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Xiaoya Zhan
Affiliated Stomatological Hospital of Guizhou Medical University
Peng Cai
Affiliated Hospital of Guizhou Medical University
Niannian Peng
Affiliated Hospital of Guizhou Medical University
Xue Zhao
462334703@qq.com

Affiliated Hospital of Guizhou Medical University

Article

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Xiaoya Zhan[1, 2✉], Peng Cai [3], Niannian Peng[4], Xue Zhao[5✉]

[1] Department of Nursing, Affiliated Stomatological Hospital of Guizhou Medical University, Guiyang 55004

[2] School of Nursing, Guizhou Medical University, Guiyang 561113

[3] Department of Nursing, Affiliated Hospital of Guizhou Medical University, Guiyang 550001

[4] Hypertension Department, Affiliated Hospital of Guizhou Medical University, Guiyang 550001

[5] Comprehensive Area, Affiliated Hospital of Guizhou Medical University, Guiyang 550001

✉email：2380046093@qq.com；✉email：462334703@qq.com

Corresponding author: Xue Zhao

Abstract

Objective: To identify latent profiles of health problem-solving ability among elderly patients with hypertension and analyse influencing factors for each profile, thereby providing evidence for developing personalised strategies to enhance this ability.

Methods: Elderly patients with hypertension attending a tertiary-A hospital in Guizhou Province between February and October 2024 were recruited via convenience sampling. Participants completed questionnaires, including the Chinese-version Health Problem-Solving Scale, Hypertension-related Knowledge Scale, Hypertension Patient Self-Efficacy Questionnaire, Social Support Rating Scale, and a sociodemographic and clinical characteristics questionnaire. Latent profile analysis (LPA) was conducted using Mplus software to identify profiles of health problem-solving ability. Multinomial logistic regression analysis was applied to explore associated influencing factors.

Results: A total of 423 elderly patients were included. Three latent profiles of health problem-solving ability were identified : the Low-Ability Avoidance Profile (14.9%),

the Moderate-Ability Impulsive/Careless Profile (27.7%), and the High-Ability Negative-Transfer Profile (57.4%). Multinomial logistic regression revealed that hypertension-related knowledge, treatment method, blood pressure control status, social support, and self-efficacy level were significant influencing factors of health problem-solving ability.

Conclusions: Substantial heterogeneity in health problem-solving ability exists among elderly patients with hypertension. Therefore, clinical nurses should implement personalised interventions tailored to these specific profiles to enhance patients' health problem-solving skills and self-management outcomes, thereby facilitating better disease control and preventing complications.

Keywords: Aged; Hypertension; Health problem-solving ability; Latent profile analysis; Nursing

Introduction

Population ageing is becoming increasingly prominent worldwide, accompanied by a growing burden of chronic diseases among elderly adults. Hypertension is one of the most common chronic conditions in this population, and its prevalence increases steadily with advancing age. More than one billion people worldwide are affected by hypertension and its associated complications, making it an important global public health concern[1]. Relevant reports indicate that ischaemic heart disease and stroke are among the leading causes of mortality worldwide, with hypertension serving as a major contributing cause of cardiovascular and cerebrovascular diseases, including ischaemic heart disease and stroke[1] .Over the past three decades, the disease burden attributable to hypertension has continued to increase globally[2, 3].

China has the largest population of elderly adults in the world [4]. According to data from the seventh national population census, the prevalence of hypertension among adults aged 65 years and elderly exceeds 55% [5]. Previous national surveys have shown that although the awareness and treatment rates of hypertension among adults aged 60 years and elderly are both close to 50%, the hypertension control rate remains only 13.4%–14.8% [6]. Effective blood pressure control in elderly adults can not only reduce the incidence of major adverse cardiovascular events, such as stroke,

but also help preserve cognitive function and prevent Alzheimer's disease [7].Effective self-management can substantively optimize blood pressure control outcomes in elderly patients with hypertension; however, only about 40% of elderly hypertensive patients in China adopt active and positive self-management[8].

Many studies have documented that health problem-solving ability exerts a direct influence on self-management performance among individuals living with chronic illness[9-12]. The self-management guiding framework proposed by the American Association of Diabetes Educators also identifies health problem-solving ability as a core component of disease self-management[13]. Given the absence of a universally agreed upon definition for this construct, the present study synthesises existing literature and defines health problem-solving ability as an individual's ability to deploy relevant knowledge and behavioural strategies to cope with and resolve health related challenges. It encompasses intrinsic contributing factors including problem-solving skill, problem-solving orientation, disease-specific knowledge, and transfer of past experience. These interrelated elements jointly shape individuals' coping performance within health contexts such as chronic disease management[10, 12, 14, 15]. In addition, extrinsic contextual factors such as social support may influence the effectiveness of health problem-solving behaviours. However, empirical studies on the health problem-solving ability of elderly patients with hypertension remain scarce both domestically and internationally. The population characteristics and related influencing factors of this profile's health problem-solving ability are not yet well understood. Most existing studies adopt a variable-centered analytical approach, which overlooks intra-group individual heterogeneity and thus fails to identify distinct patient subgroups with different characteristics.

Latent profile analysis (LPA) is a person centered analytical technique that employs latent categorical variables to interpret relationships among observed continuous indicators. This approach assigns individuals with similar response patterns into homogeneous subgroups, enabling the exploration of distinct profiles of health problem-solving ability in elderly adults with hypertension[16, 17]. Compared with conventional approaches that rely exclusively on total scale scores to evaluate

health problem-solving aibility, LPA facilitates a more nuanced characterisation of both inter-group disparities and intra-group similarities. Guided by the problem-solving model of chronic disease self-management[14], this study aims to investigate the status of health problem-solving ability among elderly adults with hypertension, identify distinct subgroups using latent profile analysis, and explore influencing factors associated with these derived profiles. Findings from this work may inform the development of targeted clinical interventions for healthcare practitioners, with the ultimate goal of enhancing health problem-solving ability, improving self-management behaviours, and optimising blood pressure control among elderly adults living with hypertension.

1. Methods

1.1 Study participants

Elderly patients with hypertension who attended a tertiary hospital in Guizhou Province between February and October 2024 were recruited as study participants. The inclusion criteria were as follows: (1) conforming to the diagnostic criteria for elderly hypertension as specified in the Chinese Guidelines for the Management of Hypertension in the Elderly 2023[6]; (2) able to read and write independently or complete the questionnaire with assistance from researchers; (3) had clear consciousness; (4) had normal hearing and verbal communication. (5) Patients who provided informed consent to participate in the investigation. The exclusion criteria were as follows: (1) comorbidities including severe arrhythmia, cerebral hemorrhage, malignant tumor, or heart failure that hindered survey participation; (2) comorbid Alzheimer's disease; (3) complete dependence in activities of daily living. Based on the principle of sample-size calculation[18], this study included 29 independent variables. The sample size was set at 5 to 10 times the number of independent variables. Considering a 20% invalid questionnaire rate, approximately 182 to 363 samples were required. This study was approved by the Ethics Committee of the Affiliated Hospital of Guizhou Medical University (approval No. 2024-163). All methods were performed in accordance with the relevant guidelines and regulations.

1.2 Instruments

1.2.1 Sociodemographic and clinical characteristics questionnaire

A self-designed sociodemographic and clinical characteristics questionnaire for elderly patients with hypertension was developed based on a literature review. It covered 15 items, including age, sex, ethnicity, educational level, marital status, current or former occupation, average monthly household per-capita income, medical payment method, place of residence, living arrangement, hypertension duration, treatment method, family history of hypertension, blood pressure control status, and comorbid chronic diseases.

1.2.2 Chinese Version of the Health Problem-Solving Scale (HPSS)

The HPSS was originally developed by Hill-Briggs[10]in 2007 and translated into Chinese by Wang[15]in 2023. It consists of six dimensions and 30 items. The dimensions of Avoidant Problem Solving, Impulsive/Careless Problem Solving, Negative Transfer, and Negative Motivation/Orientation represent negative problem-solving subscales and require reverse scoring, whereas Rational Problem Solving, and Positive Motivation/Orientation and Positive Transfer are scored in the forward direction. Items are rated on a 5-point Likert scale ranging from 0 ("not at all true") to 4 ("completely true"). Higher dimension-level scores indicate a more prominent problem-solving characteristic for that respective dimension. The total score is calculated as the sum of mean scores from all dimensions, with a maximum possible score of 24 points; a higher total score reflects greater health problem-solving ability among participants. The original scale had a Cronbach's α coefficient of 0.911, and the Cronbach's α in the present study was 0.710.

1.2.3 Social Support Rating Scale (SSRS)

The Social Support Rating Scale (SSRS) was developed by Xiao [19]. It comprises three dimensions encompassing 10 items in total: objective support (3 items), subjective support (4 items), and utilization of social support (3 items). The total score ranges from 0 to 66, with higher scores reflecting higher levels of social support. A total score < 22 indicates a low level of social support, 22–44 indicates a moderate level, and 45–66 indicates a high level. The Cronbach's α coefficient for this scale

was reported as 0.90.

1.2.4 Hypertension Patient Self-Efficacy Scale

Patients' self-efficacy was assessed using the Hypertension Patient Self-Efficacy Scale developed by Yang [20]. The scale comprises 11 items across four domains: daily living (Items 1, 3, and 7), medication adherence (Items 2, 5, and 8), health behaviors (Items 4 and 6), and adherence to medical recommendations (Items 9, 10, and 11). Each item is rated on a five-point Likert scale ranging from 0 to 4, with a maximum total score of 44. Higher scores indicate higher levels of self-efficacy. The scale has a Cronbach's α coefficient of 0.80.

1.2.5 Hypertension-Related Knowledge Scale

The Hypertension-Related Knowledge Scale was developed by Tang [21]. It consists of 10 items that primarily assess patients' understanding of hypertension diagnostic cut-offs, hypertension-related risk factors, hypertension-related complications, and medication-related knowledge. Each item is scored 0 for an incorrect response and 1 for a correct response, yielding a maximum total score of 10; higher scores reflect better hypertension-related knowledge. The content validity index for this scale was reported as 0.906, and the Cronbach's α coefficient was reported as 0.824.

1.3 Data collection and quality control procedures

Data were collected by rigorously trained investigators.The study's Eligible participants were screened strictly according to the inclusion and exclusion criteria. Prior to data collection, investigators provided uniform, standardized objective instructions for completing questionnaires, and leading questions were strictly prohibited.Participants filled out questionnaires independently based on their real-life experiences. Each participant underwent a face-to-face survey administered by an investigator. For participants who could not complete the questionnaires on their own, the investigator carefully read out response options using standardized non-leading language and recorded their replies. Any missing data identified after questionnaire collection were immediately completed by re-contacting the patients.

1.4 Statistical analysis

Data were entered using EpiData 3.1 and analysed using SPSS 26.0 and Mplus 8.3. Scores from the Chinese version of HPSS, the Social Support Rating Scale, the Hypertension Patient Self-Efficacy Scale, and the Hypertension-Related Knowledge

Scale were subjected to normality testing and found to follow a normal or approximately normal distribution; therefore, they were summarised as mean ± standard deviation. Categorical data were presented as frequencies and percentages.

For latent profile analysis, modelling began with a one-class baseline model, and the number of latent classes was gradually increased to identify optimal model fit. The model fit indices[20] were as follows: (1) smaller values of the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted Bayesian Information Criterion (aBIC) indicated better model fit; (2) Entropy reflects classification precision, with Entropy ≥ 0.8 corresponding a classification accuracy of ≥ 90%; (3) the bootstrap likelihood ratio test (BLRT) and the Lo–Mendell–Rubin likelihood ratio test (LMRT) were used for model comparison. *P* values < 0.05 for BLRT and LMRT indicated that the k-class model fitted significantly better than the k-1-class model. The optimal latent-class model was finally selected by comprehensive consideration of all fit indices.

In univariate analysis, unordered categorical data were analyzed using the chi-square test or Fisher's exact test, ordered categorical data were analysed using the Kruskal-Wallis H-test, and continuous data were analyzed using one-way analysis of variance (ANOVA). Multinomial logistic regression was performed with the latent classes of health problem-solving ability among elderly hypertensive patients as the dependent variable and statistically significant variables from univariate analyses as independent variables, to explore factors associated with these latent classes. A *P* value < 0.05 was regarded as statistically significant.

2 Results

2.1 Sociodemographic and Clinical Characteristics of Elderly Hypertensive Patients

A total of 450 questionnaires were distributed. After excluding 27 invalid responses, 423 valid responses were retained, yielding an overall valid response rate of 94%. The mean age of participants was 70.09 ± 6.26 years, ranging from 65 to 89 years. The remaining general characteristics of participants are presented in Table 3.

2.2 Health problem-solving scale scores among elderly hypertensive patients

The total HPSS score among elderly hypertensive patients was 15.75 ± 3.60, indicating a moderate level of health problem-solving ability. Of the six dimensions, the Avoidant Problem Solving dimension yielded the highest score (3.37 ± 0.77), whereas the Rational Problem Solving dimension had the lowest score (1.91 ± 0.77). Scores for the remaining four dimensions are shown in Table 1.

Table 1 Scores of the Health Problem-Solving Scale in elderly patients with hypertension (n=423)

item	Total score	Score ($\bar{x} \pm s$)	Mean Item score ($\bar{x} \pm s$)
Avoidant Problem Solving	20	16.84±3.84	3.37±0.77
Motivation/Orientation	20	15.09±3.46	3.02±0.69
Negative Transfer	16	11.17±3.73	2.79±0.93
Impulsive/Careless Problem Solving	20	12.34±4.54	2.47±0.91
Positive Motivation/Orientation and Positive Transfer	24	13.14±5.52	2.19±0.92
Rational Problem Solving	20	9.57±3.83	1.91±0.77
Total HPSS	24	15.75±3.60	2.62±0.60

2.3 Results of Latent Profile Analysis of Health Problem-Solving Ability Among Elderly Hypertensive Patients

Health problem-solving Classes 1, 2, and 3 were named according to their overall HPSS scores and performance across the six dimensions. The scores of each class on the six dimensions are presented in Table 3. Class 1 had relatively low scores across all dimensions; notably, its score on the Avoidant Problem Solving dimension was substantially below the mean with the largest deviation, indicating that patients in this profile had the poorest health problem-solving performance on this dimension. Accordingly, Class 1 was named the "Low-Ability Avoidance Profile," comprising 63 patients (14.9%). Class 2 scored between Classes 1 and 3 across all dimensions, with an overall moderately low level; its scores on all dimensions were slightly below the mean, but the deviation from the mean was largest for the Impulsive/Careless

Problem Solving dimension. Therefore, Class 2 was named the "Moderate-Ability Impulsive/Careless Profile," comprising 117 patients (27.7%). Class 3 scored higher than Classes 1 and 2 overall, with above-mean scores on all dimensions; however, its score on the Negative Transfer problem solving dimension was relatively low and close to the mean. Accordingly, Class 3 was named the "High-Ability Negative-Transfer Profile," comprising 243 patients (57.4%).

Table 2 Fitting indicators for potential profile analysis of hypertensive health problem-solving ability in the elderly

model	AIC	BIC	aBIC	Entropy	LMRT	BLMRT	Class probabilities
1	6248.232	6296.800	6258.720	-	-	-	-
2	5388.674	5465.574	5405.280	0.930	0.000	0.000	0.75887/0.24113
3	5156.951	5262.183	5179.676	0.883	0.0391	0.000	0.14894/0.2766/0.57447
4	4991.534	5125.097	5020.377	0.889	0.1622	0.000	0.137/0.281/0.076/0.510

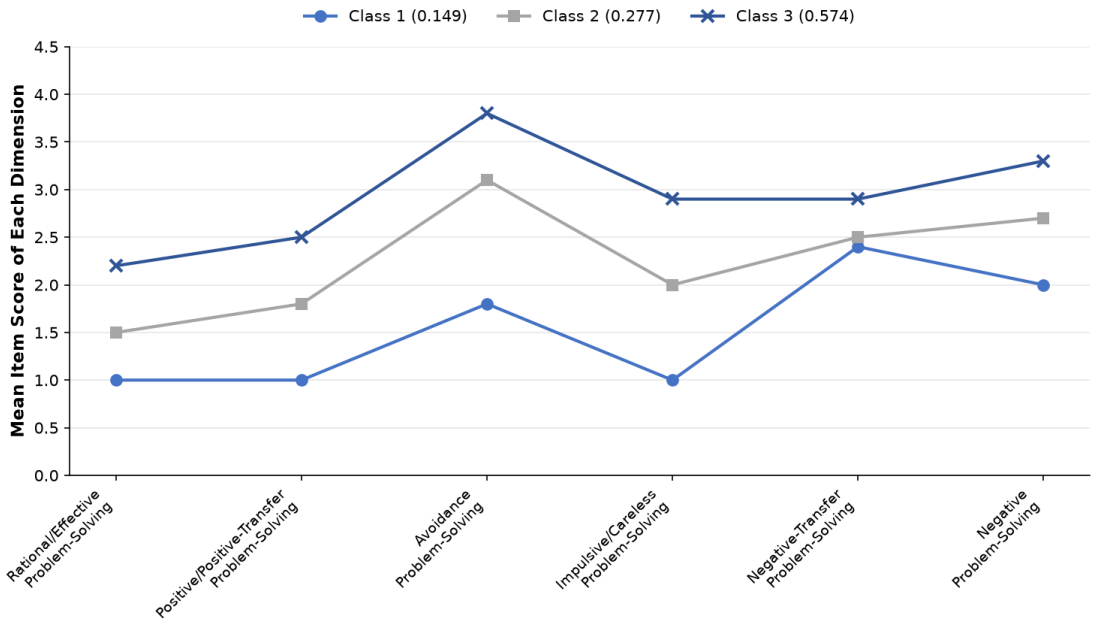


Fig. 1 Characteristic distribution of three potential categories of health problem-solving ability of elderly patients with hypertension

Table 3 Descriptive analysis of health problem-solving in different categories of elderly patients with hypertension (n=423)

item	total	Class 1 (n=63)	Class 2 (n=117)	Class 3 (n=243)	*F*	*P*
Total HPSS	15.75±3.60	9.66±2.11	14.02±1.60	18.16±1.83	620.862	＜0.001
Rational Problem Solving	1.91±0.77	1.07±0.77	1.58±0.58	2.29±0.57	126.469	＜0.001
Positive Motivation/Orientation and Positive Transfer	2.19±0.92	1.10±0.92	1.86±0.76	2.63±0.65	126.681	＜0.001
Avoidant Problem Solving	3.37±0.77	1.85±0.44	3.12±0.36	3.88±0.18	1287.614	＜0.001
Impulsive/Careless Problem Solving	2.47±0.91	1.12±0.64	2.13±0.71	2.98±0.54	259.494	＜0.001
Negative Transfer	2.79±0.93	2.44±1.05	2.58±0.98	2.98±0.83	13.432	＜0.001
Negative Motivation/Orientation	3.02±0.69	2.08±0.60	2.75±0.60	3.39±0.40	200.586	＜0.001

Note: Class 1, Low-Ability Avoidance Profile ; Class 2, Moderate-Ability Impulsive/Careless profile; class 3, High-Ability Negative-Transfer Profile

2.4 univariate analysis of health problem-solving ability across different latent classes among elderly patients with hypertension

The univariate analysis revealed statistically significant inter-group differences across the three latent classes for the following variables ($P < 0.05$): educational level, average monthly household per-capita income, place of residence, current or fomer occupation, medical payment method, treatment method, blood pressure control status, hypertension-related knowledge, self-efficacy, and social support (Table 4).

Table 4 Univariate analysis of health problem-solving in different categories of elderly patients with hypertension (n=423)

project	overall	Class 1 (n=63)	Class 2 (n=117)	Class 2 (n = 243)	Estimates	*P*
Gender[n, (%)]					4.148[a]	0.126
male	191(45.20%)	34(54.00%)	57(48.70%)	100(41.20%)		
female	232(54.80%)	29(46.00%)	60(51.30%)	143(58.80%)		
Age[n, (%)]					1.223[b]	0.543
65 -74	322(76.10%)	43(68.30%)	94(80.30%)	185(76.10%)		
75~84	92(21.70%)	18(28.60%)	23(19.70%)	51(21.00%)		
≥85	9(2.10%)	2(3.20%)	0(0.00%)	7(2.90%)		

Table 4 （Continued）Univariate analysis of health problem-solving in different categories of elderly patients with hypertension (n=423)

project	overall	Class 1 (n=63)	Class 2 (n=117)	Class 2 (n = 243)	Estimates	*P*
Education level[n, (%)]					22.532[b]	<0.001
No formal education	25(5.90%)	10(15.90%)	6(5.10%)	9(3.70%)		
Primary school	78(18.40%)	15(23.80%)	32(27.40%)	31(12.80%)		
Junior high school	126(29.80%)	23(36.50%)	30(25.60%)	73(30.00%)		
High school / Technical secondary school	93(22.00%)	7(11.10%)	21(17.90%)	65(26.70%)		
College diploma	64(15.10%)	7(11.10%)	19(16.20%)	38(15.60%)		
Bachelor's degree or above	37(8.70%)	1(1.60%)	9(7.7.%)	27(11.10%)		
Ethnicity[n, (%)]					0.033[a]	0.983
Han ethnicity	380(89.80%)	57(90.50%)	105(89.70%)	218(89.70%)		
Ethnic minorities	43(10.20%)	6(9.50%)	12(10.30%)	25(10.30%)		
Marital Status[n, (%)]					10.06[c]	0.088
married	340(80.40%)	44(69.80%)	96(82.10%)	200(82.30%)		
unmarried	4(0.90%)	2(3.20%)	0(0.00%)	2(0.80%)		
Widowed	64(15.10%)	16(25.40%)	17(14.50%)	31(12.80%)		
divorced	15(3.50%)	1(1.60%)	4(3.40%)	10(4.10%)		
average monthly Household per-capita income[n, (%)]					25.325[b]	<0.001
<1500(CNY)	11(2.60%)	3(4.80%)	4(3.40%)	4(1.60%)		
1500~3000(CNY)	63(14.90%)	24(38.10%)	16(13.70%)	23(9.50%)		
3001~4500(CNY)	126(29.80%)	15(23.80%)	35(29.90%)	76(31.30%)		
>4500(CNY)	223(52.70%)	21(33.30%)	62(53.00%)	140(57.60%)		
Palce of residence [n, (%)]					17.330[c]	0.020
Rural area	45(10.60%)	11(17.50%)	16(13.70%)	18(7.40%)		
Township	12(2.80%)	3(4.80%)	3(2.60%)	6(2.50%)		
County seat	49(11.60%)	13(20.60%)	13(11.10%)	23(9.50%)		
County-level city	16(3.80%)	3(4.80%)	4(3.40%)	9(3.70%)		
Prefecture-level city	301(71.20%)	33(52.40%)	81(69.20%)	187(77.00%)		
Living arrangement[n, (%)]					12.254[a]	0.057
Living with spouse and children	135(31.90%)	14(22.20%)	46(39.30%)	75(30.90%)		
Living with spouse only	185(43.70%)	28(44.40%)	44(37.60%)	113(46.50%)		
Living with children only	56(13.20%)	13(20.60%)	10(8.50%)	33(13.60%)		
Living alone	47(11.10%)	8(12.70%)	17(14.50%)	22(9.10%)		
Occupation or former occupation[n, (%)]					22.633[a]	<0.001
Manual labour	193(45.60%)	33(52.40%)	64(54.70%)	96(39.50%)		
Non-manual labour	208(49.20%)	22(34.90%)	46(39.30%)	140(57.60%)		
Unemployed	22(5.20%)	8(12.70%)	7(6.00%)	7(2.90%)		

Table 4 (Continued) Univariate analysis of health problem-solving in different categories of elderly patients with

hypertension (n=423)

project	overall	Class 1 (n=63)	Class 2 (n=117)	Class 2 (n = 243)	Estimates	*P*
Medical payment method [n, (%)]					29.570[a]	<0.001
Employee medical insurance	290(68.60%)	32(50.80%)	68(58.10%)	190(78.20%)		
Resident medical insurance	65(15.40%)	12(19.00%)	23(19.70%)	30(12.30%)		
New rural cooperative medical insurance	64(15.10%)	18(28.60%)	25(21.40%)	21(8.60%)		
Commercial medical insurance	4(0.90%)	1(1.60%)	1(0.90%)	2(0.80%)		
Duration of hypertension [n, (%)]					0.660[b]	0.883
<1year	44(10.40%)	1(6.30%)	13(11.10%)	27(11.10%)		
1~5years	109(25.80%)	18(28.60%)	29(24.80%)	62(25.50%)		
6~10years	109(25.80%)	17(27.00%)	29(24.80%)	63(25.90%)		
>10years	161(38.10%)	24(38.10%)	46(39.30%)	91(37.40%)		
Family history of hypertension[n, (%)]					1.071[a]	0.585
Yes	269(63.60%)	37(58.70%)	73(62.40%)	159(65.40%)		
No	154(36.40%)	26(41.30%)	44(37.60%)	84(34.60%)		
Treatment method [n, (%)]					35.602[a]	<0.001
Untreated	38（9.00%）	6（9.50%）	19(16.20%)	13（5.30%）		
Pharmacological treatment	220(52.00%)	45(71.40%)	66(56.40%)	109(44.90%)		
Pharmacological treatment combined with lifestyle intervention	165(39.00%)	12(19.00%)	32(27.40%)	121(49.80%)		
Blood pressure control status[n, (%)]					14.869[b]	0.002
SBP ≤ 140 mmHg and/or DBP ≤ 90 mmHg	124(29.30%)	14(22.20%)	25(21.40%)	85(35.00%)		
SBP 140－59 mmHg and/or DBP 90－99 mmHg	134(31.70%)	18(28.60%)	37(31.60%)	79(32.50%)		
SBP 160－179 mmHg and/or DBP 100－109 mmHg	88(20.80%)	13(20.60%)	28(23.90%)	47(19.30%)		
SBP ≥ 180 mmHg and/or DBP ≥ 110 mmHg	77(18.20%)	18(28.60%)	27(23.10%)	32(13.20%)		

Table 4 （Continued）Univariate analysis of health problem-solving in different categories of elderly patients with

hypertension (n=423)

project	overall	Class 1 (n=63)	Class 2 (n=117)	Class 2 (n = 243)	Estimates	*P*
comorbid chronic diseases[n, (%)]					2.036[a]	0.361
Yes	254(60.00%)	35(55.60%)	66(56.40%)	153(63.00%)		
No	169(40.00%)	28(44.40%)	51(43.60%)	90(37.00%)		
Hypertension-related knowledge score (points, $\bar{x} \pm s$)	6.40±251	4.30±2.56	6.28±2.45	7.01±2.22	33.788[d]	＜0.001
Hypertension patient self-efficacy questionnaire score (points, $\bar{x} \pm s$)	35.13±5.12	30.24±5.74	34.07±4.71	36.91±4.09	58.396[d]	＜0.001
Social Support Rating Scale score (points, $\bar{x} \pm s$)	36.59±6.27	32.19±6.38	36.49±6.52	37.77±5.60	21.795[d]	＜0.001

Note: Class 1, Low-Ability Avoidance Profile ; Class 2, Moderate-Ability Impulsive/Careless Profile; Class 3, High-Ability Negative-Transfer Profile

[a]Represents the value of χ^2. [b]Represents the H-value.

[c]Represents Fisher's exact probability method results. [d]Represents the value of *F*.

2.5 Multinomial logistic regression analysis of health problem-solving ability among elderly hypertensive patients across different latent classes

The three latent classes of health problem-solving ability among elderly hypertensive patients were set as the dependent variable. The "Low-Ability Avoidance Profile", "Moderate-Ability Impulsive/Careless Profile", and "High-Ability Negative-Transfer Profile" were coded as 1, 2, and 3, respectively. The scores for social support, hypertension-related knowledge, and hypertension-patient self-efficacy were entered as raw values. Coding schemes for the remaining independent variables are presented in Table 5. Multivariate logistic regression was performed, incorporating variables with $P < 0.05$ from the univariate analysis as independent variables. The results indicated that, when comparing the "Low Ability–Problem Avoidance Profile" with the "High Ability–Negative Transfer Group," patients with higher scores on hypertension-related knowledge, social support, and hypertension self-efficacy were more likely to be classified in the "high ability–negative transfer group."In the comparison between the "Moderate-Ability Impulsive/Careless Profile" and the "High-Ability Negative-Transfer Profile", participants without antihy pertensive

treatment were more likely to be classified into the "Moderate-Ability Impulsive/Careless Profile", whereas participants with higher hypertension self-efficacy scores and those with blood pressure controlled within the normal range (systolic blood pressure ≤ 140 mmHg and/or diastolic blood pressure ≤ 90 mmHg) were more likely to belong to the "High-Ability Negative-Transfer Profile". In the comparison between the "Low-Ability Avoidance Profile" and the "Moderate-Ability Impulsive/Careless Profile", participants with higher scores on hypertension-related knowledge, social support scores, and hypertension self-efficacy were more likely to belong to the "Moderate-Ability Impulsive/Careless Profile" (Table 6).

Table 5 Assignment methods of independent variables

Independent variable	Variable assignment
Age	65–74 = 1, 75–84 = 2, ≥85 = 3
Gender	Male = 0, female = 1
Educational level	No formal education = 1, primary school = 2, junior high school = 3, technical secondary school/high school/technical school = 4, college diploma = 5, bachelor's degree and above = 6
Occupation (or pre-retirement occupation)	Manual labour = 1(Z1=1, Z2=0), non-manual labour = 2 (Z1=0, Z2=1), unemployed = 3 (Z1=0, Z2=0)
Marital status	Married = 1(Z1=1, Z2=0,Z3=0), unmarried = 2(Z1=0, Z2=1, Z3=0), widowed = 3(Z1=0,Z2=0, Z3=1), divorced = 4 (Z1=0, Z2=0, Z3=0)
Living arrangement	Living with spouse and children = 1 (Z1=1, Z2=0, Z3=0), living with spouse only = 2 (Z1=0, Z2=1, Z3=0), living with children only = 3 (Z1=0, Z2=0, Z3=1), living alone = 4 (Z1=0, Z2=0, Z3=0)
Duration of hypertension(years)	＜1 = 1, 1–5 = 2, 6–10 = 3, ＞10 = 4
Long-term residence	Rural area = 1 (Z1=0, Z2=0, Z3=0, Z4=0), township = 2 (Z1=1, Z2=0, Z3=0, Z4=0), county seat = 3 (Z1=0, Z2=1, Z3=0, Z4=0), county-level city = 4(Z1=0,Z2=0, Z3=1, Z4=0), prefecture-level city = 5 (Z1=0, Z2=0, Z3=0, Z4=1)
Family history of hypertension	No = 0, yes = 1

Table 5 （Continued）Assignment methods of independent variables

Independent variable	Variable assignment
Blood pressure control level	SBP ≤140 mmHg and/or DBP ≤90 mmHg = 1 (Z1=1, Z2=0, Z3=0); SBP 140–159 mmHg and/or DBP 90–99 mmHg = 2 (Z1=0, Z2=1, Z3=0); SBP 160–179 mmHg and/or DBP 100–109 mmHg = 3(Z1=0, Z2=0, Z3=1); SBP≥180 mmHg and/or DBP ≥110 mmHg = 4 (Z1=0, Z2=0, Z3=0)
Per-capita monthly household income (CNY)	＜1500 = 1, 1501–3000 = 2, 3001–4500 = 3, ＞4500 = 4
Treatment method	Untreated = 1 (Z1=1, Z2=0), pharmacological treatment = 2 (Z1=0,Z2=1), pharmacological treatment+lifestyle intervention = 3 (Z1=0, Z2=0)
Comorbidity with other chronic diseases	Yes = 1, no = 0

Table 6 Multivariate logistic regression analysis of different potential categories of health problems in elderly patients with hypertension (n=423)

Item	β	SE	Wald χ^2	*P*	OR	95%CI
C1: C3[2)]						
Constant	11.609	2.966	15.324	<0.001	—	—
Hypertension-related knowledge score	−0.230	0.088	6.828	0.009	0.794	0.668–0.944
Hypertension patient self-efficacy questionnaire score	−0.253	0.044	32.274	<0.001	0.777	0.712–0.848
Social Support Rating Scale score	−0.089	0.035	6.459	0.011	0.915	0.855–0.980
C2: C3[2)]						
Constant	4.431	2.104	4.434	0.035	—	—
Hypertension patient self-efficacy questionnaire score	−0.149	0.032	22.261	<0.001	0.861	0.809–0.916
Treatment modality (untreated)	1.064	0.479	4.936	0.026	2.899	1.134–7.413
Blood pressure control level(SBP ≤140 mmHg and/or DBP ≤90 mmHg)	−0.941	0.395	5.688	0.017	0.390	0.180–0.846

Table 6 （Continued）Multivariate logistic regression analysis of different potential categories of health problems in elderly patients with hypertension (n=423)

Item	β	SE	Wald χ^2	*P*	OR	95%CI
C1: C2[1)]						
Constant	−6.947	2.924	5.646	0.017	—	—
Hypertension-related knowledge score	0.277	0.089	9.761	0.002	1.320	1.109–1.571
Hypertension patient self-efficacy questionnaire score	0.103	0.042	6.044	0.014	1.109	1.021–1.204
Social Support Rating Scale score	0.082	0.035	5.522	0.019	1.086	1.014–1.163

Notes: C1, Low-Ability Avoidance Profile; C2, Moderate-Ability Impulsive/Careless Profile; C3, High-Ability Negative-Transfer Profile.

[1)] Reference Profile C1. [2)] Reference Profile C3.

OR, odds ratio; CI, confidence interval; SE, Standard Errors;

SBP, systolic blood pressure; DBP, diastolic blood pressure.

3.Discussion

3.1 Heterogeneity in health problem-solving ability among elderly adults with hypertension

The results of this study indicate that there is heterogeneity in health problem-solving ability among elderly patients with hypertension. The total HPSS score of participants was 15.75 ± 3.60 points, indicating an overall moderate level. This score was lower than that reported among individuals with type 2 diabetes and metabolic syndrome[22], yet higher than the score observed in patients with coronary heart disease[23].Differences may stem from variations in participant demographics, disease characteristics, and study settings across investigations. The High-Ability Negative-Transfer profile accounted for 57.4 % of the sample, with a mean HPSS score of 18.16 ± 1.83 points, representing the highest overall health problem-solving ability across subgroups. Although the Avoidant Problem Solving dimension had the highest score, the score for Negative-Transfer Problem Solving was close to the overall mean. Participants in this profile did not tend to avoid health-related problems but showed a greater tendency toward negative transfer, characterized by inappropriate reliance on or misapplication of previous experiences and knowledge. For example, some participants discontinued medication or took medicines irregularly

under the belief that long-term drug intake would produce adverse physical effects [24]. Nursing interventions should focus on helping these patients develop an accurate understanding of hypertension-related knowledge and appropriately apply relevant knowledge and previous experiences. The Moderate-Ability Impulsive/Careless Profile accounted for 27.7% of the participants, with a mean HPSS score of 14.02 ± 1.60, close to the overall mean. This profile exhibited a relatively low level of health problem-solving ability, characterized by limited systematic problem-solving skills and insufficiently rational decision-making.When confronted with complex health-related problems, patients in this profile tended to respond impulsively or without sufficient consideration and to use problem-solving strategies in an incomplete or unsystematic manner. Nursing interventions should focus on improving patients' hypertension-related knowledge and self-efficacy. Problem-solving therapy can be incorporated into these interventions to help patients develop health problem-solving skills [25], thereby enhancing their overall health problem-solving ability. The Low-Ability Avoidance Profile accounted for 14.9% of the total sample, with a mean HPSS score of 9.66 ± 2.11, indicating a low overall level of health problem-solving ability. Their score on the Avoidant Problem Solving dimension showed the largest deviation from the sample mean. These participants tended to avoid addressing health-related problems, as manifested by dependence on others, procrastination, passivity, or inaction. This pattern may be associated with limited hypertension-related knowledge, low self-efficacy, and inadequate social support, which may have contributed to participants' lack of confidence in coping with health-related challenges. Particular attention should be paid to this subgroup's psychological status and hypertension-related knowledge, and targeted nursing interventions should be implemented to improve their health problem-solving ability.

3.2 Analysis of factors associated with latent profiles of health problem-solving ability among elderly adults with hypertension

3.2.1 Higher hypertension-related knowledge is associated with greater health problem-solving ability

The findings of the present study indicated that patients with higher

hypertension-related knowledge scores were more likely to be classified into the Moderate-Ability Impulsive/Careless Profile and the High-Ability Negative-Transfer Profile compared with the Low-ability avoidance Profile . Identifying health problems is the first step in health problem-solving, and patients' mastery of disease-specific knowledge serves as the foundation for recognizing these problems[14]. Good command of hypertension-related knowledge helps patients promptly detect abnormal blood pressure and associated symptoms. Understanding the severity of hypertension-related complications can raise patients' awareness of hypertension-relevant health concerns, which further motivates them to adopt effective measures including blood pressure monitoring, limiting intake of high-salt and high-fat foods, and increasing physical activity to control blood pressure and prevent complications[26]. Nevertheless, patients may misinterpret relevant knowledge. For instance, some patients discontinue antihypertensive medication on their own due to concerns about potential side effects on organs such as the kidneys and liver. Healthcare providers should therefore correct patients' misinterpretations and inappropriate application of hypertension-related knowledge, namely this negative-transfer phenomenon, to prevent prior experiences from interfering with the management of new health problems. Mobile applications can be utilized to disseminate disease-related knowledge to patients and deliver tailored health interventions [27], Furthermore, health education programs can be designed based on the Information-Motivation-Behavioral Skills (IMB) model [28]. These approaches can be personalized according to individual needs to improve hypertension-related knowledge among elderly adults with hypertension, thereby enhancing their health problem-solving ability.

3.2.2 Patients with higher self-efficacy and well-controlled blood pressure are more likely to be classified into the high-ability negative-transfer profile

The findings indicated that patients with higher levels of self-efficacy were more likely to be classified into the High-Ability Negative-Transfer Profile. Self-efficacy refers to an individual's belief in their own capacity to complete a given task or achieve a specific goal，it influences individuals' behavioral choices and actions and

may facilitate effective health problem-solving[29]. Previous research has demonstrated that patients with higher self-efficacy are more confident in their ability to manage disease-related health problems. When confronted with difficulties, these patients may be better equipped to regulate their emotional responses, identify potential solutions, and engage actively in problem-solving. When facing difficulties, they can better regulate their mindset, possess greater confidence and motivation to seek solutions, and make efforts to actively address health-related concerns[30].We need to integrate cognitive behavioral therapy and use cases of patients with well-controlled blood pressure to positively motivate patients, encouraging them to take active measures and continuously accumulate successful experiences. Successful resolution of practical problems will further strengthen patients' confidence in their own capabilities[31]. In addition, compared with patients in the Moderate-Ability Impulsive/Careless Profile, participants with blood pressure within the normal range were more likely to be assigned to the High-Ability Negative-Transfer Profile. Effective blood pressure control may provide positive reinforcement, thereby strengthening patients' confidence in their ability to address health-related problems. Structured interventions, such as self-care training based on Orem's theory[32] and the hypertension training manual[33], could be implemented to strengthen patients' self-care skills. Regular text-message reminders could also be provided to reinforce adherence to the recommended measures and support their sustained implementation.

3.2.3 Higher social support levels are associated with stronger health problem-solving ability among elderly adults with hypertension

In the current study, participants with higher levels of social support were more likely to be classified into the Moderate-Ability Impulsivity/Carelessness Profile or the high-ability negative-transfer profile than into the Low-Ability Avoidance Problems Profile. This finding is consistent with the results reported by Ji[34], who reported that greater social support was associated with higher health problem-solving ability. Previous studies have shown that adequate emotional, financial, and informational support from family members, friends, and healthcare providers can enhance self-confidence among elderly adults with hypertension[35]. These social resources may strengthen patients' perceived ability to manage health-related challenges, thereby fostering greater initiative and more proactive coping strategies when addressing health-related problems.Nevertheless, excessive social support may

contribute to learned helplessness. For example, long-term dependence on family members for assistance with medication procurement, activities of daily living, and healthcare seeking may undermine patients' sense of autonomy[36]. Healthcare workers from communities and hospitals，together with family members，can make effective use of resources such as community-based health management WeChat groups to facilitate health education sessions for patients. These initiatives can help patients acquire knowledge about hypertension, understand treatment options and recommended lifestyle practices, and develop practical skills for managing common hypertension-related health problems[37].In addition, relevant support resources for chronic disease management can be proactively introduced to patients. Medical insurance big data can be used to identify eligible individuals who have not yet accessed entitled benefits, followed by targeted reminders. This practice facilitates patients' active utilization of tangible social support including special medical insurance policies for chronic diseases and free community health screenings. Such interventions alleviate learned helplessness stemming from long-term financial dependence on family members, enabling patients to better cope with disease-related health concerns and improve their quality of life[38].

3.2.4 Health problem-solving ability is lower among patients with untreated hypertension

The results of this study showed that, compared with patients in the High-Ability Negative-Transfer Profile, those who had not received treatment for hypertension were more likely to be classified into the Moderate-Ability Impulsive /Careless Profile. A plausible explanation is that patients undergoing treatment have opportunities to accumulate experience in managing health-related problems with the guidance of healthcare professionals. Such as learning proper blood pressure measurement techniques and adjusting diet and physical activity according to the blood pressure control status.Untreated patients have fewer opportunities to acquire such knowledge and practical experience in managing health-related problems. Consequently, when facing hypertension-related health problems, they may lack systematic problem-solving strategies to guide their responses and tend to adopt more impulsive approaches.

Furthermore, prolonged absence of treatment may result in inadequate blood

pressure control, while poor self-perceived health among patients with hypertension may increase the risk of depressive and other negative emotional states [39]. These factors may impair patients' ability to focus on addressing health-related problems, making them more likely to respond carelessly or inadequately when attempting to solve such problems. For these patients, nurses can consider implementing brief, intensive mindfulness-based interventions to help alleviate depressive symptoms, anxiety, and other negative emotional states. In addition, following diagnosis, healthcare professionals should provide patients with comprehensive education on the basic aspects of hypertension, including its risk factors, treatment options, and potential health consequences, to enhance their understanding of the disease and awareness of the importance of its management. Patients should also be supported in developing practical knowledge and skills related to antihypertensive medication use, dietary management, physical activity, and other lifestyle modifications[40], thereby enhancing their confidence in addressing health-related problems.

4 Limitations

Several limitations of this study should be considered. First, a convenience sampling method was used, and the investigation was conducted at a single hospital in Guizhou Province. This restriction to a single region and hospital level means that the sample is not representative of the national population of older adults with hypertension, thereby limiting the generalizability of the findings. Second, data were collected using self-report scales. Given that the participants were older adults, recall bias may have been present. Finally, the cross-sectional design of this study precludes the establishment of temporal sequence or causality.

5 Conclusion

In this study, elderly adults with hypertension exhibited distinct patterns in health problem-solving ability, differing notably in self-efficacy, social support, and hypertension-related knowledge. Nurses should actively assess patients' health problem-solving ability, identify their specific problem-solving profiles, and implement targeted interventions accordingly. Such individualized interventions may help patients address hypertension-related health problems more effectively in the future, thereby potentially improving blood pressure control among elderly adults

with hypertension. Future studies should conduct multi-center longitudinal investigations to examine the dynamic trajectories of patients' health problem-solving abilities over time. By integrating the characteristics of health problem-solving at different stages, more targeted interventions can be developed.

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Data availability statement

The datasets generated and/or analyzed in the current study are available from the corresponding author upon reasonable request.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Affiliated Hospital of Guizhou Medical University (approval No. 2024-163). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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