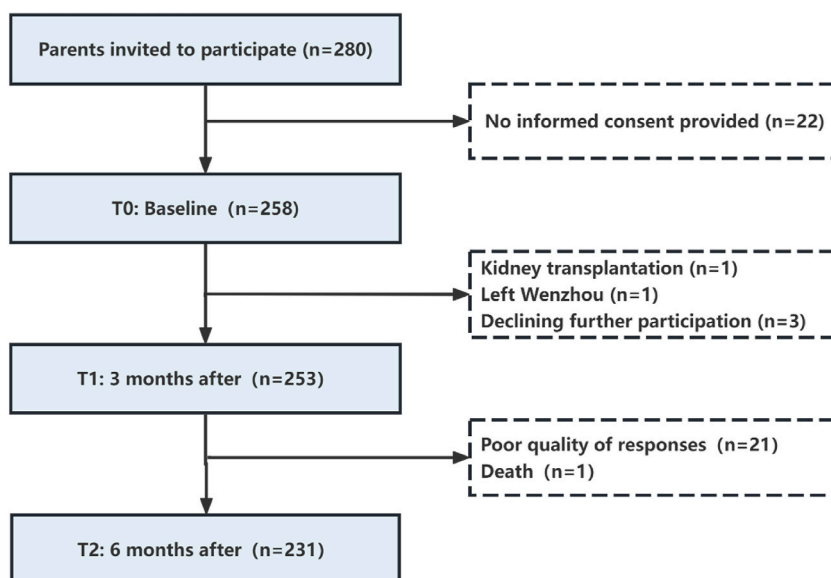

Fig. 2. The enrollment flowchart of the study.

Table 1
Fit indices for latent class growth models of psychological resilience.

Model	AIC	BIC	aBIC	Entropy	LMRT	BLRT	Sample Size per Class
					p value	p value	
1-class	5719.926	5737.139	5721.291	1	n/a	n/a	1
2-class	5694.457	5721.997	5696.641	0.942	0.0108	0.0000	0.974/0.026
3-class	5680.848	5718.715	5683.851	0.675	0.0347	0.0000	0.022/0.411/0.567
4-class	5675.671	5723.865	5679.493	0.606	0.4042	0.0206	0.130/0.026/0.472/0.372
5-class[a]	**5666.689**	**5725.210**	**5671.330**	**0.729**	**0.0316**	**0.0156**	**0.087/0.074/0.554/0.030/0.255**
6-class	5667.407	5736.256	5672.867	0.767	0.2258	0.2211	0.048/0.087/0.325/0.026/0.489/0.025

AIC = Akaike information criterion; BIC=Bayesian information criterion; aBIC = sample-size adjusted BIC; Entropy = a quality of classification; LMRT = Lo-Mendell-Rubin Adjusted likelihood ratio test; BLRT= Bootstrap likelihood ratio test; n/a, not applicable in single.
[a] The preferred 5-class model is presented in bold.

Table 2
Psychological resilience scores over time in maintenance hemodialysis patients for the five classes trajectories and the entire analytic sample (n = 231).

Classes	T0(M, SD)	T1 (M, SD)	T2 (M, SD)
declining group (n = 20, 8.66 %)	85.20(5.45)	67.40(10.68)	49.95(12.65)
rising group (n = 17, 7.36 %)	42.35(6.20)	63.47(18.15)	82.24(7.90)
moderate-stable group (n = 128, 55.41 %)	62.55(7.57)	60.03(12.32)	57.37(13.06)
high-stable group (n = 7, 3.03 %)	92.14(7.13)	88.00(10.54)	82.29(11.57)
low-stable group (n = 59, 25.54 %)	42.56(6.25)	47.64(11.09)	53.39(10.22)
Analytic sample (n = 231, 100 %)	59.24(15.06)	57.35(13.72)	59.58(14.95)

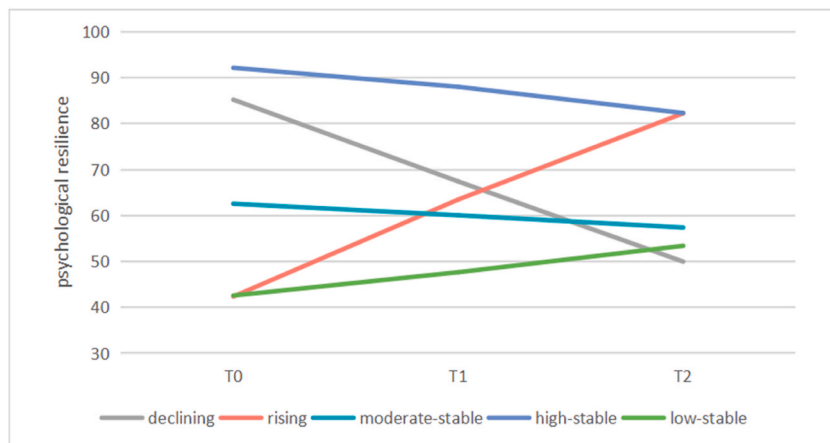M = mean; SD = standard deviation.

Fig. 3. Estimated trajectories of psychological resilience for the five latent class.

group" because it had a low psychological resilience at baseline and a steep psychological resilience increase with time, changing from 42.35 to 82.24. Class 3, which accounted for 55.41 % (n = 128) was named the "moderate-stable group" because it had stable and moderate psychological resilience at three-time points, ranging from 62.55 to 57.37. Class4, which accounted for 3.0 % (n = 7) was named the "high-stable group" because it always had high psychological resilience scores, ranging from 92.14 to 82.29. Class5, which accounted for 25.54 % (n = 59) was named the "low-stable group" because it maintained a low level of psychological resilience scores at the beginning and only a slight rise over time, ranging from 42.56 to 53.39.

3.3. Factors of trajectory group

Due to the limited number of patients in the high-stable group (n = 7), which constituted a small proportion of the overall patient population. To avoid a decrease in statistical validity, it was merged with the moderate stable group and named the well-psychological resilience group.

Table 3 presented that the results of the Chi-squared test showed significant differences among the four groups concerning age ($\chi2$ = 6.382, p = 0.094), religion ($\chi2$ = 11.129, p = 0.011), education level ($\chi2$ = 26.433, p < 0.001), monthly household income per capita

Table 3

| Comparison of socio-demographic and clinical characteristics among different trajectory groups.

Variables	Total sample	declining group	rising group	well-psychological resilience group	low-stable group	χ2	P
Demographic and clinical variables							
Gender						3.055	0.383
Male	156(67.5)	15(75.0)	13(76.5)	93(68.9)	35(59.3)		
Female	75(32.5)	5(25.0)	4(23.5)	42(31.1)	24(40.7)		
Age						6.382	0.094
< 60years	117(50.6)	14(70.0)	5(29.4)	70(51.9)	28(47.5)		
≥60years	114(49.4)	6(30.0)	12(70.6)	65(48.1)	31(52.5)		
Religion						11.129	**0.011**
No	114(49.4)	15(75.0)	12(70.6)	57(42.2)	30(50.8)		
Yes	117(50.6)	5(25.0)	5(29.4)	78(57.8)	29(49.2)		
Marital status						5.901	0.117
Single/divorced/widow/ separated	27(11.7)	0(0.0)	4(23.5)	18(13.3)	5(8.5)		
Married/cohabitating	204(88.3)	20(100.0)	13(76.5)	117(86.7)	54(91.5)		
Education level						26.433	**0.000**
Middle School and below	149(64.5)	6(30.0)	14(82.3)	8059.3)	49(83.0)		
High School/Secondary school	53(22.9)	7(35.0)	2(11.8)	38(28.1)	6(10.2)		
College or higher	29(12.6)	7(35.0)	1(5.9)	17(12.6)	4(6.8)		
Monthly household income per capita						17.290	**0.008**
<2000 RMB	33(14.3)	1(5.0)	6(35.3)	14(10.4)	12(20.3)		
2000–6000 RMB	150(64.9)	13(65.0)	10(58.8)	86(63.7)	41(69.5)		
>6000 RMB	48(20.8)	6(30.0)	1(5.9)	35(25.9)	6(10.2)		
Medical insurance						3.492	0.322
No	5(2.2)	0(0.0)	0(0.0)	2(1.5)	3(5.1)		
Yes	226(97.8)	20(100.0)	17(100.0)	133(98.5)	56(94.9)		
Duration of disease						1.868	0.931
< 5year	57(24.7)	5(25.0)	2(11.8)	34(25.2)	16(27.1)		
5- < 10years	49(21.2)	4(20.0)	4(23.5)	28(20.7)	13(22.1)		
≥10years	125(54.1)	11(55.0)	11(64.7)	73(54.1)	30(50.8)		
Comorbidities						2.073	0.557
No	67(29.0)	8(40.0)	4(23.5)	36(26.7)	19(32.2)		
One or more	164(71.0)	12(60.0)	13(76.5)	99(73.3)	40(67.8)		
Primary caregivers						9.981	0.352
Spouse	192(83.1)	19(95.0)	12(70.6)	111(82.2)	50(84.7)		
Children	6(2.6)	1(5.0)	0(0.0)	3(2.2)	2(3.4)		
Parents	20(8.7)	0(0.0)	2(11.8)	14(10.4)	4(6.8)		
Siblings	13(5.6)	0(0.0)	3(17.6)	7(5.2)	3(5.1)		

Data presented as frequency (percentage). Bold signifies the statistical significance to P < 0.1.

($\chi2 = 17.290$, $P = 0.008$).

Table 4 presented the results of the Kruskal-Wallis test showed significant differences in social support and family resilience among the 4 groups of patients at the 3-time points ($p < 0.1$). Given the imperative of early intervention in clinical practice, this study focused on baseline (T0) social support and family resilience as key influencing factors to ensure the practical clinical relevance of the findings.

Table 5 showed the results of a multinomial logistic regression model that describes the association between socio-demographic influencing factors and class membership. The well-psychological resilience group served as the reference group for all other groups in this study since it was the largest and most prevalent group, making it more representative and effective in reducing model bias. The likelihood ratio test result for the model that included all independent variables versus the model that only included the intercept was $p < 0.05$. Therefore, the model fit was good. Patients with maintenance hemodialysis younger than 60 years of age (OR: 0.252; 95 % CI: 0.066,0.966) had lower odds when compared to those older than 60 years of age, to be in the rising group than in the well-psychological resilience group. Regarding religion, maintenance hemodialysis patients without religion had higher odds to belong to the declining group (OR: 4.240; 95 % CI: 1.310,13.718) or the rising group (OR: 3.868; 95 % CI:1.154,12.961) than the well-psychological resilience group. Compared to those with household income >6000RMB/month/person, those with household income <2000 RMB/month/person (OR:23.783; 95 % CI:1.951, 289.867) were more likely to be in the rising group than in the well-psychological resilience group. In addition, compared with the well-psychological resilience group, the higher the level of family resilience at baseline, the more likely maintenance hemodialysis patients belonged to the declining trajectory (OR:1.040; 95 % CI:1.000,1.082), but less likely to be belong to the low-stable trajectory (OR:0.862; 95 % CI:0.797, 0.932). The results of the model constructed from the sensitivity analysis using mean imputation data are generally consistent with the results of the study, as described in Supplementary file 2.

Table 4
Comparison of social support and family resilience among different trajectory groups [M ($P_{25} \sim P_{75}$)].

Classes	Total sample	T0 social support	T0 family resilience	T1 social support	T1 family resilience	T2 social support	T2 family resilience
declining group	20	77.50 (64.25,85.50)	132.00 (129.25,152.75)	71.00 (60.25,76.75)	129.50 (128.25,135.50)	64.00 (56.00,68.75)	131.00 (126.25,133.75)
rising group	17	59.00 (55.00, 70.00)	129.00 (120.50,131.50)	75.00 (58.00,79.50)	129.00 (128.50,141.50)	73.00 (63.00,87.00)	137.00 (132.00,165.50)
well-psychological resilience group	135	68.00 (60.00,75.00)	129.00 (127.00,132.00)	68.00 (59.00,76.00)	129.00 (127.00,132.00)	65.00 (60.00,73.00)	132.00 (128.00,135.00)
low-stable group	59	60.00 (53.00,64.00)	127.00 (121.00,129.00)	59.00 (53.00,65.00)	127.00 (122.00,130.00)	60.00 (55.00,66.00)	130.00 (126.00,133.00)
H		35.906	38.208	21.758	23.653	21.009	20.385
P		**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**

Continuous variables are presented as median and interquartile range. Kruskal-Wallis test were used to test for significant differences for continuous variables. Bold signifies the statistical significance to $P < 0.1$.

Table 5

| Multinomial logistic regression analysis.

Variables	declining group vs well-psychological resilience group			rising group vs well-psychological resilience group			low-stable group vs well-psychological resilience group		
	OR	95%CI	P	OR	95%CI	P	OR	95%CI	P
Age									
< 60years	2.317	0.725–7.402	0.156	**0.252**	**0.066–0.966**	**0.044**	0.818	0.390–1.714	0.594
≥60years	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Religion									
No	**4.240**	**1.310–13.718**	**0.016**	**3.868**	**1.154–12.961**	**0.028**	1.307	0.628–2.718	0.474
Yes	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Education level									
Middle school and below	0.288	0.070–1.185	0.085	1.056	0.095–11.713	0.965	1.640	0.400–6.724	0.492
High school/secondary school	0.577	0.144–2.310	0.437	0.564	0.039–8.235	0.675	0.486	0.095–2.489	0.387
College or higher	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Monthly household income per capita									
<2000 RMB	0.898	0.084–9.614	0.929	**23.783**	**1.951–289.867**	**0.013**	3.271	0.830–12.895	0.090
2000–6000 RMB	1.500	0.430–5.252	0.525	4.953	0.505–48.591	0.198	2.215	0.739–6.641	0.156
>6000 RMB	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
T0 social support	1.030	0.977–1.086	0.272	0.952	0.903–1.003	0.066	0.967	0.934–1.002	0.061
T0 family resilience	**1.040**	**1.000–1.082**	**0.049**	0.921	0.836–1.016	0.100	**0.862**	**0.797–0.932**	**0.000**

OR, odds ratio; CI, confidence interval. Bold signifies the statistical significance to P < 0.05.

4. Discussion

In this study, the mean psychological resilience score of Chinese maintenance hemodialysis patients at three time points was lower than the Chinese norm of 65.46 (SD13.93) [37]. This result suggests that ESRD patients with maintenance hemodialysis treatment have lower psychological resilience, which implies that they are less able to cope with crises and challenges. Failure to cope well with crises and challenges not only increases their psychological burden but also reduces their quality of life [38]. This, in turn, may further increase the patient's risk of developing mental illness [9]. Therefore, early screening of psychological resilience in maintenance hemodialysis patients by healthcare providers is necessary to facilitate the provision of appropriate psychological interventions and promote a positive prognosis.

Based on the trajectories of LCGM, the results indicated the heterogeneity in the developmental trajectory of psychological resilience characteristics among maintenance hemodialysis patients. Five distinct trajectories were identified and were named as declining group, rising group, moderate-stable group, high-stable group, and low-stable group. The moderate-stable group accounted for 55.41 %, while the low-stable and high-stable groups accounted for 25.54 % and 3.0 %, respectively, indicating that a majority of maintenance hemodialysis patients maintained stable levels of psychological resilience. AD Mancini and GA Bonanno [39] suggests that despite reduced psychological resilience, when individuals are exposed to the highest and greatest demands, more than half of persons are still able to maintain stable psychological resilience, which is consistent with this study. The declining group accounted for 8.66 % and the rising group accounted for 7.36 %. These findings highlight a significant proportion of maintenance hemodialysis patients continue to grapple with psychological distress, and fewer maintenance hemodialysis patients are able to improve their psychological resilience. This suggests the importance for healthcare professionals to promptly identify patients exhibiting diverse patterns of psychological resilience and allocate additional attention towards maintenance hemodialysis patients whose psychological resilience remains consistently low or exhibits a declining trend.

In this study, when compared to patients older than 60 years of age, patients with maintenance hemodialysis younger than 60 years of age had lower odds to be in the rising group than in the well-psychological resilience group. This may be related to the higher realistic pressures experienced by patients younger than 60 years of age. As the primary workforce, individuals below 60 years old not only bear the responsibility of caring for elderly family members but also play a crucial role in shaping the future generation [40]. Undergoing maintenance hemodialysis not only entails physical and financial burdens but may also disrupt their familial roles [41]. The illness adversely affects their daily life and work, impeding their ability to fulfill family responsibilities. The accumulation of multiple stressors (e.g., illness, financial strain, family dynamics) inevitably hinder the improvement of their psychological resilience [42]. Therefore, when improving patients' psychological resilience, healthcare professionals should pay more attention to maintenance hemodialysis patients under the age of 60. Healthcare professionals should enhance comprehension of the origins of psychological distress in their patients and provide targeted interventions.

In terms of religion, the results showed that compared to patients with religion, patients without religion were more likely to be in the declining group or rising group rather than the well-psychological resilience group, suggesting that patients without religion were more likely to have a change in psychological resilience and more unstable. In other words, as one of the buffering factors of psychological resilience, religious beliefs enable patients to better maintain their consistency when they are caught in distress such as illness and treatment [43]. It is seen not only as a coping mechanism for stressful life experience but also as a conscious, emotional, moral and spiritual "carrier" for the maintenance hemodialysis patients that help them to solve psychological problems [44]. Therefore, for patients without religion, healthcare professionals should be concerned about the availability of a source of spiritual support during their maintenance hemodialysis treatment. The patient's sense of belief needs to be promoted in order to avoid a

decrease in psychological resilience due to the breakdown of the patient's spirit during long-term treatment.

The multinomial logistic regression analysis also revealed that individuals with a household income of less than 2000 RMB/month/person were more likely to belong to the rising group rather than the well-psychological resilience group, when compared to those with a household income exceeding 6000 RMB/month/person. This may be related to their relatively low initial level of psychological resilience. Variations in financial burden were observed across different income levels [45]. Due to their lower income levels, patients with household income <2000 RMB/month/person require additional consideration of financial stress alongside concerns about the disease itself when initially confronted with the reality of lifelong treatment [46]. Owing to higher financial stress, they are likely to experience more negative emotions such as fear and anxiety, potentially leading to lower baseline psychological resilience [47]. This suggests that there is more room for improvement in their psychological resilience, which may account for the subsequent upward trend in psychological resilience as they become acquainted with the treatment. Therefore, healthcare professionals should intervene as early as possible for maintenance hemodialysis patients with low-income levels. Attention needs to be given to their psychological resilience during the initial stage of treatment, and patients who express concerns should be promptly informed about the anticipated costs and assisted in accessing social support resources to alleviate their anxiety regarding financial burden.

With regard to the family resilience, in this research, patients with higher initial family resilience were more likely to be in the declining group, but less likely to be in the low-stable group. This result supports the assertion that baseline family resilience may play a protective effect on baseline psychological resilience in patients with maintenance hemodialysis, and that this relationship may change over time possibly due to other positive or negative factors [48]. As part of the immediate environment in which a person lives, the family has a direct impact on the psychosocial characteristics of the individual [49]. When there is a member of the family who is ill, family resilience, as a supporting force, might not only cultivate a warm environment for identifying problem-solving strategies cohesively, but also mobilize kin and social resources to effectively cope with their diagnoses and treatment [23]. Therefore, maintenance hemodialysis patients could benefit from interventions targeted at fostering family resilience. Healthcare providers need to fully recognize and utilize the strength of patients' families to help patients improve their psychological resilience.

The current study highlights the heterogeneity in the development of psychological resilience among maintenance hemodialysis patients. At the same time, without intervention, only a minority of patients with maintenance hemodialysis were able to elevate their psychological resilience. The overall trajectory showed that maintenance hemodialysis patients on different psychological resilience trajectories differed primarily in age, religion, monthly household income per capita, and baseline family resilience. This may provide evidence for identifying vulnerable populations and provide a basis for developing targeted interventions in the future.

5. Limitations

Despite our study providing some significant findings, several limitations need to be taken into account. Firstly, as a longitudinal study, this study faced inherent challenges in participant retention and attrition, which may have affected the internal validity of the study. Although we implemented regular follow-up communication and incentives for continued participation, attrition rates remain a concern. Future studies could strengthen communication with participants and set up feedback mechanisms to promote retention. Secondly, although the independence assumption, multicollinearity assumption and sensitivity analysis were performed in constructing the multinomial logistic regression model in this study, the reliability of the model still needs to be further validated due to the lack of external validation. Third, despite efforts to control confounding variables, potential inherent biases in self-report measures, such as social desirability bias and recall bias, cannot be completely eliminated. This study attempted to enhance the accuracy of the collected data by utilizing validated scales and providing participants with clear instructions; yet, residual confounders remain potential. The incorporation of objective measures would significantly benefit future research whenever feasible. Fourth, although the effect of disease duration on patients' psychological resilience was considered, this study only followed up for 6 months due to time and resource constraints. Future studies could extend the duration of follow-up to further explore long-term changes in patients' psychological resilience. Fifth, a convenience sampling method was used in this study, which may pose selection bias. Therefore, future studies should consider adopting more randomized sampling methods, such as stratified sampling, to reduce selection bias and enhance the generalizability of findings. Sixth, we combined the high-stable and moderate-stable groups for statistical analysis due to their small sample sizes, but this may weaken the distinctiveness of the identified trajectories. Hence, the sample sizes should be expanded and cover a wider range of regions and populations in the future to enhance the representativeness and diversity of the study. Additionally, it is suggested that future studies should include a more comprehensive range of impact factors such as depressive symptoms, coping strategies, quality of life, and specific psychological interventions.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Funding Statement

CRediT authorship contribution statement

Yao Zhang: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Yingying Huang:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Yuan Qiu:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Yiwen Hu:** Writing – original draft, Investigation. **Jingrui Tao:** Writing – original draft, Investigation. **Qiongying Xu:** Writing – original draft, Investigation. **Liping Zhang:** Writing – review & editing, Supervision, Resources, Methodology. **Chaoqun Dong:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e37200.

References

[1] GBD Chronic Kidney Disease Collaboration, Global, regional, and national burden of chronic kidney disease, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017, Lancet 395 (10225) (2020) 709–733, https://doi.org/10.1016/s0140-6736(20)30045-3.

[2] G.G. Powathil, R.A. K, The experience of living with a chronic illness: a qualitative study among end-stage renal disease patients, J Soc Work End Life Palliat Care (2023) 1–19, https://doi.org/10.1080/15524256.2023.2229034.

[3] J. Himmelfarb, R. Vanholder, R. Mehrotra, M. Tonelli, The current and future landscape of dialysis, Nat. Rev. Nephrol. 16 (10) (2020) 573–585, https://doi.org/10.1038/s41581-020-0315-4.

[4] Hemodialysis Adequacy Collaborative Group NB, Chinese medical doctors' association, China. **Clinical practice guidelines for hemodialysis adequacy in China**, Chin. J. Med. 34 (95) (2015) 2748–2753, https://doi.org/10.3760/cma.j.issn.0376-2491.2015.34.004.

[5] X. Yu, S.M. Cao, X.J. Ji, M. Chang, Jun Xu, The impact of exercise intervention during hemodialysis on patients undergoing maintenance hemodialysis, Nurs. J. 17 (36) (2021) 5–8, https://doi.org/10.3870/j.issn.1001-4152.2021.17.005.

[6] L. Zhang, M.H. Zhao, L. Zuo, Y. Wang, F. Yu, H. Zhang, H. Wang, China kidney disease Network (CK-net) 2016 annual data report, Kidney Int. Suppl. 10 (2) (2020) e97–e185, https://doi.org/10.1016/j.kisu.2020.09.001.

[7] C. Xie, L. Li, Y. Li, Trajectories of learned helplessness in maintenance haemodialysis patients and their predictive effects on self-management: a latent growth mixture modeling approach, Psychol. Res. Behav. Manag. 16 (2023) 351–361, https://doi.org/10.2147/prbm.S401380.

[8] J. Wen, Y. Fang, Z. Su, J. Cai, Z. Chen, Mental health and its influencing factors of maintenance hemodialysis patients: a semi-structured interview study, BMC Psychol 11 (1) (2023) 84, https://doi.org/10.1186/s40359-023-01109-2.

[9] Y.M. Liu, H.J. Chang, R.H. Wang, L.K. Yang, K.C. Lu, Y.C. Hou, Role of resilience and social support in alleviating depression in patients receiving maintenance hemodialysis, Therapeut. Clin. Risk Manag. 14 (2018) 441–451, https://doi.org/10.2147/tcrm.S152273.

[10] P. García-Martínez, R. Ballester-Arnal, K. Gandhi-Morar, J. Castro-Calvo, V. Gea-Caballero, R. Juárez-Vela, C. Saus-Ortega, R. Montejano-Lozoya, E.M. Sosa-Palanca, M.D.R. Gómez-Romero, et al., Perceived stress in relation to quality of life and resilience in patients with advanced chronic kidney disease undergoing hemodialysis, Int. J. Environ. Res. Publ. Health 18 (2) (2021) 536, https://doi.org/10.3390/ijerph18020536.

[11] A.V. Wister, K.L. Coatta, N. Schuurman, S.A. Lear, M. Rosin, D. MacKey, A lifecourse model of multimorbidity resilience: theoretical and research developments, Int. J. Aging Hum. Dev. 82 (4) (2016) 290–313, https://doi.org/10.1177/0091415016641686.

[12] S. Couch, Psychiatric problems faced by patients on dialysis, Clin. J. Am. Soc. Nephrol. 14 (9) (2019) 1275–1276, https://doi.org/10.2215/cjn.08300719.

[13] S.S. Luthar, D. Cicchetti, B. Becker, The construct of resilience: a critical evaluation and guidelines for future work, Child Dev. 71 (3) (2000) 543–562, https://doi.org/10.1111/1467-8624.00164.

[14] S.M. Saadati, F. Rezazadeh, Stress, resilience, and the immune system: a health psychology analysis, KMAN Counseling & Psychology Nexus 1 (1) (2023) 109–117, https://doi.org/10.61838/kman.psychnexus.1.1.14.

[15] N.J. Thompson, D. Fiorillo, B.O. Rothbaum, K.J. Ressler, V. Michopoulos, Coping strategies as mediators in relation to resilience and posttraumatic stress disorder, J. Affect. Disord. 225 (2018) 153–159, https://doi.org/10.1016/j.jad.2017.08.049.

[16] C.M. Martin, E. Schofield, S. Napolitano, I.K. Avildsen, J.C. Emanu, R. Tutino, A.J. Roth, C.J. Nelson, African-centered coping, resilience, and psychological distress in Black prostate cancer patients, Psycho Oncol. 31 (4) (2022) 622–630, https://doi.org/10.1002/pon.5847.

[17] H. Galatzer-Levy, S, H, G.A. Bonanno, Trajectories of resilience and dysfunction following potential trauma: a review and statistical evaluation, Clin. Psychol. Rev. 63 (2018) 41–55, https://doi.org/10.1016/j.cpr.2018.05.008.

[18] S. Tagay, A. Kribben, A. Hohenstein, R. Mewes, W. Senf, Posttraumatic stress disorder in hemodialysis patients, Am. J. Kidney Dis. 50 (4) (2007) 594–601, https://doi.org/10.1053/j.ajkd.2007.06.018.

[19] T. Li, T. Liu, J. Han, M. Zhang, Z. Li, Q. Zhu, A. Wang, The relationship among resilience, rumination and posttraumatic growth in hemodialysis patients in North China, Psychol. Health Med. 23 (4) (2018) 442–453, https://doi.org/10.1080/13548506.2017.1384553.

[20] A.D. Mancini, G.A. Bonanno, Predictors and parameters of resilience to loss: toward an individual differences model, J. Pers. 77 (6) (2009) 1805–1832, https://doi.org/10.1111/j.1467-6494.2009.00601.x.

[21] B. Muthén, Latent Variable Analysis: Growth Mixture Modeling and Related Techniques for Longitudinal Data, 2004.

[22] C.A. Denckla, A.D. Mancini, N.S. Consedine, S.M. Milanovic, A. Basu, S. Seedat, G. Spies, D.C. Henderson, G.A. Bonanno, K.C. Koenen, Distinguishing postpartum and antepartum depressive trajectories in a large population-based cohort: the impact of exposure to adversity and offspring gender, Psychol. Med. 48 (7) (2018) 1139–1147, https://doi.org/10.1017/s0033291717002549.

[23] H. Kukihara, N. Yamawaki, M. Ando, M. Nishio, H. Kimura, Y. Tamura, The mediating effect of resilience between family functioning and mental well-being in hemodialysis patients in Japan: a cross-sectional design, Health Qual. Life Outcome 18 (1) (2020) 233, https://doi.org/10.1186/s12955-020-01486-x.

[24] S. Duran, D. Avci, F. Esim, Association between spiritual well-being and resilience among Turkish hemodialysis patients, J. Relig. Health 59 (6) (2020) 3097–3109, https://doi.org/10.1007/s10943-020-01000-z.

[25] Y. Qiu, Y. Huang, Y. Wang, L. Ren, H. Jiang, L. Zhang, C. Dong, The role of socioeconomic status, family resilience, and social support in predicting psychological resilience among Chinese maintenance hemodialysis patients, Front. Psychiatr. 12 (2021) 723344, https://doi.org/10.3389/fpsyt.2021.723344.

[26] H. Igarashi, C. Aldwin, An ecological model of resilience in late life, Annu. Rev. Gerontol. Geriatr. 32 (1) (2012) 115–130, https://doi.org/10.1891/0198-8794.32.115.

[27] Z. Naghiloo, Global health interventions in resource-limited settings: successes and lessons learned, Health Nexus 1 (3) (2023) 56–60, https://doi.org/10.61838/kman.hn.1.3.8.

[28] S.Y. Kim, Determining the number of latent classes in single- and multi-phase growth mixture models, Struct. Equ. Model. 21 (2) (2014) 263–279, https://doi.org/10.1080/10705511.2014.882690.

[29] X. Li, C.L. Zhang, X.P. Zhao, Analysis of trajectory and influencing factors of psychological resilience in patients with coronary heart disease receiving percutaneous coronary intervention based on latent class growth model, Journal of practical cardio-cerebral pulmonary vascular diseases 32 (7) (2024) 110–115, https://doi.org/10.12114/j.issn.1008-5971.2024.00.154.

[30] Y. Shan, X. Liu, W. Chen, et al., Predictors of psychological resilience trajectories in patients with knee arthroplasty: a longitudinal study, J. Adv. Nurs. 79 (5) (2023) 1926–1938, https://doi.org/10.1111/jan.15421.

[31] D.S. Yu, D.T. Lee, J. Woo, Psychometric testing of the Chinese version of the medical outcomes study social support survey (MOS-SSS-C), Res. Nurs. Health 27 (2) (2004) 135–143, https://doi.org/10.1002/nur.20008.

[32] C. Dong, C. Gao, H. Zhao, Reliability and validation of family resilience assessment scale in the families raising children with chronic disease, J Nurs Sci 33 (10) (2018) 93–97.

[33] X. Yu, J. Zhang, Factor analysis and psychometric evaluation of the Connor-Davidson Resilience Scale (CD-RISC) with Chinese people, SBP (Soc. Behav. Pers.): Int. J. 35 (1) (2007) 19–30.

[34] L.K. Muthén, B.O. Muthén, Mplus User's Guide, sixth ed., 1998.

[35] G.E. Schwarz, Estimating the dimension of a model, Ann. Stat. 6 (2) (1978).

[36] L. Yungtai, N.R. Mendell, D.B. Rubin, Testing the number of components in a normal mixture, Biometrika (3) (2001) 767–778.

[37] X.N. Yu, J.T. Lau, W.W. Mak, J. Zhang, W.W. Lui, J. Zhang, Factor structure and psychometric properties of the Connor-Davidson Resilience Scale among Chinese adolescents, Compr. Psychiatr. 52 (2) (2011) 218–224, https://doi.org/10.1016/j.comppsych.2010.05.010.

[38] C.J. González-Flores, G. Garcia-Garcia, C. Lerma, R.M.E. Guzmán-Saldaña, A. Lerma, Effect of cognitive behavioral intervention combined with the resilience model to decrease depression and anxiety symptoms and increase the quality of life in ESRD patients treated with hemodialysis, Int. J. Environ. Res. Publ. Health 20 (11) (2023), https://doi.org/10.3390/ijerph20115981.

[39] A.D. Mancini, G.A. Bonanno, Resilience in the face of potential trauma: clinical practices and illustrations, J. Clin. Psychol. 62 (8) (2006) 971–985, https://doi.org/10.1002/jclp.20283.

[40] M.E. Lachman, S. Teshale, S. Agrigoroaei, Midlife as a pivotal period in the life course: balancing growth and decline at the crossroads of youth and old age, Int. J. Behav. Dev. 39 (1) (2015) 20–31, https://doi.org/10.1177/0165025414533223.

[41] M.S.N. Ng, D.N.S. Chan, Q. Cheng, C. Miaskowski, W.K.W. So, Association between financial hardship and symptom burden in patients receiving maintenance dialysis: a systematic review, Int. J. Environ. Res. Publ. Health 18 (18) (2021), https://doi.org/10.3390/ijerph18189541.

[42] H.E. Yeom, J. Lee, Gender difference in the relationship among family function, health behavior, and stress in midlife, Int. J. Aging Hum. Dev. 91 (4) (2020) 476–500, https://doi.org/10.1177/0091415019896225.

[43] J. Michalczyk, J. Dmochowska, A. Aftyka, J. Milanowska, Post-traumatic growth in women with breast cancer: intensity and predictors, Int. J. Environ. Res. Publ. Health 19 (11) (2022), https://doi.org/10.3390/ijerph19116509.

[44] G. Lucchetti, H.G. Koenig, A.L.G. Lucchetti, Spirituality, religiousness, and mental health: a review of the current scientific evidence, World J Clin Cases 9 (26) (2021) 7620–7631, https://doi.org/10.12998/wjcc.v9.i26.7620.

[45] S. Gopal, The case for prioritizing malignant hematology services in low- and middle-income countries, Semin. Hematol. (2023), https://doi.org/10.1053/j.seminhematol.2023.08.005.

[46] I. Ur Rahman, D. Jian, L. Junrong, M. Shafi, Socio-economic status, resilience, and vulnerability of households under COVID-19: case of village-level data in Sichuan province, PLoS One 16 (4) (2021) e0249270, https://doi.org/10.1371/journal.pone.0249270.

[47] C.J. González-Flores, G. García-García, A. Lerma, H. Pérez-Grovas, R.M. Meda-Lara, R.M.E. Guzmán-Saldaña, C. Lerma, Resilience: a protective factor from depression and anxiety in Mexican dialysis patients, Int. J. Environ. Res. Publ. Health 18 (22) (2021), https://doi.org/10.3390/ijerph182211957.

[48] J.J. Chen, Q.L. Wang, H.P. Li, T. Zhang, S.S. Zhang, M.K. Zhou, Family resilience, perceived social support, and individual resilience in cancer couples: analysis using the actor-partner interdependence mediation model, Eur. J. Oncol. Nurs. 52 (2021) 101932, https://doi.org/10.1016/j.ejon.2021.101932.

[49] Y. Zhang, R. Tang, L. Bi, D. Wang, X. Li, F. Gu, J. Han, M. Shi, Effects of family-centered positive psychological intervention on psychological health and quality of life in patients with breast cancer and their caregivers, Support. Care Cancer 31 (10) (2023) 592, https://doi.org/10.1007/s00520-023-08053-2.