

The Relationship Between the Number of Chronic Diseases and Health-Related Quality of Life Among Middle-Aged and Older Adults in Rural Areas of Yunnan Province, China: moderating Effect of Health Lifestyle

Jie Chen^{1,*}, Yan Xiao^{2,*}, Chaofang Yan¹, Xiaoju Li¹, Yafang Zhang¹, Ying Chen¹, Yuan Huang¹, Rui Deng¹

¹School of Public Health, Kunming Medical University, Kunming, Yunnan, People's Republic of China; ²Foreign Languages Department, Kunming Medical University, Kunming, Yunnan, People's Republic of China

*These authors contributed equally to this work

Correspondence: Rui Deng; Yuan Huang, Email dengruirita@126.com; huangyuan@kmmu.edu.cn

Purpose: With population aging, individuals in underdeveloped areas may experience a higher prevalence of chronic non-communicable diseases (NCDs), a lower level of health-related quality of life (HRQoL), and distinct lifestyles. However, this triadic association remains inadequately studied, particularly regarding the role of health lifestyle. This study aims to examine the relationship between the number of NCDs and HRQoL, while considering the moderating effect of health lifestyle among middle-aged and older adults residing in resource-limited areas.

Methods: This cross-sectional study was conducted in Yunnan Province from July to December 2022. Participants completed a self-report questionnaire related to socio-demographic information, NCDs conditions, health lifestyle status, and HRQoL, which was assessed using the EuroQol five-dimension five-level (EQ-5D-5L) scale. Hierarchical regression and simple slope tests were used to examine the moderating effect of health lifestyle.

Results: Out of the total 2704 participants, 57.91% presented at least one NCD. The mean scores for health lifestyle and health utility value were 11.109 and 0.944 respectively. The number of NCDs was negatively associated with health utility value, while positively correlated with the health lifestyle score ($P < 0.001$). The results of hierarchical regression indicated that health lifestyle exerted a negative moderating effect on the relationship between the number of NCDs and HRQoL ($\beta = 0.006$, $P < 0.001$), which was also observed for specific health-related behaviors such as sleep duration ($\beta = 0.013$, $P < 0.001$), physical examination attendance ($\beta = 0.006$, $P < 0.05$) and physical activity ($\beta = 0.013$, $P < 0.001$).

Conclusion: These findings highlight the crucial role of a healthy lifestyle in attenuating the association between the number of NCDs and HRQoL. Recognizing the potential modulating influence of a healthy lifestyle in this relationship could be pivotal for developing effective interventions for this population, even within resource-constrained rural settings.

Keywords: chronic non-communicable diseases, health-related quality of life, health lifestyle, health-related behavior, rural, moderating effect

Introduction

With the global phenomenon of population aging and shifts in lifestyles, chronic non-communicable diseases (NCDs) have emerged as a predominant and burgeoning health concern globally.¹ Notably, low- and middle-income countries are experiencing a disproportionately higher burden of NCDs compared to their high-income counterparts.² Moreover, the

prevalence of NCDs tends to escalate with advancing age, rendering individuals in mid-life and beyond particularly susceptible.³ Over the past few decades, China has witnessed a consistent rise in the prevalence of NCDs, particularly among middle-aged and older demographic segments. The Sixth National Health Services Survey in 2018 reported that the prevalence rates of NCDs among Chinese individuals aged 45–54 years, 55–64 years, and 65 years and above were 31.3%, 48.4%, and 62.3%, respectively. These figures surpass those observed in 2013, underscoring the escalating NCDs burden within the country.⁴

To subjectively gauge the impact of NCDs, health-related quality of life (HRQoL) has been widely adopted as a metric for assessing an individual's self-perceived capacity to perform physical, psychological, and social functions.⁵ To date, research on the impact of NCDs on HRQoL primarily revolves around two key dimensions: the first centered on specific diseases such as diabetes⁶ and cancer;⁷ while the second dimension explores multimorbidity, characterized by the coexistence of multiple NCDs, encompassing both the number⁸ and the clustering.⁹ In terms of the number of NCDs, numerous studies have demonstrated that individuals with NCDs are more prone to experiencing lower HRQoL, especially in individuals with multimorbidity.^{9,10} This phenomenon has been empirically substantiated within the middle-aged and elderly demographic, where the simultaneous presence of numerous chronic conditions leads to a substantial deterioration in both the mental and physical dimensions of HRQoL.^{8,10}

The recognition of the influence of health lifestyle on both NCDs and HRQoL has seen a notable increase in attention within the health profession. Health lifestyle is typically characterized as a repertoire of health-related behaviors that exert varying impacts on an individual's health outcomes, encompassing both health-risk behaviors (eg, tobacco use) and health-promoting behaviors (eg, obtaining adequate sleep duration).^{11,12} Compelling evidence substantiates that the adoption of a healthy lifestyle, inclusive of smoking cessation,¹³ moderate alcohol consumption,¹⁴ adequate sleep duration,¹⁵ regular physical examination¹⁶ and engagement in physical activity,¹⁷ possesses the capacity to not only thwart the incidence and progression of NCDs but also safeguard against their onset. Furthermore, a multitude of empirical investigations have underscored a discernible association between an increased adherence to a healthy lifestyle and elevated levels of HRQoL.^{18,19} Consequently, the advocacy for promoting a health-conscious lifestyle has transcended global borders, gaining recognition as the most cost-effective and efficacious approach for NCDs prevention and the enhancement of HRQoL, particularly within resource-constrained settings.²⁰

However, the triadic association among health lifestyle, NCDs and HRQoL remains insufficiently explored, with a notable dearth of understanding the role played by health lifestyle. Recent evidence accentuates the significant influence of socioeconomic factors such as place of residence and household income on individuals' chronic conditions,²¹ HRQoL,²² and lifestyle choices.²³ Notably, individuals residing in China's rural areas with lower household incomes may experience a higher prevalence of NCDs, a lower level of HRQoL, and distinct lifestyles.

The situation is even more pronounced in Yunnan Province. Situated in the southwestern region of China, Yunnan Province is characterized by its underdeveloped status with complex terrain, limited resources, inadequate transportation and healthcare infrastructure.²⁴ Meanwhile, Yunnan is also a multi-ethnic province within the country, where ethnic minority areas highly overlap with underdeveloped rural areas, contributing to the regional and demographic distinctiveness of this territory. Nowadays, Yunnan Province is witnessing a demographic shift towards an aging population, leading to a continual rise in the proportion of middle-aged and older adults. Official data from the 6th (2010) and 7th (2020) China Population Census indicate a surge in the percentage of individuals aged 45 years and above in Yunnan Province, escalating from 27.65% to 38.40%.^{25,26} In this context, NCDs have emerged as primary determinants influencing health status among middle-aged and older adults residing in Yunnan Province.

In recent years, the Chinese government has placed substantial emphasis on addressing NCDs and improving HRQoL for middle-aged and the elderly populations, in alignment with the *Healthy China 2030 Planning Outline* in 2016. Consequently, healthy aging has gained national prominence, with a central focus on promoting healthier lifestyle among seniors, and ultimately enhancing their overall health status.²⁷ Given its status as a prototypical underdeveloped multi-ethnic region in China, the health status of middle-aged and older adults in Yunnan Province assumes a pivotal role in China's overarching pursuit of healthy aging.

The aim of this study is to scrutinize the relationship between the number of NCDs and HRQoL, while exploring the potential moderating effect of health lifestyle among middle-aged and older adults residing in rural areas, represented by

Yunnan Province, China. It is anticipated that conceptualizing health lifestyle as an intermediate intervention mechanism may furnish valuable, evidence-based insights for formulating more cost-effective strategies aimed at enhancing HRQoL among seniors residing in resource-constrained regions, particularly those grappling with NCDs.

Methods

Study Design and Participants

This study adopted a cross-sectional research design based on a questionnaire survey. The survey instrument was a structured questionnaire, comprising four principal sections designed to capture sociodemographic attributes, chronic conditions, health lifestyle information and HRQoL. Data collection transpired during the period spanning from July to December 2022, within the geographic confines of Yunnan Province, China. A stratified cluster sampling approach was employed to ensure a representative and diversified sample. The determination of the sample size adhered to the following formula:

$$N = \frac{\mu_a^2 \times P(1 - P)}{\delta^2} \times deff$$

The prevalence rate of NCDs among individuals aged 45 and above in China for the year 2018²⁸ was used to set P at 50%. The significance level (α) and the permissible error (δ) were set at 0.05 and 0.1 P , respectively. In the light of the application of the “Design effect” for cluster sampling method ($deff=3$), a minimum sample size of 1382 subjects was calculated, with an anticipated non-response rate estimated at 20%. To ensure sample diversity and representativeness, five counties were randomly selected, considering their economic status, geographical characteristics, and distribution of ethnic minorities. Subsequently, two administrative villages were randomly designated from each of the selected counties. Inclusion criteria mandated participants to be aged 45 and above and to have maintained local residency for a minimum of three months. Exclusion criteria encompassed the presence of cognitive and mental disorders, or unwillingness to participate.

Prior to commencing the survey, all interviewers underwent rigorous training. Well-trained interviewers conducted face-to-face interviews to distribute questionnaires and collect responses from the participants. Only questionnaires with complete responses were deemed valid. A total of 2704 participants were included in the final analysis after excluding 26 individuals with missing data concerning item in the questionnaires, resulting in a validity rate of 99%.

Measures

The Number of NCDs

According to the World Health Organization (WHO), NCDs are defined as illnesses that are not transmitted from person to person, endure for an extended duration, and progress gradually. In this research, data regarding the number of NCDs among participants was gathered from a predefined list. The list encompassed five principal categories of NCDs, namely cardiovascular diseases (such as heart attacks and strokes), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma), diabetes and musculoskeletal disorders (such as rheumatoid arthritis, intervertebral disc disease).^{29,30} Additionally, an “other” option were provided to allow participants to specify NCDs not explicitly listed. Participants were instructed to indicate whether they had received a formal diagnosis by health professionals for each of these NCDs. Subsequently, a cumulative count of the NCDs was calculated for each participant. Multimorbidity was defined as the concurrent presence of two or more NCDs within a single individual.^{8,31} Based on the number of NCDs self-reported by participants, four distinct classifications were established, namely 0, 1, 2, 3+.

Health-Related Quality of Life (HRQoL)

The concept of HRQoL can be defined as an individual’s subjective perception of their overall health status, encompassing three broad domains: physical, psychological, and social functioning.⁵ In this study, HRQoL was measured by the health utility value of the EuroQol five-dimension five-level (EQ-5D-5L).³² The EQ-5D-5L is a preference-based scale that evaluates HRQoL across five distinct dimensions (Mobility, Self-Care, Usual Activities, Pain/Discomfort, and

Anxiety/Depression), with each dimension featuring five gradations denoting varying levels of issues (ranging from none to slight, moderate, severe, and extreme problems).

The measurement outcomes obtained from the EQ-5D-5L were converted into health utility value using a Chinese value set.³³ Ultimately, health utility values among all participants in this study were ranged from -0.391 to 1.00, with higher values signifying a superior HRQoL.

Health Lifestyle

The term “health lifestyle” pertains to the collective patterns of health-related behavior that individuals adopt based on the choices within the context of their life circumstances.³⁴ In order to comprehensively assess the health lifestyle of the participants, this study incorporated five commonly utilized behavioral indicators from previous researches,^{19,35,36} namely smoking status, alcohol consumption, sleep duration, physical examination attendance, and physical activity. Following the scoring methodology employed in previous researches, this study assigned scores to various manifestations of these five health-related behaviors, which reflected their degree of alignment with established public health recommendations. Subsequently, a composite health lifestyle score was derived by summing the scores of the aforementioned five health-related behaviors.^{37,38}

Smoking status was categorized by daily cigarette consumption into three groups: “Non-smoker (complete abstinence from smoking)”, “Light/moderate smoker (1–20 cigarettes per day)”, and “Heavy smoker (>20 cigarettes per day)”.³⁹ Each smoking category was assigned a score ranging from 3 to 1 in ascending order, with higher scores indicating less severe smoking habits.

Alcohol consumption was evaluated by the risk of daily ethanol intake and categorized as follows: “Non-drinker (total abstinence from alcohol)”, “Light/moderate drinker (1–40g ethanol per day for females/1–60g ethanol per day for males)”, and “Heavy drinker (>40g ethanol per day for females/>60g ethanol per day for males)”.⁴⁰ Correspondingly, scores ranging from 3 to 1 were assigned to each category in ascending order, where higher values indicating less severe drinking habits.

Sleep duration was assessed by the average number of hours slept during the night into two groups: “Adequate sleep (≥ 7 and < 9 hours of sleep each night)” and “Inadequate/excess sleep (< 7 hours or ≥ 9 hours of sleep each night)”.⁴¹ Individuals with “Adequate sleep” received a score of 2, while those with “Inadequate/excessive sleep” were assigned a score of 1.

Physical examination attendance was measured by the frequency of annual health check-ups and classified into three groups: “Regular”, “Irregular” and “Not at all”.⁴² Each type of physical examination attendance was allocated scores ranging from 3 to 1 in ascending order, with higher values indicating greater regularity.

Physical activity was evaluated based on the frequency and duration of weekly exercise engagement and categorized into three groups: “Regular (≥ 3 times per week and ≥ 30 minutes per session)”, “Irregular (< 3 per week or < 30 minutes per session)”, and “Not at all”.⁴³ Each level of physical activity received scores ranging from 3 to 1 in ascending order, with higher values indicating better physical activity.

The participants’ overall health lifestyle was evaluated using a health lifestyle score that ranged from 5 to 14 points, where a higher score indicated a more favorable health-conscious lifestyle.

Covariates

This study mainly included covariates related to demographic characteristics: gender (male, female), age (45–59, 60–74, ≥ 75), marital status (married, unmarried/divorced/widowed), education level (primary school and below, junior high school, senior high school and above), occupation (technician/office workers/civil servant, individual business, retired, worker, farmer, unemployed, others) and monthly household income (0–2999, 3000–4999, 5000–6999, 7000–8999, ≥ 9000). This study synthesized a socioeconomic status (SES) index based on three socio-economically relevant indicators: education level, occupation, and monthly household income.

Detailed explanations for all variables employed in this study are provided in [Table 1](#).

Statistical Analysis

Data entry and validation checks were conducted using EpiData 3.2, while data analysis was performed using Stata 15.1 statistical software. Initially, we employed five health-related behaviors as indicators of health lifestyle, implemented a robust instrument to measure HRQoL, and collected data on participants’ number of NCDs. Subsequently, pairwise

Table 1 Variable Description

Variable type	Variable Name	Description of Variable Categories and Score Setting
Independent variable	The number of NCDs	0, 1, 2, 3+
Dependent variable	Health-related quality of life (HRQoL)	Higher health utility value indicating better health-related quality of life
Moderating variable	Health lifestyle	Higher health lifestyle score indicating healthier lifestyle
	Smoking status	Non-smoker=3, Light/moderate smoker=2, Heavy smoker=1
	Alcohol consumption	Non-drinker=3, Light/moderate drinker=2, Heavy drinker=1
	Sleep duration	Adequate sleep=2, Inadequate/excess sleep=1
	Physical examination attendance	Regular=3, Irregular=2, Not at all=1
	Physical activity	Regular=3, Irregular=2, Not at all=1
Control variable	Gender	Female, Male
	Age	45–59, 60–74, ≥75
	Marital status	Married, Unmarried/divorced/widowed
	Education level	Primary school and below, Junior high school, Senior high school and above
	Occupation	Technician/office workers/civil servant, Individual business, Retired, Worker, Farmer, Unemployed, Others
	Monthly household income	0–2999, 3000–4999, 5000–6999, 7000–8999, ≥9000
	SES	The higher score indicating higher socioeconomic status

Abbreviations: NCDs, chronic non-communicable diseases; HRQoL, health-related quality of life; SES, socioeconomic status index.

correlations among the number of NCDs, HRQoL, health lifestyle, and health-related behaviors were examined using both Spearman correlation test and Pearson's correlation test.

Principal component analysis (PCA) was carried out to generate the SES index. In this study, the number of principal components in PCA was determined based on the cumulative contribution rate (greater than 70%). Then, hierarchical regression analysis was performed to explore the relationship between the number of NCDs and HRQoL, as well as the potential moderating effect of health lifestyle on this relationship. Specifically, the hierarchical regression analysis consisted of four steps. In step 1, only the covariates were incorporated into the regression model. In step 2 and 3, the number of NCDs and health lifestyle score/each health-related behavior score were introduced into the regression model respectively. Finally, in step 4, interaction terms were added between the number of NCDs with health lifestyle score/each health-related behavior score to the regression model. The hypothesis regarding the moderating effect was deemed supported if these interactions demonstrated statistically significant. Additionally, for a visual representation of these interaction terms, significant interactions were examined using simple slope analysis by considering values at one standard deviation above and below the mean of health lifestyle score or specific health-related behavior score.⁴⁴ The level of statistical significant was set at $\alpha = 0.05$.

Results

Demographic Characteristics of Participants

Out of the total 2704 participants in this study, there was a slight predominance of females, with a male-to-female ratio of 1:1.23. The age range spanned from 45 to 99 years (mean: 62.05±10.21). The study participants comprised 69.93% individuals from ethnic minority groups, whereas 30.07% were Han people. In terms of marital status, a significant

portion of participants were married, accounting for 75.86%. Furthermore, the majority of participants had attained primary education or below this threshold, constituting 79.44%. The predominant occupation was farming, encompassing 70.30%. Moreover, 54.29% participants reported a monthly household income of less than 3000 RMB. Regarding the generation of the SES index, both the Kaiser-Meyer-Olkin (KMO) and Bartlett's test indicated that the data obtained in this study were suitable for PCA (KMO>0.60; Bartlett's test: $P<0.001$). As a result of the PCA, the principal components with a cumulative contribution rate of 77.58%, were retained as the SES index, which ranged from -1.152 to 3.821 .

Regarding the number of NCDs, approximately 57.91% of the participants exhibited at least one NCD, while 16.01% had been diagnosed with two NCDs, and 10.24% were burdened with three or more NCDs. The study also calculated the mean health lifestyle score and health utility value among the participants, yielding values of 11.109 and 0.944, respectively.

Correlation Analysis

Table 2 presented the results of correlation analysis. A significantly negative association was observed between the number of NCDs and the health utility value, while a positive correlation was identified between the number of NCDs and health lifestyle score ($P<0.001$). Among the behavioral indicators of health lifestyle, smoking status, alcohol consumption, physical examination attendance and physical activity were positively associated with the number of NCDs. On the contrary, sleep duration exhibited a negative correlation with the number of NCDs ($P<0.001$). Regarding health utility value, smoking status and alcohol consumption showed negative correlations ($P<0.001$). Conversely, sleep duration and physical activity demonstrated a significantly positive association ($P<0.001$).

Moderating Effect of Health Lifestyle on the Relationship Between the Number of NCDs and HRQoL

Overall Health Lifestyle

To explore the potential moderating effect of health lifestyle on the relationship between the number of NCDs and HRQoL, hierarchical regression analysis were employed. In model 1, the dependent variable was health utility value, while four covariates were included to examine their primary effects. The results revealed significant association between all covariates (with the exception of gender) and health utility value ($P<0.01$). In model 2, the number of NCDs was introduced as an independent variable, revealing a significant negative relationship with health utility value ($\beta=-0.026$, $P<0.001$). Model 3 incorporated the moderating variable, health lifestyle score, which exhibited a positive relationship with health utility value ($\beta=0.008$, $P<0.001$). Finally, in model 4, the interaction term (the number of NCDs \times health lifestyle score) was added to reveal a significant positive correlation with health utility value ($\beta=0.006$, $P<0.001$),

Table 2 Correlation Analysis Between Variables

Variables	1	2	3	4	5	6	7	8
1 The number of NCDs	—							
2 Health utility value	-0.324***	—						
3 Health lifestyle score	0.119***	0.003	—					
4 Smoking status	0.124***	-0.087***	0.482***	—				
5 Alcohol consumption	0.125***	-0.111***	0.479***	0.430***	—			
6 Sleep duration	-0.094***	0.123***	0.254***	-0.066***	-0.059***	—		
7 Physical examination attendance	0.102***	-0.030	0.602***	0.081***	0.080***	-0.018	—	
8 Physical activity	0.049*	0.084***	0.617***	0.067***	0.077***	-0.002	0.148***	—

Notes: * P -value<0.05, *** P -value<0.001.

Abbreviation: NCDs, chronic non-communicable diseases.

Table 3 Moderating Effect of Health Lifestyle on the Relationship Between the Number of NCDs and HRQoL

Variables	Mode 1	Mode 2	Mode 3	Mode 4
Step 1				
Gender (ref:Male)				
Female	-0.007	-0.004	-0.012**	-0.011*
Age(ref:45–59)				
60–74	-0.019***	-0.008	-0.011*	-0.012**
≥75	-0.059***	-0.044***	-0.049***	-0.051***
Marital status (ref:Married)				
Unmarried/divorced/widowed	-0.014**	-0.013**	-0.012*	-0.013**
SES	0.007**	0.007**	0.006*	0.005*
Step 2				
The number of NCDs		-0.026***	-0.027***	-0.027***
Step 3				
Health lifestyle score			0.008***	0.008***
Step 4				
The number of NCDs×Health lifestyle score				0.006***
<i>F</i>	26.350	49.710	48.020	45.410
<i>R</i> ²	0.047	0.100	0.111	0.119

Notes: **P*-value<0.05, ***P*-value<0.01, ****P*-value<0.001.

Abbreviations: NCDs, chronic non-communicable diseases; HRQoL, health-related quality of life; SES, socio-economic status index.

indicating that health lifestyle exerted a negative moderating effect on the relationship between the number of NCDs and HRQoL (Table 3).

To further elucidate the effects of interaction term, simple slope analysis were conducted on two distinct groups: one characterized by a healthier lifestyle (defined as having a health lifestyle score higher than the mean score, *M* +1 SD) and another group characterized by relatively less healthy lifestyle (defined as having a health lifestyle score lower than the mean score, *M* –1 SD). The findings uncovered that the negative relationship between the number of NCDs and health utility value remained significant in both healthier ($\beta=-0.018$, $P<0.001$) and less healthy ($\beta=-0.037$, $P<0.001$) lifestyle groups. However, the magnitude of this relationship was notably weaker for individuals adhering to healthier lifestyles compared to those with less favorable lifestyles. This suggests that the connection between the number of NCDs and HRQoL is more pronounced among individuals who adopt an unhealthy lifestyle. Consequently, it can be inferred that health lifestyle negatively moderates the association between the number of NCDs and HRQoL (Figure 1).

Five Health Lifestyle Indicators

To identify the specific contributions of distinct health-related behaviors to the moderating effect of health lifestyle, this study further examined the individual moderating effects exhibiting by various behavioral indicators of health lifestyle on this relationship. Specifically, we conducted a series of hierarchical regression analysis from step 1 to step 4 to investigate the moderating effects of each five health-related behaviors (smoking status, alcohol consumption, sleep duration, physical examination attendance and physical activity). In Table 4, subsequent to the inclusion of covariates, the number of NCDs, the aforementioned health-related behaviors, and their respective interaction terms, it was discerned that the

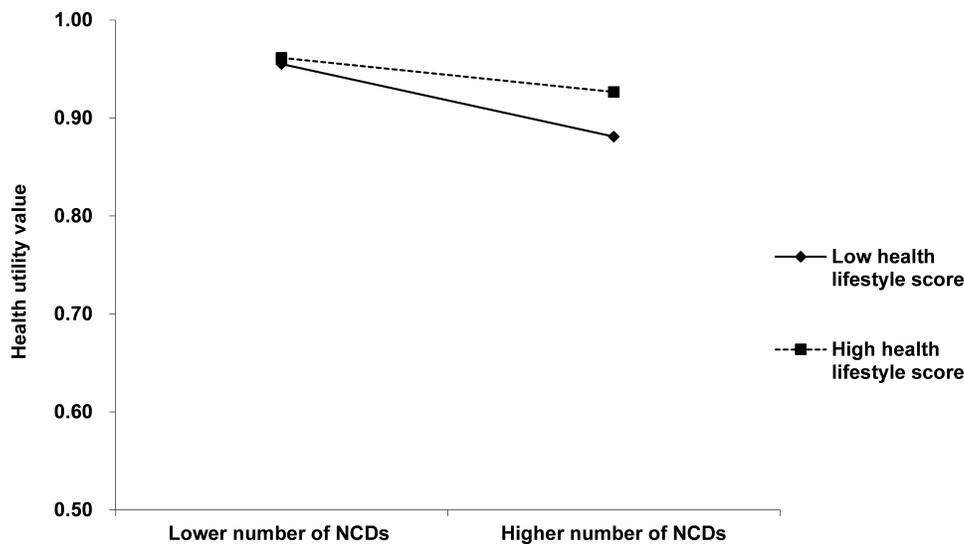


Figure 1 Simple slope plot of the interaction between the number of NCDs and health lifestyle on HRQoL.

Notes: Low, 1 SD below the mean on health lifestyle score; High, 1 SD above the mean on health lifestyle score; The values of number of NCDs and health lifestyle score were centered before regression analysis; Gender, age, marital status and SES were adjusted.

Abbreviations: NCDs, chronic non-communicable diseases; HRQoL, health-related quality of life; SES, socioeconomic status index; SD, standard deviation.

interaction term of the number of NCDs and sleep duration ($\beta=0.013$, $P<0.001$)/physical examination attendance ($\beta=0.006$, $P<0.05$)/physical activity ($\beta=0.013$, $P<0.001$) emerged as significant and positive predictor of the health utility value while the interaction term of the number of NCDs and smoking status/alcohol consumption did not. These findings suggest that sleep duration, physical examination attendance, and physical activity exert negative moderation effects on the correlation between the number of NCDs and HRQoL.

Table 4 Moderating Effect of Each Health-Related Behaviors on the Relationship Between the Number of NCDs and HRQoL

Variables	Smoking Status	Alcohol Consumption	Sleep Duration	Physical Examination Attendance	Physical Activity
Step 1					
Gender(ref:Male)					
Female	-0.003	-0.001	-0.002	-0.005	-0.005
Age(ref:45–59)					
60–74	-0.008	-0.007	-0.007	-0.009*	-0.012**
≥75	-0.044***	-0.043***	-0.043***	-0.046***	-0.049***
Marital status(ref:Married)					
Unmarried/divorced/widowed	-0.014**	-0.014**	-0.012*	-0.014**	-0.013**
SES	0.007**	0.007**	0.006**	0.007**	0.004
Step 2					
The number of NCDs	-0.026***	-0.026***	-0.026***	-0.027***	-0.027***

(Continued)

Table 4 (Continued).

Variables	Smoking Status	Alcohol Consumption	Sleep Duration	Physical Examination Attendance	Physical Activity
Step 3					
Smoking status	-0.002				
Alcohol consumption		-0.007			
Sleep duration			0.018***		
Physical examination attendance				0.006*	
Physical activity					0.019***
Step 4					
The number of NCDs×Smoking status	0.001				
The number of NCDs×Alcohol consumption		-0.004			
The number of NCDs×Sleep duration			0.013***		
The number of NCDs×Physical examination attendance				0.006*	
The number of NCDs×Physical activity					0.013***
<i>F</i>	37.300	37.740	44.290	38.650	49.420
<i>R</i> ²	0.100	0.101	0.116	0.103	0.128

Notes: **P*-value<0.05, ***P*-value<0.01, ****P*-value<0.001.

Abbreviations: NCDs, chronic non-communicable diseases; HRQoL, health-related quality of life; SES, socioeconomic status index.

In line with the analysis above, we investigated the significant interaction effects through simple slope analysis. Each behavior was categorized into two groups: a healthier behavior group (defined as having a health-related behavior score higher than the mean score, $M + 1$ SD), comprising those who exhibited healthier sleep duration/physical examination attendance/physical activity, and a relatively less healthy behavior group (defined as having a health-related behavior score lower than the mean score, $M - 1$ SD), consisting of those who engaged in less healthy sleep duration/physical examination attendance/physical activity. As depicted in Figure 2, there is a significant negative relationship between the number of NCDs and health utility value in both groups engaging in healthier sleep duration/physical examination attendance /physical activity ($\beta = -0.019/-0.022/-0.016$, $P < 0.001$) and less healthy sleep duration/physical examination attendance/physical activity ($\beta = -0.032/-0.031/-0.037$, $P < 0.001$), albeit with a lower slope for the former compared to the latter group of behaviors related to sleep duration/physical examination attendance/physical activity. These findings suggest that healthier behaviors including sleep duration, physical examination attendance, and physical activity gradually diminish the predictive effect of number of NCDs on HRQoL. Thus, specific health-related behaviors negatively moderated the association between the number of NCDs and HRQoL.

Discussion

The health utility value was found to be 0.944 in this study. This score surpasses investigation conducted in urban (0.907) and rural (0.861) regions of China among middle-aged and older adults.⁴⁵ Furthermore, it slightly deviates from the reported value for the general population in China (0.946).⁴⁶ These results are plausibly attributable to the multi-ethnic settlement dynamics of Yunnan Province where ethnic minority groups exhibit relatively enhanced resilience, thereby engendering a subjectively higher HRQoL.⁴⁷ Additionally, these findings convey that Health Program for Poverty

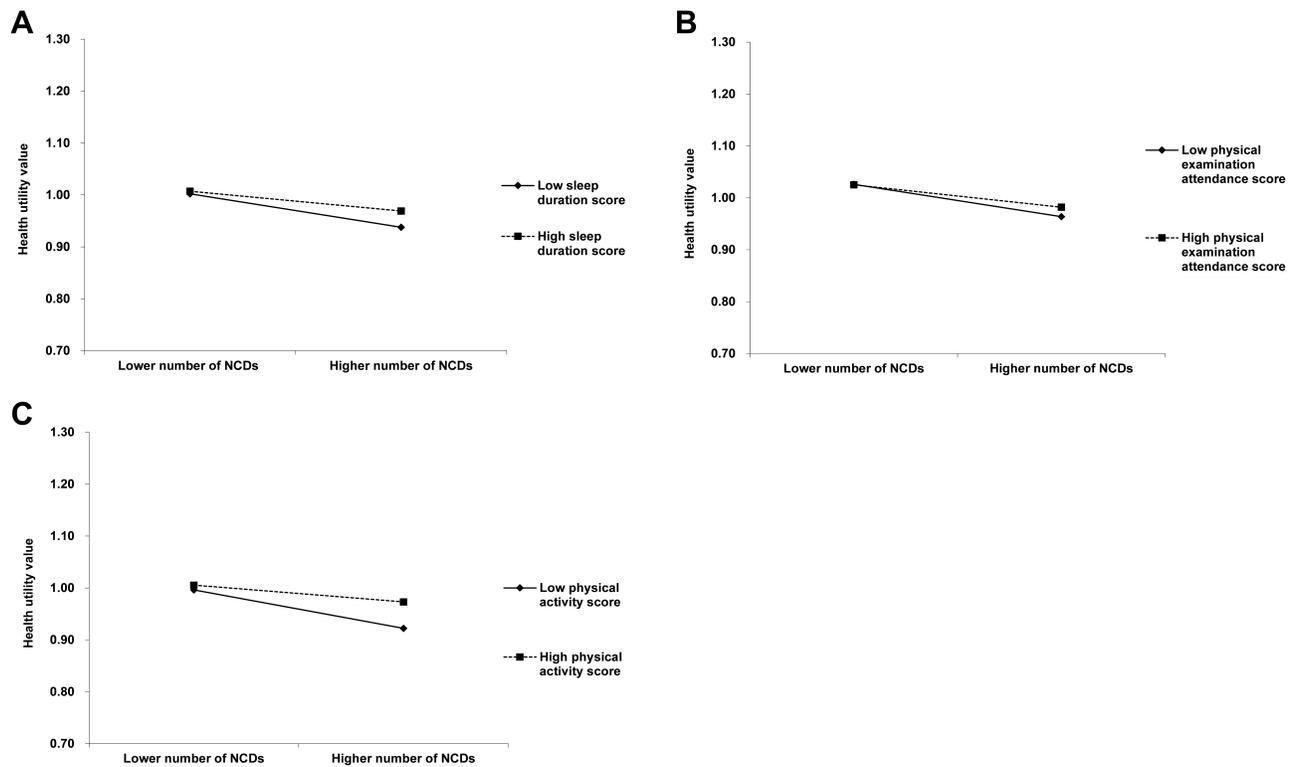


Figure 2 Simple slope plot of the interactions between the number of NCDs and health-related behaviors on HRQoL. **(A)** The moderating effect of sleep duration on the relationship between the number of NCDs and HRQoL. **(B)** The moderating effect of physical examination attendance on the relationship between the number of NCDs and HRQoL. **(C)** The moderating effect of physical activity on the relationship between the number of NCDs and HRQoL.

Notes: Low, 1 SD below the mean on sleep duration **(A)** /physical examination attendance **(B)** /physical activity **(C)** score; High, 1 SD above the mean on sleep duration/physical examination attendance/physical activity score; The values of number of NCDs and health-related behaviors score were centered before regression analysis; Gender, age, marital status and SES were adjusted.

Abbreviations: NCDs, chronic non-communicable diseases; HRQoL, health-related quality of life; SES, socioeconomic status index; SD, standard deviation.

Alleviation implemented over recent years has effectively ameliorated the health status of middle-aged and older adults, as well as individuals with chronic conditions within the precincts of Yunnan Province.²⁴

Consistent with previous findings, this study also found that individuals afflicted by NCDs commonly report diminished HRQoL. This phenomenon can be attributed to the dual burden of physiological and psychological distress encountered by patients with NCDs. Firstly, many NCDs are associated with constant pain,⁴⁸ limitations in functional abilities,⁴⁹ and even the development of disability,⁵⁰ which contribute to a compromised physical well-being. Moreover, NCDs typically exhibit a protracted and gradual progression, necessitating continuous medical treatment.²⁹ Apart from the psychological distress deriving from disease symptoms and treatment side-effects, patients with NCDs often grapple with social and psychological challenges, including feelings of isolation, perceived burdensomeness on others, and the stigma attached to their conditions, all of which can detrimentally affect their HRQoL.^{51,52} It is worth noting that the acquisition of multimorbidity can further exacerbate patients' HRQoL. This exacerbation can be attributed to the coexistence of multiple NCDs, which prompts a more severe clinical scenario, thereby yielding inferior HRQoL outcomes.⁵³ One plausible explanation for this is that worsened conditions not only generate heightened physical distress but also necessitate intricate therapeutic interventions. This, in turn, engenders challenges such as detrimental polypharmacy and overwhelming financial burdens associated with intensified medical care and potential unemployment.^{54,55}

Previous studies have posited an association between NCDs and health lifestyle. Generally, individuals embracing healthier lifestyles are less prone to the onset of NCDs.⁵⁶ In this study, significant correlations were discerned in the number of NCDs among individuals with diverse health-related behaviors. Additionally, a positive relationship emerged between the number of NCDs and health lifestyle. Specifically, smoking status, alcohol consumption, physical examination attendance and physical activity all exhibited positive association with the number of NCDs. These findings provide

two significant insights. Firstly, it is arguable that individuals may modify their previously unhealthy behaviors in response to the progression of acquired NCDs,⁵⁷ prompting them to engage more frequently with healthcare services and adopt compliant medical behaviors.⁵⁸ This result further underscores the imperative of furnishing health management services to individuals aged 35 and above with chronic conditions through initiatives like the National Basic Public Health Services Project in China. Secondly, although being diagnosed with NCDs can potentially serve as a catalyst for unhealthy behavioral modifications, the effective transition to and sustained adoption of a healthy lifestyle at a younger age remains an ongoing challenge for patients.⁵⁷ Initiating a healthy lifestyle at an early stage confers substantial benefits to individual health and represents a cost-effective intervention approach. Therefore, it is prudent to prioritize the promotion of healthy lifestyles, particularly among economically disadvantaged populations.

Based on the data presented in Table 2, no significant correlation was discerned between health utility value and health lifestyle score. Nonetheless, it is noteworthy that the health utility value demonstrated negative associations with scores pertaining to smoking status and alcohol consumption, while positive correlations with scores related to sleep duration and physical activity. These results are consistent with several other investigations. For instance, a study involving 1920 community-dwelling elderly individuals in Korea reported lower HRQoL among participants who abstained from alcohol consumption, yet elevated HRQoL among those engaged in physical activity.¹⁸ Similarly, another study comprising 2037 community-dwelling adults in Japan identified insufficient physical activity and inadequate sleep as factors linked to lower HRQoL, while individuals with alcohol consumption habits exhibited higher HRQoL.¹⁹ Moderate alcohol consumption has been shown to enhance self-perceived happiness in previous study.⁵⁹ However, it is crucial to provide tailored recommendations regarding optimal levels of alcohol consumption and physical activity for distinct age groups.

To date, although pairwise correlations between NCDs, HRQoL, and health lifestyle have been extensively examined, the moderating role of health lifestyle in the relationship between the number of NCDs and HRQoL remained a relatively unexplored area of inquiry. Firstly, this study confirmed that the adoption of a healthy lifestyle negatively moderates the relationship between the number of NCDs and HRQoL among middle-aged and older adults. In other words, the maintenance of a health-promotion lifestyle can act as a protective factor mitigating the adverse impacts of NCDs and promoting an enhanced state of HRQoL. Moderation effect analyses of each behavior further indicated that several specific behaviors, namely sufficient sleep duration, regular physical examinations, and engagement in physical activity significantly, moderate the relationship between the number of NCDs and HRQoL. The incongruities noted in the influence of smoking status and alcohol consumption on this relationship remain enigmatic but may be imputable to a diminished statistical power from a lower prevalence of these behaviors within our study sample. Consequently, a pressing need exists for further research endeavors to comprehensively clarify the intricate interplay between specific behavioral factors and their influence on the relationship between the number of NCDs on HRQoL. Overall, the adoption of a healthy lifestyle emerges as a potentially effective mechanism linking NCDs with improved HRQoL.

Our findings propose a novel perspective on the promotion of HRQoL among middle-aged and older adults in rural areas, particularly those with chronic conditions. It is recommended to implement targeted healthy lifestyle interventions for individuals within this population. The current results highlight distinct focal points compared to previous intervention strategies, with particular emphasis on three health-related behaviors: sleep duration, physical examination attendance, and physical activity.

As for sleep, it is pertinent to recognize that both the aging process and the presence of NCDs can adversely affect the sleep patterns of older adults.⁶⁰ Therefore, efforts to ameliorate the sleep quality of this population should not be overlooked. Additionally, long-term agricultural labor may lead rural residents to neglect regular physical activity in their daily lives.⁶¹ Hence, there is a pressing need to enhance health education and promote healthy lifestyle within rural areas by encouraging residents to engage in scientifically appropriate physical activities beyond their occupational work and cultivate good sleep habits. Furthermore, regular physical examinations assume a pivotal role in the early detection and treatment of NCDs among middle-aged and older adults. Over the years, while Chinese government has made commendable strides in offering complimentary physical examinations for individuals aged 65 and above through the National Basic Public Health Service Project, the needs of middle-aged individuals have been underestimated. Given the

vulnerability of rural populations in terms of economic capacity and disease incidence, it is recommended to further advance and expand this provision to encompass middle-aged adults residing in rural areas.

This study exhibits several notable strengths. It uniquely centers on the middle-aged and older adults residing in multi-ethnic rural areas of Yunnan Province, China, thereby furnishing fundamental empirical insights for further health research within these specific demographic segments. The implications of our findings could potentially be extrapolated to other similar contexts characterized by the presence of multiple ethnic minority groups. Furthermore, while the exploration of the relationship between NCDs and HRQoL is not unprecedented, the innovative aspect of this study lies in its consideration of modifiable health lifestyle factors as potential coping mechanisms to mitigate the adverse effects of NCDs on HRQoL. This introduces novel avenues for enhancing HRQoL among middle-aged and older adults in resource-constrained areas, particularly among those afflicted with chronic diseases. However, two primary limitations warrant acknowledgment in this study. Firstly, our assessment of participants' chronic condition relied on a count of NCDs. This counting method does not consider the differential impact of specific types of NCDs on HRQoL. Secondly, our data collection was reliant upon self-reported questionnaires, a methodology susceptible to memory bias during the interview process.

Conclusions

This study highlights the role of a healthy lifestyle as a negative moderator in the relationship between the number of NCDs and HRQoL among middle-aged and older adults in rural areas of Yunnan Province, China. Similar moderating effects were observed for specific health-related behaviors, including sleep duration, physical examination attendance, and physical activity. Given the high prevalence of NCDs and substantial decline in HRQoL among middle-aged and older adults, recognizing health lifestyle as a moderator in this relationship holds importance for the development of effective interventions tailored to this population. Consequently, the imperative arises for the promotion of healthy lifestyle interventions across all segments of the population, regardless of the presence or absence of NCDs, and extending to resource-limited rural settings.

Abbreviations

NCDs, Chronic Non-communicable Diseases; HRQoL, Health-related Quality of Life; PCA, Principal Component Analysis; KMO, Kaiser-Meyer-Olkin; WHO, World Health Organization; SES, Socioeconomic Status Index.

Data Sharing Statement

The datasets used and/or analyzed during the current study available from the corresponding author (Rui Deng) on reasonable request.

Ethics Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the ethics committee of the Kunming Medical University (NO. KMMU2021MEC095).

Consent to Participate

Informed consent was obtained from all individual participants included in the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically

reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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