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ORIGINAL RESEARCH

The Sleep Patterns and Influencing Factors of Chronic Heart Failure Patients in China: A Latent Profile Analysis

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Purpose: Sleep problems such as reduced sleep efficiency, difficulty initiating sleep, and increased sleep disturbances significantly affect the quality of life and health status of patients with chronic heart failure (CHF). However, the sleep patterns of CHF patients and their influencing factors need to be further studied. Therefore, this study aimed to explore the latent sleep patterns in patients with CHF and to analyze the factors influencing different sleep patterns.

Patients and Methods: A convenience sampling method was adopted to select 290 patients with CHF who were hospitalized in the Department of Cardiology of a tertiary hospital in Yangzhou City, Jiangsu Province, China, from January to August 2024. The investigation utilized a general information questionnaire, the Pittsburgh Sleep Quality Index (PSQI), and the Fear of Progression Questionnaire-Short Form (FoP-Q-SF). Utilizing Mplus version 8.3 for potential profile analysis, the influences on potential categorization were examined through univariate and multivariate logistic regression analyses.

Results: The sleep quality score of 290 patients with CHF was (12.00±3.95). The findings from latent profile analysis indicated that the sleep quality patterns of patients with CHF were categorized into three distinct profiles: relatively good sleep group (n=87, 30.3%), low sleep efficiency-low medication use group (n=160, 54.9%), and sleep disorder-substance dependence group (n=43, 14.8%). Multiple logistic regression analysis showed that age, monthly income, number of hospitalizations for heart failure in a year, number of comorbidities, and fear of progression were influential factors ($P < 0.05$).

Conclusion: Sleep quality among patients with CHF exhibits distinct distributional profiles. Healthcare providers should implement tailored sleep management strategies and psychological interventions, aligning with the sleep patterns and influencing factors specific to patients with CHF. However, it is necessary to note that this study employed a cross-sectional design, and future research could benefit from a longitudinal design.

Keywords: chronic heart failure, sleep quality, latent profile analysis, fear of progression, influencing factors

Introduction

Chronic heart failure (CHF) is a significant clinical and public health challenge worldwide, with the current estimate suggesting that 64 million people are living with CHF worldwide.[1] Approximately 8.9 million individuals in China are affected by CHF, and the prevalence continues to rise.[2] In patients with CHF, common symptoms encompass dyspnea, peripheral edema, fatigue, and sleep disturbances.[3] The prevalence of sleep disorders in CHF patients has been reported to range from 55.0% to 85.8%,[4–8] often characterized by early awakening, difficulty in sleep initiation and maintenance, and insomnia.[6,9] Inadequate quality sleep may trigger an inflammatory response and altered hormone levels, further aggravating the burden on the patient's cardiac condition.[10] This may contribute to a deterioration of health status and a diminished quality of life.[11] A study showed that sleep efficiency was also associated with lower self-care maintenance.[12] Furthermore, difficulty in falling asleep and early rising serves an essential function in the maintenance of cognitive health.[13] Therefore, it is necessary to investigate the different sleep patterns of CHF patients and their relevant factors to decrease the underlying health hazards.

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Several studies have delved into the sleep characteristics of CHF patients. The cross-sectional study conducted by Esnaasharieh et al[6] revealed that patients with CHF exhibited shorter sleep duration and more frequent sleep disorders. Wang et al,[14] on the other hand, reported low sleep efficiency and short nighttime sleep duration in patients with CHF. Javadi et al[15] observed a significant prolongation of sleep latency in patients with CHF. Furthermore, some socio-demographic characteristics such as gender, education level, monthly income, occupational status,[16] number of heart failure (HF) hospitalizations in the past year, number of HF medications, and NYHA classification are correlates of sleep in patients with CHF.[4,6] In particular, Xiong et al[4] have shown that fear of progression (FoP) accounts for 9.1% of the variance in poor sleep quality independently. However, the above studies have predominantly concentrated on the overall sleep quality of patients but were unable to reveal the diverse sleep patterns among different patients due to individual heterogeneity. Consequently, this makes it challenging for healthcare providers to implement precise and effective sleep management for CHF patients with distinct sleep patterns.

Currently, assessment tools for sleep disorders are categorized between objective assessment tools that are monitored using instrumentation and subjective assessment tools that are self-reported by the individual. Objective assessment tools, such as polysomnography (PSG) and actigraphy, are generally limited in their application among patients with CHF due to factors such as high cost, complexity, and stringent requirements for environmental and equipment settings.[17,18] As compared to objective assessment methods, subjective assessment tools, such as the Pittsburgh Sleep Quality Index(PSQI), which are low-cost and user-friendly, are extensively used in the clinic.[19] Although PSQI can determine whether a patient has a sleep problem and its severity, it is not possible to identify the specific sleep patterns of CHF patients. Therefore, using the PSQI, this study explores the sleep patterns and characteristics of different CHF patients based on the individual level, aiming to provide detailed insights into the specific sleep patterns in this population.

In contrast to traditional cluster analysis, Latent Profile Analysis (LPA) is an emerging method of individual-centered statistical analysis that identifies homogeneous subgroups characterized by similar distributions, rather than merely examining overall average trends. Consequently, the present study employed LPA to identify distinct subgroups within the sleep patterns of CHF patients exhibiting diverse phenotypes and to elucidate the influencing factors associated with each subgroup. Understanding the sleep patterns of CHF patients could aid healthcare professionals in delivering a precise and personalized sleep management strategy for patients with CHF.

Materials and Methods

Participants

This study utilized a cross-sectional design. A convenience sampling method was employed to recruit 290 patients with CHF hospitalized in the Department of Cardiology at the Affiliated Hospital of Yangzhou University from January to August 2024 as the study participants. The inclusion criteria were as follows: ① a physician's diagnosis of HF; ② a stable condition; ③ age ≥ 18 years; ④ New York Heart Association (NYHA) class II–IV; ⑤ ability to understand questionnaire content; ⑥ provision of informed consent to voluntarily study participation. The exclusion criteria comprised: ① the presence of comorbid psychiatric disorders or cognitive dysfunction; ② a combination of other serious diseases and malignant tumors; ③ visual and hearing impairments. According to the requirements of the regression analysis model in G*Power 3.1, the medium effect size of 0.15, the alpha of 0.05, and the test efficacy of 0.95.[20] A maximum of 21 predictor variables was included in this study, accounting for a potential 10% invalidated questionnaires. The resulting calculated sample size was at least 252 participants.

Measures

General Information Questionnaire

Use a general information questionnaire designed jointly by the researcher and members of the subject team based on a thorough reading of the literature. It included patients' sociodemographic data: gender, age, education level, occupation, monthly income, caregiver and disease-related data: number of comorbidities, HF hospitalizations in the last year, number of medications, mean hospital duration, NYHA cardiac classification, and duration of HF.

The Pittsburgh Sleep Quality Index

The sleep quality was measured by the Pittsburgh Sleep Quality Index (PSQI). The PSQI was compiled by Buysse et al[19] and Chineseized by Liu et al.[21] The scale includes 19 items in seven dimensions: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction, of which one item is not involved in the scoring. All dimensions were summed to obtain the total PSQI scale, ranging from 0 to 21 points, with higher scores indicating poorer sleep quality. In this study, a cutoff score of 7 was used, with scores above 7 suggesting the presence of a sleep disorder.[21] The Cronbach's alpha in this study was 0.773.

The Fear of Progression Questionnaire-Short Form

FoP was measured using the Fear of Progression Questionnaire-Short Form (FoP-Q-SF), which was simplified by Mehnert et al[22] based on the original Fear of Progression Questionnaire (FoP-Q) and then simplified by Wu et al[23] The scale consists of 12 entries in 2 dimensions: physical health and social family, and is scored on a 5-point Likert scale from "never" to "always", with a total score range of 12–60 points. The higher the score, the more severe the fear, and 34 is the critical level. The Cronbach's alpha coefficient was 0.838 in this study.

Data Collection

The investigators strictly followed the inclusion and exclusion criteria to select matched CHF patients. The investigators obtained documented informed consent from participants after thoroughly explaining the study's objectives, procedures, and privacy protection statement. Patients completed the questionnaire questions independently, with the investigators providing clarification only upon request, thus not interfering with the answering process. When the patient is unable to answer the questionnaire independently, the investigators will dictate the questionnaire questions one-on-one without guiding questions and check the answers strictly according to the patient's answers. The questionnaires were checked on-site after collection to ensure the completion and quality of the questionnaires.

Statistical Analysis

Descriptive statistics were analyzed using SPSS version 25.0. Kolmogorov–Smirnov (K-S) was used to test data normality. Continuous data were described by the means ± SD and categorical data were described by frequency (percentage). Group comparisons were performed using the chi-square test, Fisher's exact test, and analysis of variance (ANOVA). We used boxplots via R version 4.4.1 to show differences in total PSQI scores by independent variable between potential classes.

In this study, the mean scores of the seven dimensions of the PSQI were used as exogenous variables for LPA using Mplus version 8.3. Starting with the assumption of a potential category of 1, the number of categories from 1 to 5 were sequentially selected for model fitting. The selection of the best model was a combination of model fitness evaluation metrics, model comparison metrics, and clinical realities. The model fitness evaluation metrics consist of the Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-size-adjusted Bayesian information criterion (aBIC). Lower values of AIC, BIC, and aBIC indicate a more favorable fit of the model. In addition, entropy is used to measure the accuracy of the model classification. Entropy ranges from 0 to 1, with values closer to 1 indicating more accurate classification and ≥ 0.8 suggesting a more satisfactory model fit. The comparative fit of various model categories was evaluated using the Lo-Mendell -Rubin Adjusted Likelihood Ratio Test (LMR) and the Bootstrap Likelihood Ratio Test (BLRT). Achieving statistical significance ($P < 0.05$) indicates that the model with k categories is significantly superior to the model with k-1 categories.

Multivariate logistic regression was applied with the categorical results of sleep patterns as the dependent variable and the variables with statistically significant differences in the between-group comparisons as the independent variables. $P < 0.05$ represents a statistically significant difference.

Results

Participants Characteristics

In the present study, a total of 312 patients were contacted, and 7 were rejected. An additional 15 questionnaires exhibiting monotonous responses were excluded, resulting in a final valid sample size of 290, yielding a response rate of

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92.95%. Among the 290 participants with CHF in this study, the mean age was 73.84 (SD = 11.41) years. There were 136 males (46.9%) and 154 females (53.1%). FoP-Q-SF scale score was 29.68 (SD = 7.20). PSQI score was 12.00 (SD = 3.95). The socio-demographic characteristics and disease-related information of the CHF patients are shown in Table 1.

Latent Classes and Naming of Sleep Patterns

In this study, latent class models of sleep patterns were analyzed sequentially for the number of classes 1–5, as shown in Table 2. As the number of classes increases sequentially from 1 to 5, AIC and aBIC gradually decrease, and the rate of decrease begins to plateau at the 3-class, suggesting that the model fit improves progressively. The BIC gradually decreased from 1-class to 4-class and began to increase slightly in 5-class, indicating a better model fit for 4-class. However, the LMR for 4-class was not statistically significant (P > 0.05), indicating that there was no significant improvement in the quality of the model fit when increasing from 3-class to 4-class. In addition, the entropy is all higher than 0.9 from 3-class onwards with a gradually increasing trend, indicating a potential risk of overfitting and decreasing clinical interpretability due to increased model complexity. Compared to 4-class, the sample exhibited a more uniform distribution across categories in 3-class, and both LMR and BLRT yielded statistically significant results (P < 0.05). For these reasons, 3-class was finally chosen as the optimal model, considering the potential overfitting and model simplicity.

Drawing a model diagram of the latent class model of sleep patterns for the 3-class model in Figure 1. Class 1 comprised 30.3% (n = 87) of the sample and exhibited the lowest mean PSQI scores across all dimensions compared to the other two classes; hence, it was designated as "relatively good sleep". Class 2, comprising 54.9% (n = 160) of the sample, had the highest

Table 1 General Data and Univariate Analysis of Potential Profiles of Sleep Characteristics in Patients with CHF

Characteristic		Total (n, %)	Relatively good sleep (n = 87)	Low Sleep Efficiency-Low Medication Use (n = 160)	Sleep Disorders-Substance Dependence (n = 43)	χ^2/F	P
Age (years)	<60	32 (11.0)	18 (20.7)	13 (8.1)	1 (2.3)	11.966	**0.002**
	≥60	258 (89.0)	69 (79.3)	147 (91.9)	42 (97.7)		
Gender	Male	136 (46.9)	44 (50.6)	75 (46.9)	17 (39.5)	1.408	0.511
	Female	154 (53.1)	43 (49.4)	85 (53.1)	26 (60.5)		
Education level	≤Primary	176 (69.7)	44 (50.6)	104 (65.0)	28 (65.1)	15.436	**0.003**
	Junior and senior high	90 (31.0)	27 (31.0)	50 (31.3)	13 (30.2)		
	≥College	24 (8.3)	16 (18.4)	6 (3.8)	2 (4.7)		
Occupation	Manual labor	239 (82.4)	66 (75.9)	139 (86.9)	34 (79.1)	5.106	0.077
	Non-manual labor	51 (17.6)	21 (24.1)	21 (13.1)	9 (20.9)		
Monthly income (RMB)	<5000	166 (57.2)	36 (41.4)	105 (65.6)	25 (58.1)	13.552	**0.001**
	≥5000	124 (42.8)	51 (58.6)	55 (34.4)	18 (41.9)		
Caregiver	Yes	259 (89.3)	80 (92.0)	144 (90.0)	35 (81.4)	3.34	0.199
	No	31 (10.7)	7 (8.0)	16 (10.0)	8 (18.6)		
Number of comorbidities	<3	239 (82.4)	75 (86.2)	136 (85.0)	28 (65.1)	10.479	0.006
	≥3	51 (17.6)	12 (13.8)	24 (15.0)	15 (34.9)		
HF hospitalizations in the last year	<3	243 (83.8)	83 (95.4)	130 (81.3)	30 (69.8)	15.625	**<0.001**
	≥3	47 (16.2)	4 (4.6)	30 (18.8)	13 (30.2)		
Number of medications	<5	131 (45.2)	46 (52.9)	70 (43.8)	15 (34.9)	4.052	0.127
	≥5	159 (54.8)	41 (47.1)	90 (56.3)	28 (65.1)		
Duration of HF (years)	<2	160 (55.2)	49 (56.3)	87 (54.4)	24 (55.8)	0.095	0.959
	≥2	130 (44.8)	38 (43.7)	73 (45.6)	19 (44.2)		
Mean hospital duration (days)	<10	174 (60.2)	58 (67.4)	96 (60.0)	20 (46.5)	5.248	0.074
	≥10	115 (39.8)	28 (32.6)	64 (40.0)	23 (53.5)		
NYHA class	II	22 (7.6)	10 (11.5)	11 (6.9)	1 (4.5)	10.076	**0.035**
	III	159 (54.8)	55 (63.2)	81 (50.6)	23 (53.5)		
	IV	109 (37.6)	22 (25.3)	68 (42.5)	19 (44.2)		
FoP-Q-SF [M(SD)]		29.7 (7.2)	25.3 (7.2)	31.3 (6.4)	32.6 (6.0)	25.684	**<0.001**
PSQI [M(SD)]		12.0 (4.0)	7.7(2.6)	13.2(2.4)	16.3(3.3)	172.38	**<0.001**

Note: Bold, P < 0.05.
Abbreviations: HF, heart failure; FoP-Q-SF, Fear of Progression Questionnaire-Short Form; PSQI, Pittsburgh Sleep Quality Index.

Table 2 Fit Indicators for Potential Profile Model

Model	Loglikelihood	AIC	BIC	aBIC	Entropy	P		Category Probability
						LMR	BLRT	
1	−2516.972	5061.944	5113.322	5068.926	—	—	—	—
2	−2219.277	4482.555	4563.292	4493.526	1.000	<0.001	<0.001	0.852/ 0.148
3	−2061.797	4183.594	4293.690	4198.555	0.926	0.0255	<0.001	0.303/0.549/ 0.148
4	−1949.114	3974.227	4113.683	3993.178	0.939	0.2961	<0.001	0.284/0.097/0.086/ 0.533
5	−1928.160	3948.319	4117.134	3971.260	0.956	0.3790	<0.001	0.288/0.013/0.086/0.529/ 0.085

Notes: — indicates no such data, P <0.05 was considered statistically significant.
Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion; aBIC, sample-size-adjusted Bayesian information criterion; Entropy, information entropy; LMR, Lo-Mendell-Rubin Adjusted Likelihood Ratio Test; BLRT, the Bootstrap Likelihood Ratio Test.

scores on the dimensions of sleep efficiency and sleep disorders and comparatively lower scores on the dimension of use of sleep medication. Consequently, this class was designated as “low sleep efficiency-low medication use”. The proportion of patients in class 3 was 14.8% (n = 43), exhibiting high scores on all dimensions, indicating a broad spectrum of sleep disturbances and a significant reliance on sleep medication. Consequently, this class was designated the “sleep disorders-substance dependence”. The differences in PSQI scores for all 3 classes were significant (P < 0.001), and post hoc comparative analyses showed that PSQI scores were Class 1 < Class 2 < Class 3, as shown in Table 1.

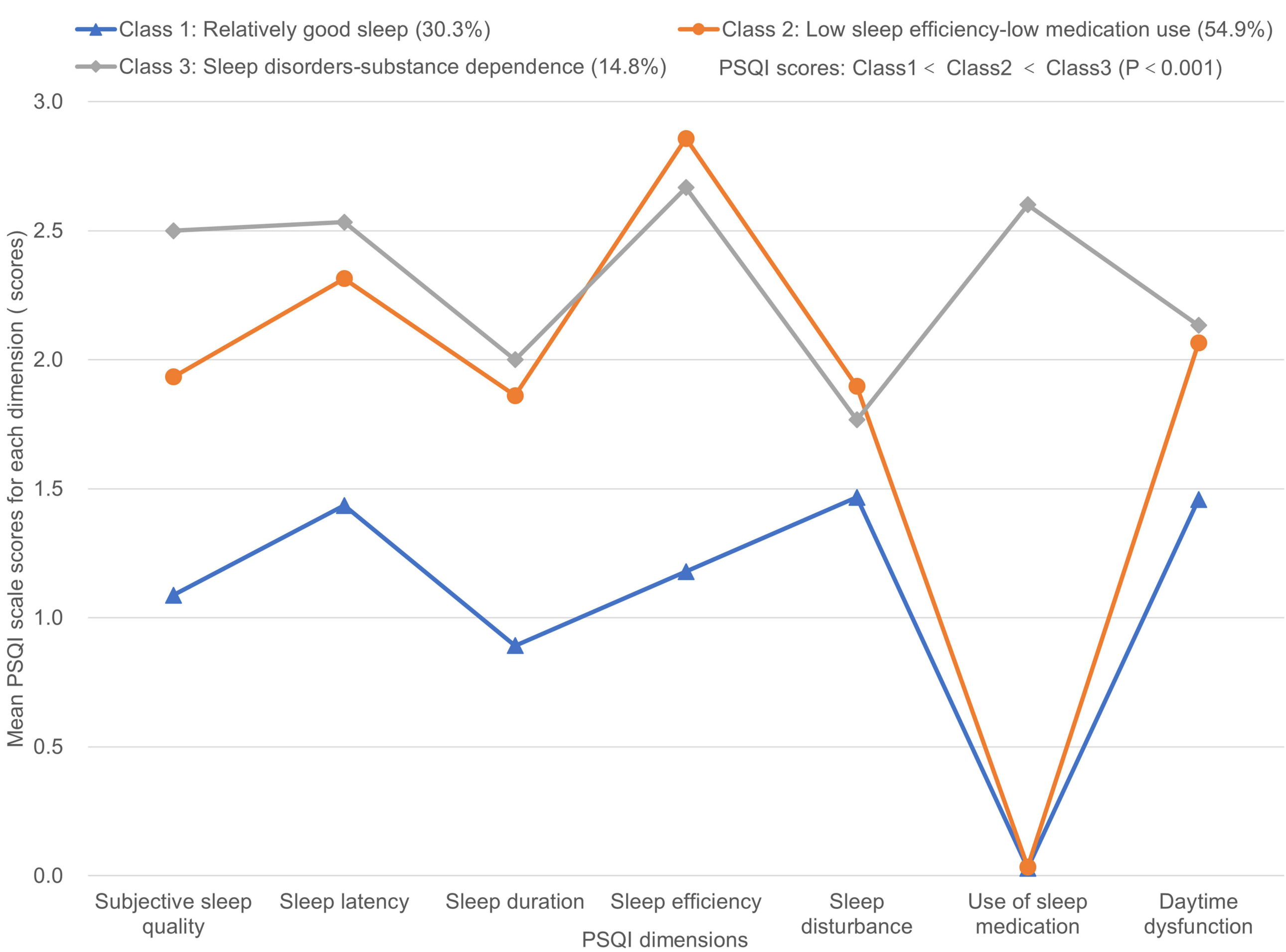

Figure 1 Characteristic distribution of three latent classes of sleep patterns in patients with CHF. This figure shows the differences in sleep characteristics on the PSQI among CHF patients in the subgroups of the 3 classes of sleep patterns. Class 1 had the lowest scores on all dimensions indicative of superior sleep quality compared to Class 2 and 3. Class 2 demonstrated lower overall PSQI scores but had poorer sleep efficiency and more pronounced sleep disturbances compared to Class 3.

Univariate Analysis of Latent Classes of Sleep Patterns in Patients with CHF

The results of the univariate analysis of the three sleep patterns classes showed statistically significant differences ($P < 0.05$) in age, education level, monthly income, number of comorbidities, HF hospitalizations in the last year, NYHA classification, and FoP-Q-SF scale scores, as shown in Table 1. In addition, the results of differences in PSQI scores for the independent variables between potential classes see Supplementary Figures S1–S13, where there were significant differences in total PSQI scores between potential classes for age and FoP (see Supplementary Figures S1 and S13).

Multifactorial Analysis of Latent Classes of Sleep Patterns in Patients with CHF

The covariance diagnostics showed that the variance inflation factor values of the independent variables ranged from 1.022 to 1.291 and the tolerances ranged from 0.774 to 0.978, indicating that there was no serious multicollinearity among the independent variables. Multivariate logistic regression analysis was performed with the three latent classes as the dependent variables, Class 1, labeled "relatively good sleep", as the reference class, and the variables with significant differences in the univariate analysis of variance as the independent variables. Transform the categorical independent variables into dummy variables. The values assigned for the respective variables are shown in Table 3. The results of the multiple logistic regression are shown in Table 4. The results showed that patients with higher FoP-Q-SF scores (OR = 1.148, $P < 0.001$; OR = 1.198, $P < 0.001$), age ≥ 60 years (OR = 3.372, P = 0.023; OR = 12.189, P = 0.029), and HF hospitalizations in the last year ≥ 3 (OR = 3.367, P = 0.048; OR = 5.478, P =0.013) were more likely to be classified into Class 2 and Class 3. Patients with monthly income ≥ 5000 RMB (OR = 0.427, P = 0.010) had a lower likelihood of being attributed to Class 2 and a higher likelihood of being attributed to Class 1. Patients with the number of comorbidities ≥ 3 (OR = 3.055, P = 0.031) had a greater probability of being classified as Class 3 compared with Class 1.

Discussion

To the best of our knowledge, this study is the first to identify the sleep patterns of CHF patients with the latent class method. Sleep patterns of CHF patients exhibited three subgroups: relatively good sleep, low sleep efficiency-low medication use, and sleep disorders-substance dependence. Factors affecting sleep characteristics included age, monthly income, number of comorbidities, HF hospitalizations in the last year, and FoP.

Subgroups of Sleep Patterns in CHF Patients

The findings of this study indicated that the relatively good sleep group comprised 30.3% of the sample, and the sleep quality within this group was comparatively favorable. This distinction may be attributed to the higher education level and stable condition of patients within this group. Patients demonstrated good self-care abilities, which enabled them to effectively manage their disease and control symptoms, resulting in less compromised sleep quality.[24] Practitioners should encourage this group of patients to continue to maintain a healthy lifestyle and self-management program, thereby consolidating and further enhancing sleep quality.

The low sleep efficiency-low medication use group comprised 54.9% of patients, and the overall sleep quality of this group was better than that of patients in the sleep disorder-substance dependence group, but it had the lowest sleep

Table 3 Assignment Table for Multifactorial Analysis of Latent Classes of Sleep Patterns in Patients with CHF

Variables	Assignment of Value
Age (year)	<60=0, ≥60=1
Education level	≤Primary (reference), X1: Junior and senior high =1, ≥College =0; X2: Junior and senior high =0, ≥College =1
Monthly income (RMB)	<5000 =0, ≥5000 =1
Number of comorbidities	<3 =0, ≥3 =1
HF hospitalizations in the last year	<3 =0, ≥3 =1
NYHA class	II (reference), X1: III =1, IV =0; X2: III =0, IV =1
FoP-Q-SF scores	Actual value

Abbreviations: HF, heart failure; FoP-Q-SF, Fear of Progression Questionnaire-Short Form.

Table 4 Multifactorial Analysis of Latent Classes of Sleep Patterns in Patients with CHF

Covariates		Low Sleep Efficiency-Low Medication Use					Sleep Disorders-Substance Dependence				
		B	OR	95% CI		P	B	OR	95% CI		P
				Lower Limit	Upper Limit				Lower Limit	Upper Limit	
Constant term		−4.175				<0.001	−9.467				<0.001
Age (years)	≥60	1.126	3.372	1.186	9.587	**0.023**	2.501	12.189	1.293	114.908	**0.029**
Education level	Junior and senior high	−0.182	0.833	0.396	1.753	0.631	−0.362	0.696	0.258	1.876	0.474
	≥College	−1.156	0.315	0.094	1.058	0.062	−0.685	0.504	0.086	2.946	0.447
Monthly income (RMB)	≥5000	−0.850	0.427	0.233	0.817	**0.010**	−0.526	0.591	0.245	1.422	0.240
Number of comorbidities	≥3	0.080	1.083	0.458	2.563	0.856	1.117	3.055	1.108	8.420	**0.031**
HF hospitalizations in the last year	≥3	1.214	3.367	1.011	11.216	**0.048**	1.701	5.478	1.429	21.001	**0.013**
NYHA class	III	0.043	1.044	0.319	3.421	0.943	1.137	3.117	0.310	31.304	0.334
	IV	0.599	1.820	0.525	6.307	0.345	1.457	4.294	0.412	44.729	0.223
FoP-Q-SF		0.138	1.148	1.092	1.207	**<0.001**	0.181	1.198	1.117	1.285	**<0.001**

Note: Bold, P < 0.05.
Abbreviations: HF, heart failure; FoP-Q-SF, Fear of Progression Questionnaire-Short Form.

efficiency and the most severe sleep disorders. It may be because patients in this category had more NYHA class III and IV patients with unfavorable health status and clinical symptoms.[25] Sleep-disordered breathing (SDB) is one of the most common sleep disorders in patients with CHF and is associated not only with the progression of HF but also with reduced sleep quality and efficiency.[17,26] The severity and persistence of sleep disturbances can disrupt the maintenance and continuity of sleep, ultimately impairing sleep efficiency.[27,28] This is consistent with the results of Türoff et al[17] using PSG. In addition, this group of patients had the lowest utilization of hypnotic drugs, and the reasons for this may be analyzed concerning drug literacy and medication adherence. The misunderstanding of hypnotic drugs caused the general low willingness of patients to take hypnotic drugs.[29] Brief behavioral treatment is effective in improving sleep efficiency in patients with CHF.[30] In addition, the cautious use of short-term, low-dose medication is advised, with monitoring of medication adherence and side effects. Adequate explanation of medication use is also recommended to minimize misunderstanding and anxiety.

The sleep disorder-substance dependence group, comprising 14.8% of the patient sample, was distinguished by disrupted multidimensional sleep patterns, severe impairment of daytime functioning, and elevated use of hypnotic medications. While hypnotics assist patients in falling asleep, prolonged usage may negatively affect their daytime functioning and disease management.[31,32] Studies have indicated that long-term use of hypnotic drugs can disrupt sleep structure, such as difficulties in maintaining sleep and daytime sleepiness.[33,34] Long-term use of benzodiazepines is associated with an increased risk of readmission.[32] Interventions that rely on medication should be lessened for this group. Cognitive behavioral therapy for insomnia, which includes sleep hygiene education, cognitive treatment, and stimulus control, can promote the transition to healthy sleep patterns in patients.

Factors Influencing Subgroups of Sleep Patterns

The results of this present study demonstrated that patients with CHF aged < 60 years and HF hospitalizations in the last year < 3 had a high probability of being attributed to the relatively good sleep group compared to the low sleep efficiency-low medication use group and the sleep disorders-substance dependence group. These results are consistent with the studies conducted by He et al[35] and Javadi et al,[15] yet they contrast with those reported by Wang et al.[14] This discrepancy may be attributed to variations in the sample demographics and clinical profiles. Results from Supplementary Figure S1 suggest that older patients could experience poorer sleep quality. Sleep patterns and structure

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change with age, and the presence of disease can further exacerbate these changes.[36] Consequently, sleep problems such as decreased sleep efficiency and nighttime awakenings are more likely to manifest.[37] In addition, fewer hospitalizations mean that HF is relatively well controlled and that patients can reduce their symptom burden through effective self-management, which in turn contributes to better sleep quality. Second, the environmental and medical practices of hospitalization, for instance, are also likely to cause sleep disruption and reduced sleep quality.[38] The study by Edmiston et al[39] also reported that CHF patients exhibited improved sleep quality post-discharge compared to their in-hospital stay. Consequently, healthcare providers should pay attention to sleep problems in elderly patients and implement strategies to enhance patient sleep and recovery during hospitalization, such as minimizing noise levels, optimizing lighting conditions, and centralizing treatment schedules. Additionally, intensive education on home self-management and sleep hygiene practices should be provided to CHF patients before discharge.

The findings of the present study showed that patients with lower FoP had a greater probability of belonging to the relatively good sleep group, which is consistent with the findings of the previous study.[4] FoP is a common psychological response during the illness adaptation process. This adaptive mental state, when dysregulated, may lead to autonomic activation and imbalanced secretion of stress hormones such as cortisol, which can disrupt sleep quality.[40] Furthermore, building on a comprehensive psychophysiological model of insomnia, persistent fear, and anxiety may result in cognitive hyperactivity that disrupts normal sleep patterns and the frequency of awakenings.[41] Healthcare providers should promptly identify patients' fears, facilitate the expression of their concerns and needs through the establishment of a trusting relationship, correct misconceptions about the disease, alleviate the FoP, and enhance their sleep quality.

The findings from this study indicated that patients with a monthly income of <5000 RMB had a greater probability of being categorized as a low sleep efficiency-low medication use group, which is in line with the research conducted by Chen.[16] It is plausible that prolonged treatment and management may lead to significant financial strain for the patients, thereby potentially imposing a psychological burden that influences mood and sleep quality. Patients with lower monthly incomes may have inadequate access to quality medical care and may be less likely to utilize hypnotic medications for alleviating sleep disturbances, ultimately leading to exacerbated sleep problems.[42] Therefore, healthcare professionals are counseled to consider the financial constraints of patients when choosing treatment options and to select affordable and effective treatment options that are within the patient's financial capacity.

Moreover, the present study found that patients with ≥ 3 comorbidities had a greater likelihood of being classified as the sleep disorders-substance dependence group, which is in line with the results of the study by Javadi et al.[15] However, this relationship was not significant in Souza's findings.[28] This may be due to the fact that the study only explored the overall sleep quality of CHF patients, which emphasizes the importance of assessing patients' sleep patterns. An increase in the number of comorbidities implies a deterioration in the patient's overall health, especially in the context of respiratory comorbidities. Patients may experience nocturnal exacerbation of dyspnea and increased nocturnal awakenings due to cardiopulmonary co-morbidities.[43] The results of Ahmed et al[44] also found that decreased cardiorespiratory fitness was associated with reduced sleep efficiency and difficulty falling asleep after awakening at night. Furthermore, patients are more likely to have sleep problems due to somatic symptoms, increasing the need for hypnotic drugs, which can cause other sleep issues as a side effect of long-term usage.[45] Accordingly, healthcare providers should actively assess and manage patient comorbidities through a multidisciplinary team, including monitoring the patient's functional status, metabolic health, and psychological status and reducing the use of medications that induce sleep disturbances or lead to polypharmacy-related adverse reactions.

Limitations and Prospects of This Study

Several limitations should be considered when interpreting the results of this study. First, the naming of sleep patterns in this study was based on the dimensional characteristics of the PSQI scale, and the accuracy and reliability need to be further verified in the future. Secondly, this present study is a cross-sectional study and causality cannot be confirmed due to the lack of longitudinal data. In addition, other potential confounding factors, such as the use of medications that affect sleep, may also affect patients' sleep patterns, which were not fully considered in this study. Future longitudinal studies could be designed to observe the dynamics of sleep patterns with time in patients with CHF and assess possible confounders to determine the optimal time for intervention. Furthermore, the sleep assessment of CHF patients in this study was based exclusively on their subjective reports of the PSQI, which lacked the support of objective parameters to cover all aspects of sleep problems. To improve the rigor and validity of the findings, future studies should consider integrating the results of subjective and objective measures, such as PSG, to provide a more comprehensive analysis of sleep patterns. Finally, the sample was drawn from a single region, limiting the broad applicability of the findings. Future research should broaden the source and number of the center of the sample to improve the generalizability of the findings.

This study identified distinct three sleep patterns among patients with CHF, and this knowledge is critical for developing targeted interventions that address the specific sleep needs of patients with CHF. Healthcare professionals further implement targeted intervention programs by identifying patients at high risk for adverse sleep patterns. Pharmacologic and non-pharmacologic treatment programs may be suitable for patients with different sleep patterns, and thus integrating them into a clinical sleep management strategy may be beneficial to the patient's sleep quality to a large extent.

Conclusion

The present study found that there was heterogeneity in the sleep quality of CHF patients, which could be classified into relatively good sleep group, low sleep efficiency-low medication use group, and sleep disorders-substance dependence group. Sleep patterns were affected by age, HF hospitalizations in the last year, monthly income, number of comorbidities, and FoP. Healthcare providers should prioritize the identification of distinct sleep typologies among patients with CHF and tailor interventions accordingly.

Data Sharing Statement

The data that support the findings of this study are available on request from the corresponding author, K.G., upon reasonable request.

Ethics Approval and Informed Consent

The authors affirm that this present study follows the ethical principles outlined in the Declaration of Helsinki. Ethical approval for this study was granted by the Ethics Review Committee of the School of Nursing, School of Public Health, Yangzhou University (YZUHL20230052).

Author Contributions

Yan Li: writing - original draft, methodology, conceptualization, formal analysis, investigation, and writing-review and editing. Jiamin Li: formal analysis, project administration, and investigation. Jingwen Qin: conceptualization, methodology, and resources. Sixin Zhou: investigation and visualization. Kaizheng Gong: methodology, conceptualization, writing - review and editing, and supervision. 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.

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Disclosure

The authors report no conflicts of interest in this work.

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