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ORIGINAL RESEARCH

# Perceived Social Support and Health-Related Quality of Life Among Hypertensive Patients: A Latent Profile Analysis and the Role of Delay Discounting and Living Alone

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**Background:** Improving health-related quality of life (HRQoL) among hypertensive individuals has emerged as a significant public health issue. However, current research has ignored the individual heterogeneity of perceived social support (PSS) among hypertensive patients. The potential mechanism of delay discounting (DD), living alone, and PSS on HRQoL remains unclear, and further exploration is required.

**Aim:** This study aimed to ascertain PSS profiles among hypertensive patients and examine the hypotheses that DD mediates the relationship between PSS and HRQoL and that this mediating process is moderated by living alone in hypertensive patients.

**Methods:** A cross-sectional study was carried out in Jiangsu, China. In total, 1815 hypertensive patients completed socio-demographic and HRQoL questionnaires, a PSS scale, and a DD task. Data analyses included a latent profile analysis, $\chi^2$-test, Spearman correlation analysis, and PROCESS macro for regression analysis.

**Results:** Four potential PSS profiles were identified: lowest (3.2%), moderate–low (26.6%), moderate–high (42.4%), and highest (27.8%). DD mediated the association between PSS and HRQoL. The first half of this mediating process was moderated by living alone.

**Conclusion:** Our findings indicated that PSS, DD, and living alone significantly influence the HRQoL of individuals with hypertension. Healthcare professionals should consider variations in PSS among hypertensive patients and implement interventions to reduce DD by enhancing PSS, in order to improve the HRQoL of this population.

**Keywords:** perceived social support, delay discounting, health-related quality of life, living alone, hypertensive patients, latent profile analysis

## Introduction

Hypertension is a major risk factor for cardiovascular disease, chronic kidney disease, and premature death worldwide.[1–4] With an aging population and changes in dietary patterns and lifestyles, the prevalence of hypertension is rising globally, especially in developing countries.[5] Hypertension is the most common chronic disease and a growing public health problem in China.[6] A recent study estimated the prevalence of hypertension to be 28.56% ± 10.44%, ranging from 14.28% to 44.28% among the Chinese population aged over 15 years.[7] The complexity of chronic disease puts stress on patients, indirectly affecting their economic situation and social activities. Even in a controlled state, it can negatively

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affect patients' overall health-related quality of life (HRQoL).[8–10] Individuals diagnosed with hypertension are more likely to suffer from mental health problems[8,11] and, if left untreated, they can affect sleep, physical activity, and interpersonal relationships, further lowering HRQoL.[12–14] Studies have shown that lower HRQoL is associated with factors such as anxiety, depression, sleep disturbances, and a lack of physical activity.[15–17] Improving the quality of life among hypertensive patients has emerged as a significant public health issue. Therefore, it is imperative to investigate the mechanisms influencing the HRQoL of such patients to generate novel strategies for enhancing HRQoL.

Perceived social support (PSS) is an important factor affecting HRQoL. PSS refers to an individual's subjective perception and evaluation of the support of others they receive in times of need, which is an important external resource.[18] PSS at sufficient levels acts as a buffer against psychological stress, relieves negative emotions, and helps individuals cope with stress more effectively, all of which are crucial for safeguarding their physical and mental well-being.[19–21] Previous studies have found PSS to be positively related to HRQoL. In one study, higher PSS was significantly associated with greater HRQoL among patients with gynecological cancer.[22] Similarly, Liu et al conducted a survey to test the relationship between profiles of chronic disease resource utilization and HRQoL among patients with coronary heart disease, revealing that access to adequate disease support resources contributes to their HRQoL.[23] Furthermore, Akanni et al found that PSS was protective of HRQoL.[24]

Although previous studies have explored the relationship between PSS and HRQoL, the relationship between the two among hypertensive patients has not been well investigated. The first World Health Organization (WHO) Global report on the devastating global impact of hypertension highlights that hypertension is a silent killer, and nearly half of those with hypertension globally are unaware of their condition.[25] This indicates that hypertensive patients often have limited high blood pressure health literacy. Extensive studies demonstrate that lower blood pressure health literacy is significantly associated with lower PSS among hypertensive patients, further impacting their HRQoL.[26,27] Therefore, it is necessary to explore the mechanisms underlying the relationship between PSS and HRQoL among hypertensive patients. Additionally, most studies have employed a "variable-centered" approach to assessing the level of PSS, overlooking heterogeneity due to individual differences. In the present study, latent profile analysis was utilized to identify potential subgroups of PSS.

As yet, little research has addressed the mediating mechanisms linking PSS and HRQoL. Most previous studies have focused on individual factors such as loneliness[28] and resilience.[29] However, to the best of our knowledge, no research has tested delay discounting (DD) as a mediator in the relationship between PSS and HRQoL among hypertensive patients.

DD may be an important behavioral economics factor associated with hypertensive patients' HRQoL. Researchers use DD tasks to quantify individuals' psychological discounting in intertemporal choices (the process by which individuals make decisions involving trade-offs between costs and benefits across distinct temporal intervals[30,31]). The most common indicators are the discounting rate (k value) and the area under the curve (AUC) from the hyperbolic discounting model.[32] DD involves choosing between immediate rewards and delayed gratification. Greater DD indicates a preference for immediate gratification, while smaller DD indicates a preference for delayed gratification. The process of DD often changes preferences with temporal distance, ie, with a tendency to assign smaller weights to future rewards (or losses) compared to near-term rewards (or losses), and thus to choose immediate and smaller rewards.[33] The progressive development of hypertension is closely related to the patient's poor health behaviors. Effective self-care behaviors can control the progression of the disease to some extent. However, when faced with the immediate decision of whether to eat calorie-dense but low-nutrient food now or to adhere to a nutritious diet, preferences may shift, impacting the ability to delay gratification and leading to a choice that compromises future health for immediate satisfaction. Existing studies show that perceptions of scarcity arising from demands on resources lead people to increase their preferences for immediate gratification.[34,35] According to the conservation of resources theory,[36] individuals are driven to obtain, safeguard, and allocate resources. Recent research indicates that social support networks help individuals acquire and mitigate the depletion of resources and that social support is significantly associated with DD.[37] Therefore, it is reasonable to hypothesize that hypertensive patients with elevated levels of PSS tend to exhibit delayed gratification. In addition, previous research indicates that DD is a significant predictor of HRQoL, with cross-sectional studies finding that lower levels of DD are linked to higher HRQoL.[38,39] A meta-analysis by Rung and Madden further supports the

association between DD and HRQoL.[40] Thus, we propose that DD may serve as a mediator in the relationship between PSS and HRQoL in hypertensive patients.

Living arrangements, as a social contextual factor, are closely related to the physical and mental health of individuals. Living alone is a potential health risk.[41] Living alone status has been shown to be an important factor influencing DD.[42] Solitary living arrangements are associated with heightened susceptibility to unhealthy behaviors such as smoking, disordered eating, and physical inactivity,[43–45] as well as an increased likelihood of experiencing mental health disorders like depression and anxiety.[46,47] These factors amplify the risk of greater DD.[48–50] According to the Social Escort Model, living arrangements are a key factor in accessing family support.[51] Several studies on PSS and solitary living suggest notable variations in PSS among individuals living alone, with living alone being associated with lower PSS.[52–54] This suggests that living alone and PSS may interact to influence hypertensive patients' DD, with PSS playing a greater role in the DD of hypertensive patients who do not live alone compared to those who do. However, whether living alone moderates the effects of PSS on DD in hypertensive patients remains unknown. Therefore, we predicted that living alone may play a moderating role in the relationship between PSS and DD in hypertensive patients.

This study investigated the impact of PSS and DD on the HRQoL of hypertensive patients, specifically exploring the mechanisms by which DD, living alone, and PSS affect hypertensive patients' HRQoL, as well as the effects of various combinations of PSS and DD on HRQoL from variable- and individual-centered perspectives. The findings may inform the development of interventions aimed at enhancing the HRQoL of hypertensive patients. The following hypotheses were proposed (Figure 1):

H1: There is heterogeneity in PSS among hypertensive patients;

H2: DD mediates the relationship between PSS and HRQoL;

H3: Living alone moderates the relationship between PSS and DD.

# Methods

## Participants

A cross-sectional study was conducted in Jiangsu, China, from March to July 2023. A multi-stage stratified random sampling technique was utilized to select two regions—Yangzhou in northern Jiangsu and Nanjing in southern Jiangsu—as study sites based on geographical location, local economic development, and medical resource allocation. A total of seven community health service centers in urban and rural areas within each city were randomly selected. With permission from these centers, we randomly selected participants from the community hypertension health records. These patients had been diagnosed with hypertension by a clinician prior to the survey.

Inclusion criteria for patients were as follows: (a) diagnosed with essential hypertension according to the 2018 Chinese guidelines for the management of hypertension[55] (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure≥90 mmHg) and consistently taking antihypertensive medication for the past 2 weeks, (b) aged ≥ 18 years, and (c) willingness to participate. Exclusion criteria were: (a) cognitive and communication impairments and (b) severe physical or mental diseases.

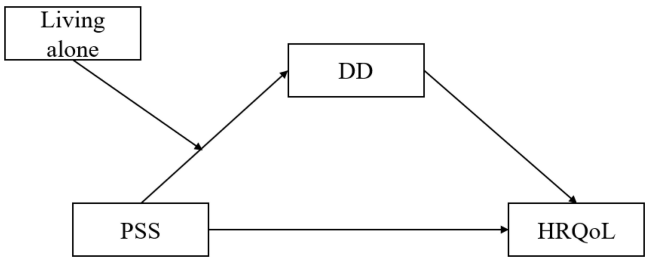


**Figure 1** Hypothesized framework for the relationship between PSS, DD, living alone, and HRQoL in hypertensive patients.
**Abbreviations**: PSS, Perceived social support; DD, Delay discounting; HRQoL, Health-related quality of life.

## Sample Size

The formula $N = z^2 p (1-p) / d^2$ was used to calculate the sample size.[56] Based on a 24.7% prevalence of hypertension[57] ($p = 0.247$), z was set to 1.96, and d was set to 0.05, so $N \approx 286$.

## Data Collection

Participants were informed about the study's objectives, significance, and relevant considerations before providing verbal consent to participate. Subsequently, trained researchers conducted face-to-face questionnaires with participants who engaged in a computer-based binary-choice delay discounting task and completed written questionnaires. Given that some participants may face difficulties reading or completing the questionnaire in person due to physical or literacy limitations, we used a method to help them check off options based on their responses to the questionnaire. If assistance was needed, the trained researcher provided verbal explanations of the study and test instructions, ensuring that participants fully understood what was being asked of them. We used simplified language where necessary to ensure the information was accessible and offered participants the opportunity to ask questions and clarify any doubts, ensuring they fully understood the test. These steps aimed to minimize the impact of poor literacy on the study's outcomes and ensure that all participants were fully informed and could participate effectively. This study (including verbal informed consent) was approved by the Ethics Committee of Nanjing Medical University (No. 2021378) and complies with the Declaration of Helsinki.

## Measures

### Socio-demographic Questionnaire

Socio-demographic characteristics were recorded, including age, sex, education level, marital status, living alone status, smoking status, and alcohol status.

### Perceived Social Support

The Perceived Social Support Scale (PSSS) was translated and revised by Qianjin Jiang.[58] PSSS is a 12-item self-report inventory divided into the following three domains: family support (spouses, children, and siblings; items 3, 4, 8, 11), friend support (items 6, 7, 9, 12), and other support (relatives, neighbors, colleagues, etc; items 1, 2, 5, 10). The PSSS is scored using a 7-point Likert scale ranging from "1" (strongly disagree) to "7" (strongly agree); the higher the total score, the more social support the individual perceives. In this study, the Cronbach's α of the scale was 0.91.

### Delay Discounting

The DD task involved a titration procedure written in E-Prime 2.0. Participants completed a 10–15 min computer-based binary-choice DD task[59] involving 54 choices. The task includes practice and formal experimental tasks. The practice experimental task familiarized participants with the structure and format before the formal experiment was conducted.

Participants were first provided an explanation and unified guidance (Figure 2), followed by six practice experiments (with a delay of 270 days) to familiarize themselves with the procedure. The processes for the practice and formal experiments are shown in Figure 3. Each trial started with a "+" of 500ms, followed by a DD task on the screen. Participants were instructed to imagine intervals in seven different future time horizons: 1 day, 7 days, 30 days, 90 days, 180 days, 1 year, and 2 years, and to choose between a smaller immediate reward and a larger delayed reward. Then, after full consideration, they were asked to press the F key (representing the left choice) or the J key (representing the right choice) to make a selection. At last, triangles denoting immediate options and squares denoting delayed options were displayed on the screen in red as feedback, each lasting for 500 ms. If participants chose the immediate reward, the amount of the immediate reward was adjusted downward; conversely, the amount of the immediate reward was adjusted upward. The amount of each subsequent adjustment was half of the preceding adjustment.[60] For example, the first choice was "500 RMB right now or 1000 RMB in 1 day". If "1000 RMB in 1 day" was chosen, the immediate amount would increase in the next trial, and the choice on the next trial would be "750 RMB right now or 1000 RMB in 1 day." If "500 RMB right now" was chosen, the immediate amount would decrease in the next trial, and the choice on the next trial would be "250 RMB right now or 1000 RMB in 1 day." The value of the immediate reward always started at 500 RMB,

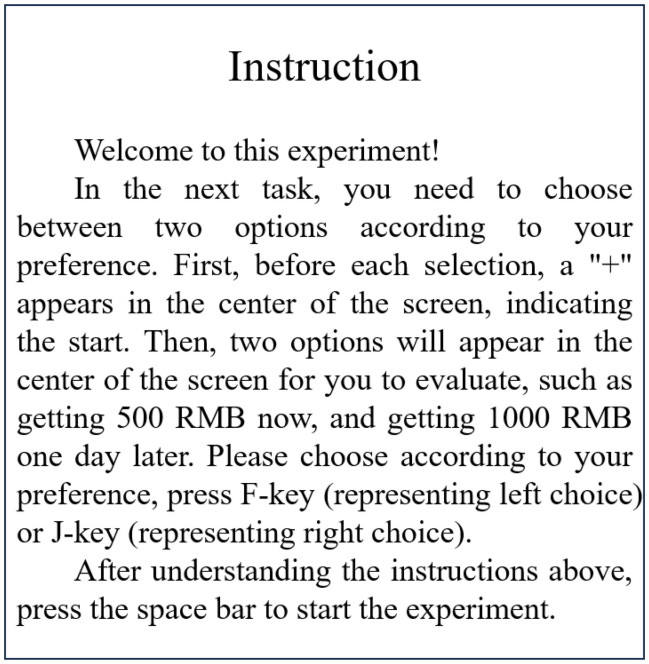


**Figure 2** Experiment instruction.

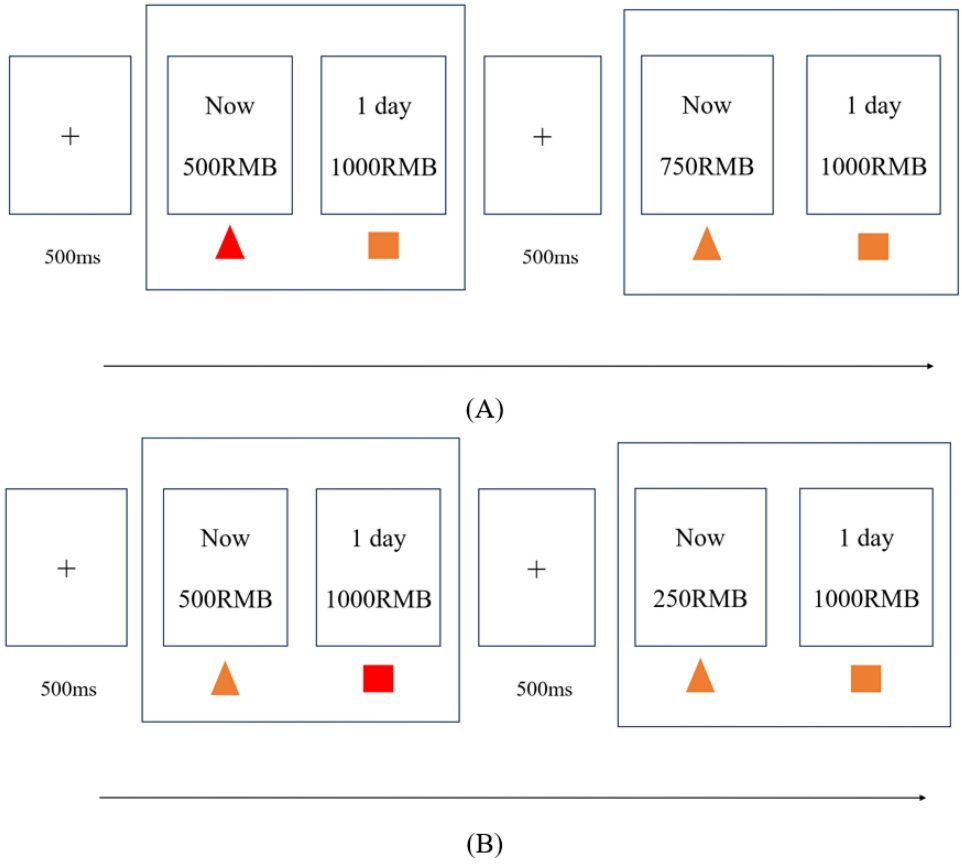


**Figure 3** Sample experiment from the intertemporal choice task.
**Notes**: (**A**) shows participants choosing the immediate reward; (**B**) shows participants choosing the delayed reward.

and the larger delayed reward remained constant at 1000 RMB. Based on each participant's immediate reward selection for each delayed time, the subjective value was determined. Then, Matlab R2018a was used to perform nonlinear regression based on the subjective value of each participant, and the subjective value (V), delayed time (D), and delayed reward (A) were substituted into the hyperbolic equation: $V = A/(1 + k*D)$ to fit the DD rate (k).[61] Since the distribution of k values deviates from normal, a natural log transformation was applied to approximate normality in order to assess the extent of DD, with higher k values indicating more pronounced discounting.

### Health-Related Quality of Life

The EQ-5D-3L is a universal scale for assessing HRQoL, encompassing five health domains and the euroQol visual analog scale (EQ-VAS). These domains consist of mobility, self-care, daily activities, pain/discomfort, and anxiety/depression, each with three levels of severity: no problem, moderate problem, and extreme problem. In this study, we used the validated Chinese version of the EQ-5D-3L self-report questionnaire to calculate patients' HRQoL scores, applying China-specific coefficients derived from patients' responses across various domains and levels of the scale.[62] The health utility value of the scale ranges from −0.391 to 1, representing the scale range from the worst to the best states. Patients self-rated their health states on the EQ-VAS scale, which ranges from 0 to 100. The primary outcome of interest in this study was the assessment of health utility.

## Statistical Analysis

First, descriptive statistics were conducted utilizing SPSS 26.0 to analyze the general demographic characteristics and variables. Subsequently, Spearman correlation analysis was employed to assess the relationships between PSS, DD, HRQoL, and living alone. Following this, a latent profile analysis was performed using Mplus 8.3 to identify the potential categories and distribution patterns of PSS among hypertensive patients. In this study, we started with a single class, gradually increased the number of categories, and analyzed each model parameter. The following model fit indices were used to determine the optimal potential profile model: (1) the Akaike information criterion (AIC), Bayesian information criterion (BIC), and adjusted Bayesian information criterion (aBIC) values, with lower values indicating superior fit; (2) an entropy (classification indicators) value≥0.80 indicated a classification accuracy exceeding 90%, with a higher value corresponding to increased classification accuracy; (3) The Lo–Mendell–Rubin (LMR) and bootstrap likelihood ratio test (BLRT) results, with a significance level of $P < 0.05$, suggested that the k-class model outperformed the k-1 class model.[63] Then, the $\chi^2$-test was performed using SPSS 26.0 to analyze categorical data and assess intergroup variances in socio-demographic attributes. Finally, PROCESS is a "macro" that can be installed in SPSS software to simplify the implementation of mediation, moderation, and conditional process analysis with observed variables. One of its advantages is its ease of use, as PROCESS only needs to select the appropriate model and set the variables accordingly. It not only generates the results of a conventional regression analysis but also directly provides the direct effect, the estimated value of the indirect effect, Bootstrap confidence intervals, and other results. The roles of DD and living alone were investigated using the PROCESS macro models 4 and 7, respectively. Considering that age, sex, education level, marital status, smoking status, and alcohol status are correlated with HRQoL,[64–66] the effects of these covariates were controlled in the analyses. *P* values below.05 indicated statistical significance.

# Results

## Common Method Bias

Since this study used self-reported questionnaires, common method bias may exist. The results of Harman's single-factor test revealed five factors with eigenvalues >1; the first factor accounted for 35.07% of the total variance, which was below the 40% criterion.[67] Therefore, there was no serious common method bias in this study.

## Participant Characteristics

A total of 2276 questionnaires were initially surveyed, with incomplete and invalid responses subsequently excluded, resulting in a final sample size of 1815 and a valid response rate of 79.7%. The mean age of participants was 65 years

**Table 1** Univariate Analysis of PSS Profiles (n = 1815)

| Characteristics | N (%) | Low PSS Group n = 57 | Moderate–Low PSS Group n = 483 | Moderate–High PSS Group n = 767 | High PSS Group n = 508 | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|---|
| Age | | | | | | 5.227 | 0.156 |
| <60 | 401 (22.1) | 16 | 108 | 181 | 96 | | |
| ≥60 | 1414 (77.9) | 41 | 375 | 586 | 412 | | |
| Sex | | | | | | | |
| Male | 852 (46.9) | 30 | 245 | 353 | 224 | 5.429 | 0.143 |
| Female | 963 (53.1) | 27 | 238 | 414 | 284 | | |
| Educational level | | | | | | 7.973 | 0.787 |
| Illiterate and semi-illiterate | 100 (5.5) | 4 | 33 | 36 | 27 | | |
| Primary school | 312 (17.2) | 11 | 84 | 123 | 94 | | |
| Middle school | 663 (36.5) | 23 | 169 | 282 | 189 | | |
| High school | 566 (31.2) | 14 | 148 | 246 | 158 | | |
| Junior college and higher | 174 (9.6) | 5 | 49 | 80 | 40 | | |
| Living alone | | | | | | 30.250 | <0.001 |
| No | 1634 (90.0) | 40 | 429 | 708 | 457 | | |
| Yes | 181 (10.0) | 17 | 54 | 59 | 51 | | |
| Consuming alcohol | | | | | | 3.964 | 0.265 |
| No | 1565 (86.2) | 51 | 404 | 668 | 442 | | |
| Yes | 250 (13.8) | 6 | 79 | 99 | 66 | | |
| Smoke | | | | | | 6.060 | 0.109 |
| No | 1477 (81.4) | 49 | 390 | 609 | 429 | | |
| Yes | 338 (18.6) | 8 | 93 | 158 | 79 | | |

**Abbreviation**: PSS, Perceived social support.

(range 24–85, SD = 8.08). Of the participants, 46.9% were males and 53.1% were females. The majority of participants had attained middle and high school education levels and reported not living alone, consuming alcohol, or smoking. Significant variations were observed in the living alone status among individuals with different PSS profiles ($\chi^2 = 30.25$, $p < 0.001$), as shown in Table 1.

## Latent Profile Analyses

The findings presented in Table 2 indicate a consistent decrease in AIC, BIC, and aBIC values as the number of categories increases. Furthermore, the LMR test suggests no statistically significant improvement in model fit when comparing a model with five potential categories to one with four potential categories ($P = 0.57$). While the 3- and 4-profile models demonstrate favorable metrics, the 4-profile model exhibits the highest entropy value. Combining the results of model comparisons and classification accuracy, the 4-profile model was the optimal potential profile model for hypertensive patients' PSS. The average attribution probabilities for each profile were 95.0%, 97.8%, 96.4%, and 95.2%, respectively, all exceeding 90%. These values indicated that the results of the 4-profile model were reliable, as shown in Table 3.

**Table 2** Model Fit Indices for PSS Profiles in Hypertensive Patients (n = 1815)

| Profile | AIC | BIC | aBIC | Entropy | LMRT(*P*) | BLRT(*P*) | Proportion |
|---|---|---|---|---|---|---|---|
| 1 | 17,106.422 | 17,139.445 | 17,120.383 | | | | |
| 2 | 15,551.289 | 15,606.327 | 15,574.558 | 0.846 | <0.001 | <0.001 | 0.31/0.69 |
| 3 | 14,775.869 | 14,852.923 | 14,808.446 | 0.910 | <0.01 | <0.001 | 0.03/0.32/0.64 |
| 4 | 14,036.365 | 14,135.434 | 14,078.249 | 0.916 | <0.05 | <0.001 | 0.03/0.27/0.28/0.42 |
| 5 | 13,749.237 | 13,870.321 | 13,800.429 | 0.934 | 0.327 | <0.001 | 0.01/0.02/0.27/0.28/0.42 |

**Table 3** The Average Attribution Probability (n = 1815)

| Category of Potential Profiles | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0.950 | 0.000 | 0.022 | 0.028 |
| 2 | 0.000 | 0.978 | 0.022 | 0.000 |
| 3 | 0.032 | 0.004 | 0.964 | 0.000 |
| 4 | 0.048 | 0.000 | 0.000 | 0.952 |

On the basis of the identified potential profile model, the four potential PSS profiles, scoring differently on the three dimensions, were obtained (Figure 4). Profile 1 (n = 57, 3.2%) scored at a low level on each item of the PSS and was named the "low PSS group." Profile 2 (n = 483, 26.6%) demonstrated moderate–low scores on each item and was classified as the "moderate–low PSS group." Profile 3 (n = 767, 42.4%) achieved moderate–high scores on all items of the PSS and was designated as the "moderate–high PSS group." Profile 4 (n = 508, 27.8%) obtained high scores on each item and was identified as the "high PSS group."

## Correlation Analysis Between PSS, DD, and HRQoL

As shown in Table 4, PSS was positively correlated with HRQoL ($r = 0.10$, $p < 0.001$). DD was significantly negatively correlated with PSS ($r = -0.18$, $p < 0.001$) and HRQoL ($r = -0.13$, $p < 0.001$).

## A Model of the Relationship Between PSS, DD, HRQoL, and Living alone—a Variable-Centered Analysis

First, the mediation effect of DD on the relationship between PSS and HRQoL was examined in the sample of hypertensive patients. The results showed that PSS was significantly negatively associated with DD (β = −0.17, t = −7.37, $p < 0.001$) and positively associated with HRQoL (β = 0.10, t = 4.27, $p < 0.001$). DD was significantly negatively associated with HRQoL (β = −0.07, t = −3.10, $p < 0.01$), indicating that DD partially mediated the relationship between PSS and HRQoL. Furthermore, the bias-corrected bootstrap test indicated that the mediating effect value was 0.001, with a 95% CI of [0.0002, 0.0009]. The mediation effect of DD was found to be statistically significant, accounting for 20.0% of the total effect (0.005).

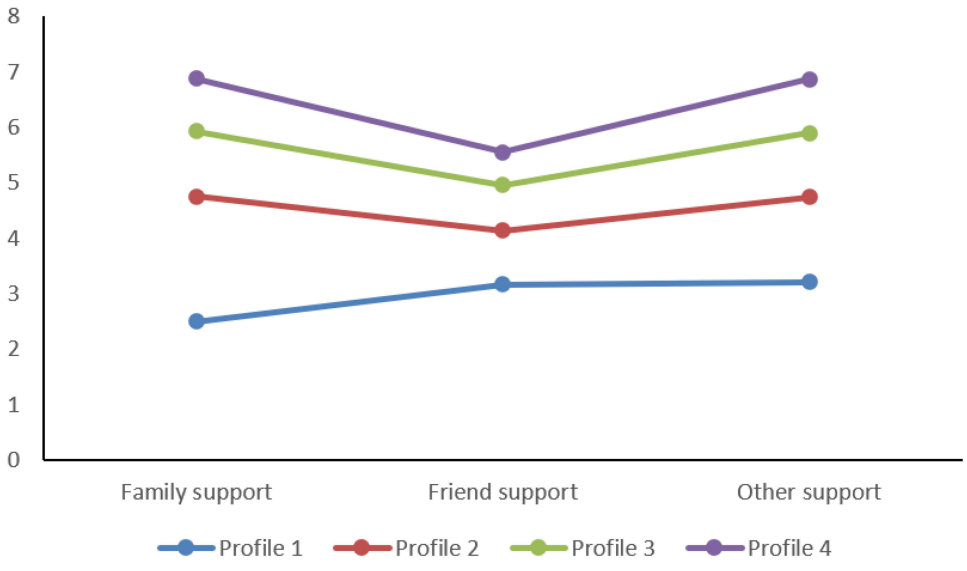


**Figure 4** The characteristic distribution of four potential categories of PSS among hypertensive patients.
**Abbreviations**: PSS, Perceived social support; Profile 1, low perceived social support group; Profile 2, moderate-low perceived social support group; Profile 3, moderate-high perceived social support group; Profile 4, high perceived social support group.

**Table 4** Descriptive Statistics and Correlation Coefficient (n = 1815)

| Variables | M±SD/M($P_{25}$, $P_{75}$) | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. PSS | 5.46±0.98 | 1 | | |
| 2. DD | −6.04±1.74 | −0.18*** | 1 | |
| 3. HRQoL | (0.97,1.00) | 0.10*** | −0.13*** | 1 |

**Notes**: ***$p$<0.001.
**Abbreviations**: PSS, Perceived social support; DD, Delay discounting; HRQoL, Health-related quality of life.

**Table 5** Moderated Mediation Effects Analysis

| Predictive Variable | Model 1 (DD) | | Model 2 (HRQoL) | |
|---|---|---|---|---|
| | β | t | β | t |
| PSS | 0.24 | 1.12 | 0.01 | 4.27*** |
| Living alone status | 1.77 | 2.87** | −0.06 | −0.99 |
| PSS * living alone status | −0.30 | −2.61** | 0.25 | 2.58* |
| DD | | | −0.01 | −3.10** |
| $R^2$ | 0.03 | | 0.02 | |
| $F$ | 21.16*** | | 16.67*** | |

**Notes**: *$p$<0.05, **$p$<0.01, ***$p$<0.001.
**Abbreviations**: PSS, Perceived social support; DD, Delay discounting; HRQoL, Health-related quality of life.

Second, the moderating effect of living alone status on the relationship between PSS and HRQoL among hypertensive patients was tested (Table 5). The results showed a significant negative predictive effect of the interaction between PSS and living alone status on DD (β = −0.30, $p$ < 0.01), indicating that living alone status moderated the first half of the mediation path of DD.

The simple slope analysis (Figure 5) indicates that the relationship between PSS and DD differs depending on living alone status. Specifically, when individuals were living alone, PSS did not significantly predict DD ($B_{simple}$ = −0.06, t = −0.55, $p$ > 0.05); However, when individuals were not living alone, PSS was found to be a significant negative predictor of DD ($B_{simple}$ = −0.35, t = −7.88, $p$ < 0.001). These findings suggest that living with others enhances the protective effect of PSS against DD among hypertensive patients.

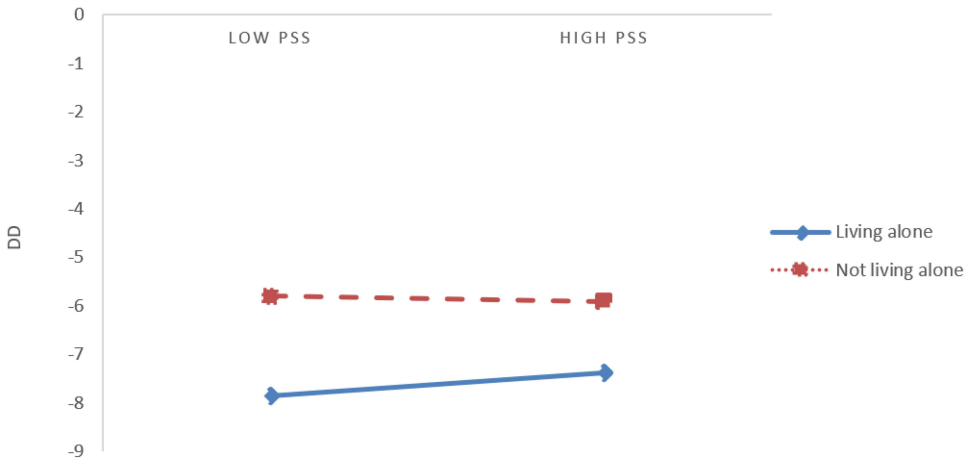


**Figure 5** Moderating effect of living alone.
**Abbreviations**: PSS, Perceived social support; DD, Delay discounting.

## Mediation Analysis of DD Based on LPA

To investigate the impact of various potential categories of PSS on HRQoL, this study treated the four potential categories as independent variables (dummy) and considered DD as a mediating variable. The "low PSS group" was utilized as the baseline for comparison. As shown in Table 6, the mediating effects of DD were found to be 0.001 for the "high PSS group", with a 95% CI of (0.0002, 0.0013), demonstrating a significant mediating effect.

# Discussion

This study explored the mechanisms underlying the relationship between PSS and HRQoL among hypertensive patients, which has certain theoretical and clinical implications. Specifically, this study is novel in its investigation of the mediating role of DD and the moderating role of living alone in the link between PSS and HRQoL in hypertensive patients. These findings offer a fresh perspective on the mechanisms underlying HRQoL in hypertensive individuals. Meanwhile, our study identified four distinct PSS profiles in hypertensive patients using an individual-centered method. This analysis enhances comprehension of the types and prevalence of PSS in this population, deepens insights into the nature of hypertensive patients' PSS, and provides references for subsequent interventions targeting different groups of hypertensive patients.

Our results confirm that PSS is a factor helping with controlling blood pressure and indicate that lower PSS is associated with DD and living alone, which are related to psychological stressors such as loneliness and depression.[21,46,49] Stress leads to transient sympathetic nervous stimulation and vascular reactivity, which in turn causes an increase in blood pressure.[68] Individuals with lower PSS and those living alone have limited access to health information, which may cause them to miss the appropriate stages for hypertension prevention.[69,70] Additionally, individuals with higher DD are more likely to seek immediate gratification and are less likely to engage in self-care behaviors.[39] These factors may contribute to the high incidence of hypertension.

In this study, latent profile analysis identified four different PSS profiles: "low level" (3.2%), "moderate–low level" (26.6%), "moderate–high level" (42.4%), and "high level" (27.8%). These findings indicate heterogeneity within PSS profiles among hypertensive patients, confirming Hypothesis 1. Our study revealed that most patients with hypertension were classified in the moderate–high category. The group with low PSS exhibited elevated scores in friend support and other forms of support, such as relatives, neighbors, and colleagues, while displaying lower scores in family support from spouses, children, and siblings. Conversely, the remaining three PSS groups demonstrated lower levels of friend support but higher levels of family support from spouses, children, and siblings and other forms of support like relatives, neighbors, and colleagues. Consequently, it is imperative to utilize assessment tools to differentiate hypertensive patients based on their PSS subtypes and implement tailored interventions.

For hypertensive patients in the low PSS group, healthcare professionals should prioritize measures to enhance family support from spouses, children, and siblings. For example, educational programs should be implemented to raise awareness of hypertension and promote knowledge of healthy lifestyles among patients and their families. Additionally, family members should be encouraged to actively engage in the formation of supportive family networks to provide essential emotional support to individuals with hypertension. For hypertensive patients in the other three PSS groups, healthcare professionals should concentrate on measures to enhance friend support levels. For example, attention can be given to the social relationships of hypertensive patients, encouraging them to establish broad social networks and

**Table 6** Different Categories of Relative Mediation Analysis Results

| Categories | Indirect Effects | | Relative Effect Size |
|---|---|---|---|
| | Effect | 95% CI | |
| Profile 2 | −0.0007 | (−0.0012, 0.0003) | – |
| Profile 3 | 0.0001 | (−0.0001, 0.0005) | – |
| Profile 4 | 0.0007 | (0.0002, 0.0013) | 11.11% |

participate in social activities to improve behavioral adherence. Additionally, a significant association was observed between living alone and hypertension among patients ($P < 0.001$). This suggests a potential need to tailor interventions according to differences in living arrangement. In other words, particular attention should be directed towards hypertensive patients living alone to improve their PSS levels.

This study found that DD mediated the relationship between PSS and HRQoL, confirming Hypothesis 2. PSS was negatively related to DD, which is in line with the conservation of resources and scarcity theories,[36,71] suggesting that hypertensive patients with low levels of PSS possess limited psychosocial resources, which can result in a scarcity mentality that impacts cognitive function. This, in turn, may manifest in detrimental behaviors, such as short-sighted decision-making that prioritizes immediate gratification over long-term benefits.[36,72] Previous research has shown that insufficient PSS can lead to negative emotions[19,54] and that there are significant differences in intertemporal decision-making under different emotional states. Negative emotions can increase an individual's delay discounting, making them more likely to prefer immediate gratification.[48,49] Consequently, hypertensive patients with low levels of PSS have higher DD. Additionally, higher DD is linked to various health risk behaviors, such as alcohol use,[73] smoking,[49] and unhealthy dietary behavior,[50] which are significantly negatively associated with HRQoL.[74] To enhance HRQoL among hypertensive patients, it is therefore crucial to help reduce DD as well as increase the level of PSS.

Our study also showed that DD mediated the relationship between PSS (categorical variable) and HRQoL (continuous variable). Notably, the "high PSS group" exhibited superior adaptability, as evidenced by hypertensive patients displaying the lowest DD scores and the highest HRQoL scores. Therefore, the results obtained from the individual-centered perspective validate the variable-centered results and provide valuable insights into the HRQoL of hypertensive patients with varying PSS profiles. This suggests that healthcare professionals should work to decrease hypertensive patients' DD in multiple ways. Studies have proven that acceptance-based/mindfulness-based trainings, particularly those focused on future-oriented manipulations, show the most promise as effective avenues for intervention.[75]

This study also found that living alone moderated the first half of the mediation effect; that is, living alone could moderate the effect of PSS on DD, thereby validating Hypothesis 3. This suggested that the protective effect of PSS on DD may be influenced by an individual's physical and social surroundings, consisted with previous findings. For instance, the protective effect of PSS on depressive symptoms is stronger in older individuals living alone.[54] However, this study showed that the protective effect of PSS on DD was stronger in hypertensive patients who do not live alone. This might be because, compared with hypertensive patients who do not live alone, those living alone may lack the social support that comes with living with family members and are more likely to experience deficient social interactions and smaller social networks,[76,77] meaning that hypertensive patients who live with others exhibit a higher level of PSS. From the perspective of the conservation of resources theory, individuals with sufficient resources will be willing to take risks and value the potential benefits of doing so.[78] In other words, hypertensive individuals who live with others are more likely to exhibit delayed gratification when experiencing elevated levels of PSS. This finding implies that although living alone is generally considered a socially disadvantaged condition, it might not necessarily be a risk factor for higher DD. Therefore, our results suggest that improving the PSS levels of hypertensive patients who live with others may help decrease DD. Future research should investigate additional variables influencing the correlation between PSS and DD among hypertensive patients living independently.

## Limitations

This study has some limitations. First, the sample comprised only one province in China. To enhance the generalizability of the findings, future studies should expand the participant pool to include hypertensive patients from different provinces and diverse cultural contexts. Second, a cross-sectional design was used, which limited causal inference between variables. Future studies could conduct a longitudinal design to determine causality. Third, the use of self-report measures could have led to social approval bias, affecting the results' credibility. Future studies could employ more objective metrics and use multi-informant approaches for data collection. Finally, this study only focused on the mediating role of DD and the moderating role of living alone in the current moderated mediation model. Future studies could explore other variables (eg, sleep quality[79,80]) to further reveal the influence mechanism of PSS and HRQoL among hypertensive patients.

## Conclusions

In summary, there was heterogeneity in PSS among hypertensive patients, which could be divided into four profiles: low level, moderate–low level, moderate–high level, and high level. PSS directly affects HRQoL in hypertensive patients and indirectly affects HRQoL through DD; living alone moderates the first half of the mediation of DD. Therefore, potential interventions could include strategies to reduce DD by enhancing the level of PSS with the aim of improving the overall quality of life of individuals with hypertension. It is important to focus on PSS levels in hypertensive patients who do not live alone and it is feasible to examine the levels of PSS among hypertensive patients who live with others. Furthermore, tailored interventions should be employed based on specific characteristics, and the PSS of hypertensive individuals should be monitored to facilitate timely intervention.

## Data Sharing Statement

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

## Ethics Approval and Informed Consent

This study was approved by the Institutional Ethics Committee of Nanjing Medical University (No. 2021378) and complies with the Declaration of Helsinki. With the approval of the Ethics Committee, written consent was waived and verbal consent was allowed. Due to the limited literacy skills of some patients, to ensure that all patients fully understood the purpose and procedures of the study, and to ensure the study progressed as planned, written informed consent from patients was waived, allowing for verbal informed consent instead. To ensure the transparency and accuracy of verbal consent, we employed the following recording methods: (a) After obtaining verbal consent, research team members immediately documented the consent details, including the date, time, and location; (b) each verbal consent record was confirmed by the signatures of two research team members to ensure the authenticity of the record. With these measures, we ensured the integrity of informed consent and the ethical compliance of the study.

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## Disclosure

The authors declare no conflicts of interest in this work.

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