Journal of Clinical and Nursing Research, 2025, Volume 9, Issue 10
http://ojs.bbwpublisher.com/index.php/JCNR
Online ISSN: 2208-3693
Print ISSN: 2208-3685

# The Mediating Effect of Pain on the Relationship between Sleep Quality and Health-Related Quality of Life among Elderly Patients with Chronic Diseases: An Empirical Analysis Based on CHARLS Data

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**Abstract:** *Objective:* Investigating the Mediating Role of Pain in the Relationship Between Sleep Quality and Health-Related Quality of Life Among Elderly Patients with Chronic Diseases. *Methods:* Using data from the 2018 China Health and Retirement Longitudinal Study (CHARLS), this study included 3,284 participants aged 60 years or older with chronic diseases. The sleep quality, pain status, health-related quality of life, and demographic-related data of these elderly patients were obtained. Pearson correlation analysis was conducted to assess the bivariate relationships among the variables. The mediating role of pain in the sleep quality-HRQoL relationship was tested using linear regression models, complemented by bootstrap sampling to verify the indirect effect. *Results:* Sleep quality was positively associated with health-related quality of life ($r$ = 0.218, $p$ < 0.001). Conversely, pain demonstrated significant negative correlations with both sleep quality ($r$ = -0.496, $p$ < 0.001) and health-related quality of life ($r$ = -0.067, $p$ < 0.001). The mediating effect results showed that pain played a partial mediating role between sleep quality and health-related quality of life in elderly patients with chronic diseases (effect value = 0.049), and the mediating effect accounted for 23.33%. *Conclusion:* Pain is a mediating variable between sleep quality and health-related quality of life in elderly patients with chronic diseases. This suggests that clinical practice should incorporate pain assessment into standard clinical care of elderly patients with sleep disorders and chronic diseases. By alleviating pain, sleep quality can be improved, and subsequently, their health-related quality of life can be enhanced.

**Keywords:** Elderly chronic diseases; Sleep quality; Health-related quality of life; Pain; Mediating effect

**Online publication:** Nov 10, 2025

# 1. Introduction

Health-related quality of life (HRQoL), also known as "quality of life", is a subjective evaluation made by individuals based on their own conditions and feelings. It encompasses physical functions, emotional states, social functions, roles and responsibilities, and health awareness, reflecting the overall health level of individuals [1,2]. Its improvement has profound significance for optimizing health resources and promoting national health development strategies [3]. The "Healthy China 2030" planning blueprint indicates that strengthening health management for the elderly can effectively promote healthy aging, and improving the HRQoL of the elderly is the core link to achieve this goal [4]. With the development of aging in China, the proportion of the elderly population has reached 22%, and the number of people with chronic diseases has reached nearly 180 million [5,6]. Chronic diseases cause functional decline through multiple pathological mechanisms, and sleep disorders are particularly prominent. The prevalence of sleep disorders among the elderly in China is 46%, and the prevalence of chronic disease combined with sleep disorders is 50.8% [7,8]. Studies demonstrate a significant correlation between pain symptoms and sleep quality among elderly patients with chronic diseases, and the two factors interact with each other, severely weakening the overall health of patients [9,10]. Pain, as an intervention risk factor, is a breakthrough point for improving health. Currently, many studies independently explore the impact of sleep quality or pain on the HRQoL of elderly patients with chronic diseases, but the mediating mechanism of pain between sleep quality and HRQoL has not been clarified, and there is a lack of empirical analysis with nationally representative samples. Therefore, this study utilized data from the China Health and Retirement Longitudinal Study (CHARLS) to examine the mediating role of pain in the relationship between sleep quality and health-related quality of life (HRQoL) among elderly patients with chronic diseases. The findings thereby aim to inform strategies for improving HRQoL in this population.

# 2. Object and method

## 2.1. Data source

This study utilized the 2018 Chinese Health and Retirement Longitudinal Study (CHARLS) database, employing a multi-stage stratified sampling method. It is an authoritative survey on health issues among the elderly [11] . The study was approved by the Medical Ethics Committee of Peking University (IRB00001052-11015). All participants in the study have provided informed consent. The data were rigorously screened, and finally 3284 valid samples were included, with the variable data extracted from the CHARLS database.

## 2.2. Study subjects

### 2.2.1. Inclusion criteria

(1) Age ≥ 60 years old

(2) Suffering from at least 1 chronic disease

(3) Completed measurements of health-related quality of life, sleep quality and pain

### 2.2.2. Exclusion criteria

(1) Data with missing key variables

## 2.3. Research tools

### 2.3.1. General information

Based on the health determinants model, the health influencing factors of elderly patients with chronic diseases were extracted from CHARLS, including biological and genetic factors (gender, age), personal health behavior factors (smoking, drinking), socioeconomic status factors (education level), and geographical distribution factors (place of residence) and more.

### 2.3.2. Health-related quality of life

This study employed the European Five-Dimensional Health Scale (EQ-5D), which consists of five dimensions: mobility, self-care ability, daily activity ability, pain or discomfort, and anxiety or depression.

Each dimension has three levels: no difficulty, some difficulty, and inability to complete/ extreme difficulty, and is assigned values of 1, 2, and 3 respectively. The questions in the questionnaire were extracted as follows: "Is there any difficulty in bending, bending knees, or squatting?" to assess mobility; "Is there any difficulty in cooking?" to assess self-care ability; "Is there any difficulty in doing household chores?" to assess daily activity ability; "Does the body feel pain?" to assess pain or discomfort; and "Do you feel depressed?" to assess anxiety or depression. The health utility value was calculated to reflect the health-related quality of life, and the closer the health utility value is to 1, the better the HRQoL [11,12] . The health utility value = 1 - the sum of the corresponding coefficient of each dimension [13].

### 2.3.3. Sleep quality

This study was based on the statement "My sleep is poor" [14]. The sleep duration was defined as 4 points for "rarely or never (< 1 day)", 3 points for "not too much (1–2 days)", 2 points for "sometimes or half of the time (3–4 days)", and 1 point for "most of the time (5–7 days)". The higher the score, the better the sleep quality.

### 2.3.4. Pain

This study was based on the question "Which parts of the body feel pain? Please list all the parts." The pain locations were counted, totaling 16 types including the head, shoulders, and any other locations. Each location was scored as 1 point, with a total score of 16 points. The higher the score, the more pain locations there were [15].

## 2.4. Statistical methods

Data cleaning and analysis were conducted using RStudio 4.5.0 and SPSS 27.0 software. Normally distributed data are presented as mean ± standard deviation ($\overline{x} \pm s$) and were compared using analysis of variance. For non-normally distributed data, which are expressed as median ($P_{25}$, $P_{75}$), non-parametric tests were employed for group comparisons， and comparisons between groups were conducted using non-parametric rank sum test.

Pearson correlation analysis was used to explore the correlations among pain, sleep quality, and health-related quality of life. The SPSS macro program Process v4.0 model (Model 4) was used for mediating effect test, with the significance level a set at 0.05 [16].

# 3. Results

## 3.1. General information

Comparison of Health-Related Quality of Life by Demographic Characteristics among Elderly Patients with Chronic Diseases: Age, gender, place of residence, educational level, marital status, and history of alcohol consumption all showed statistical significance ($p < 0.001$). These variables were included as covariates in the study, as shown in **Table 1**.

**Table 1.** Comparison of Health-related Quality of Life (HRQoL) among elderly patients with chronic diseases based on different demographic characteristics (n = 3284)

| Variable | Number of Subjects (n) | HRQoL[$\bar{x} \pm s$/M ($P_{25}$, $P_{75}$)] | Test Statistic | *p*-value |
|---|---|---|---|---|
| Age (years) | | | | |
| 60–69 | 2180 | 0.81 ± 0.17 | $F = 21.65$ | < 0.001 |
| 70–79 | 1061 | 0.79 ± 0.19 | | |
| ≥ 80 | 43 | 0.69 ± 0.64 | | |
| gender | | | | |
| Male | 915 | (0.72, 0.94） | $Z = -6.68$ | < 0.001 |
| Female | 2369 | (0.68, 0.94） | | |
| Place of residence | | | | |
| Urban | 703 | (0.72, 0.94） | $Z = -4.44$ | < 0.001 |
| Rural | 2581 | (0.69, 0.94） | | |
| Education | | | | |
| High school and below | 2053 | (0.70, 0.94） | $Z = -8.21$ | < 0.001 |
| High school education or above | 1231 | (0.72, 0.94） | | |
| marital status | | | | |
| Married | 2514 | (0.71, 0.94） | $Z = -6.99$ | < 0.001 |
| Unmarried | 770 | (0.66, 0.92） | | |
| Alcohol Use | | | | |
| Yes | 708 | (0.78, 0.94） | $Z = -7.66$ | < 0.001 |
| No | 2576 | (0.70, 0.94） | | |
| Smoking history | | | | |
| Yes | 619 | (0.71, 0.96） | $Z = -1.41$ | 0.16 |
| No | 3165 | (0.69, 0.94） | | |

## 3.2. Correlation analysis of sleep quality, pain and Health-related Quality of Life (HRQoL)

Pearson correlation analysis was conducted on the covariates such as gender, age, place of residence, educational level, marital status, and alcohol consumption history. The categorical variables were assigned values, as shown in **Table 2**.

**Table 2.** Assignment of values for categorical variables

| Variable | Variable assignment |
|---|---|
| Gender | Male = 1, Female = 2 |
| Age (years) | 60–69 = 1，70–79 = 2，≥ 80 = 3 |
| Place of residence | Urban = 1, Rural = 2 |
| Education | High school or less = 1, Education beyond high school = 2 |
| marital status | Married = 1, Unmarried = 2 |
| Alcohol Use | Yes = 1, No = 2 |

The results indicated that HRQoL was positively correlated with sleep quality ($r$ = 0.218, $p$ < 0.001), and negatively correlated with pain ($r$ = -0.067, $p$ < 0.001); sleep quality was negatively correlated with pain ($r$ = -0.496, $p$ < 0.001), as shown in **Table 3**.

**Table 3.** Correlation between sleep quality, pain and health-related quality of life in elderly patients with chronic diseases ($r$)

| Variable | Sleep quality | Pain | Health-related quality of life (HRQoL) |
|---|---|---|---|
| Sleep quality | 1 | -0.067 * | 0.218* |
| Pain | | 1 | -0.496* |
| Health-related quality of life (HRQoL) | | | 1 |

Note: * indicates $p$ < 0.001

## 3.3. Linear regression of sleep quality, pain, and Health-related Quality of Life (HRQoL)

This study treated sleep quality as the independent variable. After adjusting for covariates, Model 1 and Model 2 examined pain and health-related quality of life (HRQoL) as the dependent variables, respectively, the results showed that sleep quality had an impact on pain ($\beta$ = -0.039, $t$ = -2.574) and HRQoL ($\beta$ = -0.205, $t$ = 12.115), and the differences reached statistical significance ($p$ < 0.05). In Model 3, pain was the mediating variable and HRQoL was the dependent variable. The results showed that both sleep quality and pain had an impact on HRQoL ($\beta$ = -0.475, $t$ = 32.196), and the differences reached statistical significance ($p$ < 0.001). At the same time, $R^2$ increased from 0.088 to 0.307, indicating that the introduction of the pain mediating variable enhanced the explanatory power of the model (**Table 4**).

**Table 4.** Regression analysis

| Variable | Model 1 (Pain) | | Mode2 (HRQoL) | | Mode3 (HRQoL) | |
|---|---|---|---|---|---|---|
| | β | t | β | t | β | t |
| Gender | 0.093* | 5.521 | 0.020 | 0.135 | 0.058* | 3.511 |
| Age (years) | 0.014 | 0.946 | -0.096* | -5.224 | -0.088* | -5.964 |
| Place of residence | 0.030 | 1.946 | -0.029 | -1.665 | -0.022 | -1.466 |
| Education | -0.069* | -4.203 | 0.076* | 4.130 | 0.041* | 2.539 |
| Marital status | 0.053* | 3.431 | -0.079* | -4.592 | -0.053* | -3.512 |

**Table 4 (Continued)**

| Variable | Model 1 (Pain) | | Mode2 (HRQoL) | | Mode3 (HRQoL) | |
|---|---|---|---|---|---|---|
| | β | t | β | t | β | t |
| Alcohol Use | -0.010 | -0.633 | 0.102* | 5.695 | 0.089* | 5.676 |
| Sleep quality | -0.039** | -2.574 | 0.205* | 12.115 | 0.191* | 12.959 |
| Pain | | | | | -0.475* | -32.196 |
| $R^2$ | 0.028 | | 0.088 | | 0.307 | |
| ***F*** | 19.362* | | 46.067* | | 182.620* | |

Note: * indicates $p < 0.001$, ** indicates $p < 0.05$.

## 3.4. Mediating effect analysis of pain on sleep quality and Health-related Quality of Life (HRQoL)

After adjusting for confounding variables, we assessed the mediating role of pain in the relationship between sleep quality and HRQoL. The coding schemes for all categorical variables are detailed in **Table 2**. Analysis of Model 4 confirmed that sleep quality directly improved HRQoL ($\beta = 0.161$, $p < 0.001$) while also reducing it indirectly through its negative association with pain ($\beta = -0.250$, $p < 0.001$), which itself lowered HRQoL ($\beta = -0.196$, $p < 0.001$), as shown in **Figure 1**.

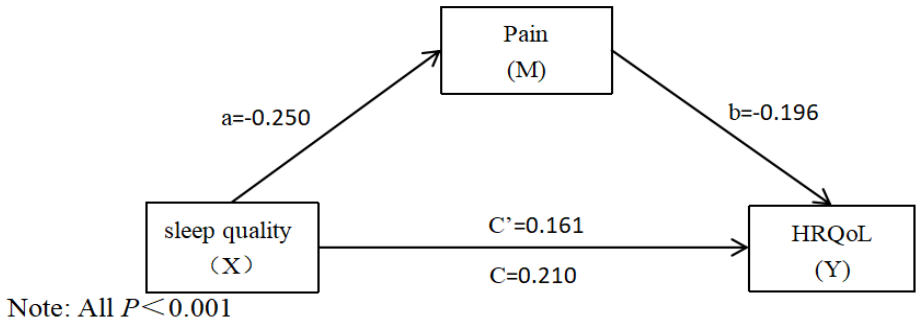


**Figure 1.** Path analysis of the mediating effect of pain between sleep Quality and Health-related Quality of Life (HRQoL).

The Bootstrap method (N = 5000 iterations) test results indicated that the effect value of pain as a mediating variable was 0.049 [95% CI (0.034, 0.056)], and the 95% CI excluded zero, thus confirming a significant mediating effect. Sleep quality could indirectly affect HRQoL through pain, with the total effect being 0.210, the direct effect being 0.161, and the mediating effect being 0.049, accounting for 23.33% of the total effect, as shown in **Table 5**.

**Table 5.** Decomposition of the mediating role of pain in sleep quality and Health-related Quality of Life (HRQoL)

| Item | Effect Size | Boot SE | 95% CI | Proportion Mediated |
|---|---|---|---|---|
| Sleep quality → HRQoL (Total effect) | 0.210 | 0.002 | (0.206,0.214) | - |
| Sleep quality → HRQoL (Direct effect) | 0.161 | 0.002 | (0.156,0.164) | 76.67% |
| Sleep quality → pain → HRQoL (Indirect Effect) | 0.049 | 0.005 | (0.034，0.056) | 23.33% |

Note: - indicates that no such data is available.

# 4. Discussion

## 4.1. Health-related Quality of Life (HRQoL) is influenced by demographic factors

The results of this study show that age, gender, marital status, place of residence, educational level, and alcohol consumption history are all related to HRQoL, which is consistent with previous findings [17].

This may be attributed to the elevated risk of age-related chronic conditions, which can cause progressive functional limitations and more frequent pain. Especially for the elderly female group, they are more susceptible to hormonal influences and have a higher incidence of chronic diseases, making HRQoL more likely to be damaged.

Moreover, unmarried elderly patients with chronic diseases exhibit significantly lower HRQoL than their married counterparts, a difference that may be exacerbated by feelings of loneliness and a relative lack of social support [18].

At the same time, there is an imbalance in medical resources between rural and urban areas, with urban residents enjoying better medical resources, which provides favorable conditions for improving HRQoL. People with higher educational levels have higher health literacy, which promotes their self-health management and has a positive impact on HRQoL. These aspects are highly consistent with the key points of the "Healthy China 2030 Plan Outline", focusing on elderly, solitary, rural, and low-education-level patients with chronic diseases. This suggests that in nursing practice, regular screenings for elderly patients with chronic diseases who have these characteristics should be conducted to provide them with precise health interventions. At the same time, to "reduce the gap in health levels", services such as remote guidance should be provided to rural elderly people for pain management and sleep intervention, thereby improving HRQoL.

## 4.2. Correlation between sleep quality, pain and Health-related Quality of Life (HRQoL) in elderly patients with chronic diseases

The results of this study show that pain is inversely associated with sleep quality and HRQoL ($r$ = -0.496, -0.067, $p$ < 0.001), which is in line with the outcomes of Huang Yingchun et al. [19,20]. The possible reason is that HRQoL is a multi-dimensional indicator for assessing health status. Long-term pain not only multi-dimensionally damages the health condition but also interferes with the sleep structure, forming a vicious cycle of "poor sleep–severe pain–even worse sleep", ultimately reducing HRQoL. Sleep quality is positively associated with HRQoL ($r$ = 0.218, $p$ < 0.001), which is consistent with the findings of Sun Xiuna et al. [21].

The possible reason is that factors such as physiological decline in the elderly, reduced psychological ability, and chronic diseases causing physical discomfort affect sleep quality, thereby reducing HRQoL[22].

These are in line with the strategic orientation of "combination of prevention and treatment" in the "Healthy China 2030 Planning Outline", and it is recommended to incorporate pain and sleep management as important components of the chronic disease prevention and control system. In nursing practice, it is necessary to enhance patients' cognitive education on the correlation among sleep quality, pain, and HRQoL.

## 4.3. Pain plays a partial mediating role between the sleep quality and Health-related Quality of Life (HRQoL) of older adults with chronic conditions

Mediation analysis confirmed that pain exerts a significant partial mediating effect on the sleep quality-HRQoL association in older adults with chronic conditions The mediating effect value is 23.33%, suggesting that sleep quality exerts both direct and indirect effects on HRQoL, with the latter being mediated by pain. The possible reason is that as people age and suffer from chronic diseases, elderly individuals are more prone to sleep disorders [23].

Poor sleep quality directly reduces HRQoL through causing physical decline, decreased daily activity ability, and triggering psychological stress and negative emotions [24]. Pain is a key mediating variable between sleep quality and HRQoL. Firstly, pain is negatively correlated with sleep quality and long-term chronic pain can disrupt sleep rhythms [25]. Secondly, pain is not only a body protection mechanism, but also directly affects the core dimensions of physical discomfort and functional limitations in HRQoL due to its being a crucial clinical indicator for predicting sleep disorders [26,27]. Therefore, poor sleep quality can exacerbate or maintain patients' pain, thereby negatively affecting HRQoL. These findings align with the strategy of "Fully Leveraging the Unique Advantages of Traditional Chinese Medicine" in the "Healthy China 2030 Planning blueprint", and a combination of Western medicine and analgesic treatment is recommended. It is suggested that pain assessment be included as a routine examination for elderly patients with chronic diseases who have sleep complaints, and digital health technologies should be utilized for long-term monitoring. Targeting the mediating pathway of pain may disrupt the adverse interplay between poor sleep and compromised HRQoL, ultimately leading to improved overall health in this patient population.

## 5. Conclusion

By elucidating the partial mediating role of pain, this study positions it as a key indicator for developing targeted strategies to enhance sleep quality in elderly patients with chronic conditions. It is suggested to incorporate the assessment of pain and sleep into the routine examinations of older adults with chronic conditions and to construct a multi-dimensional integrated intervention model centered on pain and sleep.

This study has certain limitations. Firstly, pain plays a partial mediating role. Besides pain, sleep quality can also affect HRQoL through other pathways. Further, more covariates need to be included to examine the relationship of key variables; Secondly, CHARLS did not distinguish between acute and chronic pain, which introduces the risk of information bias; Finally, the present study adopted a cross-sectional study of CHARLS, and could not infer the causal relationship between variables. In the future, longitudinal tracking data of CHARLS can be used for causal inference.

## Funding

Henan Provincial Government-funded Excellent Clinical Medicine Talent Training Project (Project No.: ZF2024006); Hebei Province Medical Science Research Project Plan (Project No.:20240083)

## Disclosure statement

The authors declare no conflict of interest.

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