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Socioeconomic and lifestyle determinants of prevalence of hypertension among the elderly in rural southwest China: a structural equation modeling approach

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Abstract

Background: This study examines the association between socioeconomic and lifestyle factors and the prevalence of hypertension among the elderly in rural southwest China.

Methods: A cross-sectional survey of 4,833 consenting adults aged ≥ 60 years in rural regions of Yunnan Province, China was conducted in 2017. Data on individual socioeconomic status, sleep quality, physical activity level, and family history of hypertension were collected with a standardized questionnaire. Blood pressure, fasting blood glucose, height, weight, and waist circumference were also measured. An individual socioeconomic position (SEP) index was constructed using principal component analysis. Structure equation modeling (SEM) was applied to analyze the association between socioeconomic and lifestyle factors and the prevalence of hypertension.

Results: The overall prevalence of hypertension was 50.6% in the study population. The following associated factors had statistically significant effect on hypertension: body composition, including measures of obesity and central obesity, had the greatest total effect on hypertension (0.21), followed by family history of hypertension (0.14), gender (0.08), sleep quality (-0.07), SEP (-0.06), physical inactivity (0.06), and diabetes (0.06). Body composition, SEP, and family history of hypertension had both direct and indirect effects on hypertension, whereas those of physical inactivity, diabetes, and sleep quality were directly associated with prevalence of hypertension. Gender was indirectly associated with prevalence of hypertension.

Conclusion: Individual SEP, body composition, physical inactivity, diabetes, and sleep quality critically influence the prevalence of hypertension. Future interventions to prevent and control hypertension should give increased attention to individuals with low SEP and should focus on controlling diabetes and obesity, increasing physical activity levels, and improving quality of sleep among older adults aged ≥ 60 years in rural southwest China.

Keywords: Hypertension, older adults, socioeconomic status, lifestyle, China

Background

Hypertension, also known as high or raised blood pressure, is a global public health problem. Worldwide, the prevalence of hypertension was 26.4% in 2000, and is predicted to increase to 29.2% by 2025 ^[1]. High systolic blood pressure accounted for 10.4 million deaths and 218 million DALYs globally in 2017 ^[2]. The prevalence of hypertension is higher in low- and middle-income countries than in high-income countries, especially among older adults aged ≥ 60 years^[3], and hypertension is the leading cause of stroke, coronary heart disease, heart failure, and kidney disease among older adults due to aging of the global population, low physical inactivity levels, and increased BMI ^[4].

China is the largest developing country in the world, with 1.39 billion people. The population is also aging, with those aged ≥ 60 years making up 15.5% of the population in 2014 ^[5], but projected to constitute 29.7% of the total population by 2050 ^[6]. The overall prevalence of hypertension in China is increasing; whereas prevalence among the adult population was 18% in 2002, it increased to 29.6% by 2010 ^[7]. Further, prevalence of hypertension increased from 60.1% to 65.2% between

2001 and 2010 among urban residents aged ≥ 60 years ^[8]. As the population ages and prevalence grows, China is facing an increasingly serious challenge to manage the economic cost of hypertension and its complications.

Most investigations of disease risk factors focus mainly on identifying the direct effect of the studied factors on disease. It is well known that individual educational level, household income, socioeconomic position (SEP), obesity, central obesity, family history of hypertension, diabetes, and physical inactivity have strong associations with the development of hypertension ^[9, 10]. However, hypertension is caused by the complex interplay of these various factors simultaneously, some with direct and some with indirect effects. Few studies have analyzed the indirect effect of all of these factors on hypertension and the interaction between the variables. Epidemiologists are increasingly interested in and able to explore all these factors concurrently as a network of multiple pathways leading to disease ^[11]. Specifically, structure equation modeling (SEM) offers a tool to measure both direct and indirect effects of observational and latent characteristics of observational variables on risk of diseases ^[12]. Previous studies have employed it to identify risk factors of pre-diabetes and pre-hypertension ^[11, 13].

Yunnan Province, an economically disadvantaged region in southwestern China, is home to 47.4 million people, including 6.1 million adults aged ≥ 60 years. Hypertension has become one of Yunnan's greatest public health challenges, imposing a considerable economic burden over the past several decades^[14]. Large urban-rural gaps in hypertension prevalence existed and deserved more attention of researchers^[15]. However, the literature focusing on SEP and lifestyle factors of hypertension in rural older adults aged ≥ 60 years in Yunnan is sparse, with prior epidemiological studies focusing on urban areas and overlooking rural communities. The present study aims to fill this knowledge gap.

Namely, the purpose of the present study was to use an SEM approach to test a hypothesized model of socioeconomic factors (gender, age, ethnicity, and SEP) and lifestyle factors (sleep quality, physical inactivity, obesity, central obesity, diabetes, and family history of hypertension) in terms of direct and indirect effects of prevalence of hypertension among adults aged ≥ 60 years in rural Yunnan Province.

Methods

Study area and population

We conducted a community-based cross-sectional survey in Yunnan Province. To ensure a representative study sample, we used a multistage stratified random sampling method. First, all 129 Yunnan counties were classified into three categories, advantaged economic status, normal economic status, and economically disadvantaged, according to per capita gross domestic product (GDP) based on the 2016 Yunnan Statistical Yearbook ^[16]. One county was then randomly selected from each category. Second, townships in each selected county were divided into two categories according to GDP, and one township was selected from each category, for a total of six townships. Third, three villages from each township were selected using probability proportional to size (PPS) method, for a total of 18 villages. Finally, individuals aged ≥ 60 years were selected from each village using a simple random sampling method with random number tables. Older adults with various mental diseases, malignant tumors and acute and chronic infectious diseases were excluded. A total of 5004 older adults aged ≥ 60 years were included in this study. Of these, after excluding 171 individuals with missing variables, 4833 participants were considered for the final analysis.

Data collection and measurement

Sixteen medical students from Kunming Medical University were selected as interviewers for data collection. All students participated in a training workshop before the commencement of the study to learn how to administer the questionnaire as well as how to measure height, weight, waist circumference, blood pressure (BP), and

fasting blood glucose (FBG).

Each study participant who gave informed consent was interviewed by one of these trained interviewers using a pretested and structured questionnaire to collect information on demographic characteristics, socioeconomic status, sleep quality, physical activity, and family history of hypertension.

BP, FBG, height, weight, and waist circumference were measured according to standard protocols. Following American Heart Association recommendations, BP was recorded in the sitting position in the right arm supported at the level of the heart using a sphygmomanometer after five minutes of rest ^[17]. Three BP measurements were taken at 5 minute intervals. The final recorded measurement was the average of these three BP readings.

FBG was measured using the ACCU-CHEK Perform Glucometer (Roche Diagnostics, Germany) by extracting a small drop of fingerstick blood after an overnight fast of at least 10 hours.

Height was measured in centimeters with an accuracy of 0.1 cm using a standard height-measuring ruler. Weight was measured in kilograms with an accuracy of 0.1 kg with a digital scale. The participants were asked to wear light clothes, stand in right position, take feet 30 cm apart and put arms aside the body. Waist circumference was measured in centimeters with an accuracy of 0.1 cm using a measuring tape at the level of midpoint between the lower edge of the 12th costal arch and the anterior superior iliac crest.

Definitions

Hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, use of anti-hypertension medication during the two weeks prior

to the study, and/or self-reports of a diagnosis of hypertension by a healthcare professional.

Diabetes was defined as $\text{FBG} \geq 7.0\text{mmol/l}$, when participants self-reported a diagnosis of diabetes by a healthcare professional, or when participants reported using anti-diabetes medication during the previous two weeks.

Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Obesity was defined as $\text{BMI} \geq 28 \text{ kg/m}^2$ for both men and women. Central obesity was defined as a waist circumference of $\geq 90 \text{ cm}$ for males and $\geq 80 \text{ cm}$ for females, following World Health Organization (WHO) recommendations for Asian adults ^[18].

Illiterate was defined as the inability to read or write a full sentence with understanding.

Sleep quality was assessed by the Pittsburgh Sleep Quality Index (PSQI). PSQI consists of 19 self-evaluation questions to assess quality of sleep. Seven factors are abstracted, including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction ^[19]. Each factor was scored on a 0-3 point scale for a total score of 0-21. High scores refer to worse sleep quality, with poor sleep quality defined as a score of 6 or greater.

Physical inactivity was measured by sitting time in daily life and activity intensity during household work, in accordance with WHO guidelines^[20]. Sitting time and activity intensity were used as continuous variables, and scored on a 1-3 point scale for a total score of 2-5. High scores refer to physical activity defined as a score of 3 or greater, with low scores refer to physical inactivity defined as a score of 2 or less. Specifically, physical inactivity was classified into two levels: physical inactivity referred to sitting time of ≥ 4 hours in a day and light activity as a result of household

work, whereas physical activity referred to sitting time of <4 hours in a day and engagement in moderate or vigorous activity during household work.

Household income, house made materials and toilet built were used as dichotomous variables, and scored on 1 or 2 points scale for a total scores of 3-6. High scores refer to good household assets defined as a scores of 5 or greater, while low scores refer to poor household assets defined as a scores of 4 or less. Poor household assets were defined as individuals with a annually household income of less than US\$945 and a house made from adobe or stone and without a toilet. Good household assets were defined as individuals with a household income of more than US\$945 and a house made from brick or concrete with a toilet. Good access to medical services was defined as living within a 30 minute walk to the nearest medical facility, while poor access to medical services was defined as living more than 30 minutes walking time to the nearest medical facility.

A positive family history of hypertension was defined as the presence of hypertension in at least 1 grandparent, parent, or sibling^[21].

Statistical analysis

A chi-squared test was used to compare categorical variables of socioeconomic factors(gender, age, ethnicity, education level, household assets and access to medical services) and lifestyle factors(sleep quality, physical inactivity, obesity, central obesity, diabetes, and family history of hypertension) in hypertensive participates. Principal component analysis (PCA) was conducted to derive SEP which based on education level, household assets and access to medical service. SEM analysis was used to analyze the relationship between SEP, lifestyle factors, and prevalence of hypertension. SPSS 22.0 was used for the descriptive analysis and chi-square test, whereas SEM analyses were conducted with AMOS22.0 and fitted by the Maximum Likelihood Estimation method. P-values of <0.05 were considered statistically significant.

In this study, SEM analyses were conducted in two stages. First, we constructed a hypothesized model which is based on the literature review of previous model proposed by Taherian et al^[22]. We constructed two latent variables, including SEP and body composition. SEP incorporated educational level, household assets, and access to medical services, whereas body composition was composed of obesity and central obesity. The basic model was shown in figure 1. Observed variables are represented by rectangles, whereas latent variables are represented by ellipses. Direct effects are depicted as a line with an arrow from a variable to other variables. In this model, socioeconomic characteristics—including SEP(educational level, household assets and access to medical service), age(in year), gender(female or male), ethnicity(Han majority and ethnicity minority), and family history of hypertension(yes or no)—were perceived as exogenous variables. Lifestyle factors—including body composition(obesity and central obesity), physical inactivity(sitting time in daily life and activity intensity during household work), sleep quality(good or poor), and diabetes(yes or no)—were considered endogenous variables which can be affected by both exogenous and other endogenous variables. Health outcomes were measured as dichotomous variables of hypertension (yes=1, no=0) in this model. We hypothesized 28 paths that directly or indirectly affected hypertension. These paths originated from 7 observed variables and 2 latent variables. Gender, age, ethnicity and family history of hypertension are determined at birth, but still impact on the prevalence of hypertension directly or indirectly through other variables. Second, we tested the significance of all exogenous variables and endogenous variables on hypertension and analyzed the direct and indirect effect of all variables on hypertension. The aim of this hypothesized model was to assess the modifiable factors such as body composition, physical inactivity, sleep quality and diabetes together with SEP that affected hypertension.

Modification indices were used to evaluated and selected appropriated paths for the best fitted model. We calculated Goodness-of-Fit indices, including root mean square

error of approximation (RMSEA), goodness-of-fit index(GFI), comparative fit index (CFI), Tacker-Lewis index (TLI), and weighted root mean square residual (WRMR), to evaluate the best fit model. Direct, indirect, and total effect were calculated and recorded. We have tested several paths and found a final model that fitted the hypothesis most appropriated. Non-significant paths were removed, specially age and ethnicity were eliminated because the paths were not significant($\alpha=0.05$) in this model.

Results

A total of 5000 individuals aged ≥ 60 years were involved in the survey. The response rate was 96.6% with 4833 consenting to participate. General characteristics of target participants are shown in Table 1. The older adults aged ≥ 60 years conducted the survey, including 2,198(45.5%) males and 2,635(54.5%) females. Han majority and ethnic minority participants constituted 83.3% and 16.7% of total population, respectively, whereas older adults aged ≥ 60 years with poor household assets and poor access to medical services accounted for 28.6% and 21.4%, respectively. The higher educational level(65.0%), physical inactivity(51.1%), poor sleep quality(46.7%), obesity(6.6%), central obesity(52.8%), diabetes(10.2%), and family history of hypertension(15.3%), were observed respectively among the study population.

Table 1 Characteristics of study participants

Variables	n	%	95% CI
Gender			
Male	2198	45.5	44.0 to 46.9
Female	2635	54.5	53.1 to 56.0
Age Group			
60-64 years	1326	27.4	26.1 to 28.7
65-69 years	1284	26.6	25.4 to 27.9
70-74 years	1047	21.7	20.4 to 22.8
≥ 75 years	1176	24.3	23.2 to 25.6
Ethnicity			
Han	4026	83.3	82.3 to 84.3
Minority	807	16.7	15.7 to 17.7

Educational level			
Illiterate	1690	35.0	33.7 to 36.4
Primary (grade 1-6) or higher	3143	65.0	63.6 to 66.3
Household assets			
Good	3453	71.4	70.1 to 72.7
Poor	1380	28.6	27.3 to 29.9
Access to medical service			
Good	3797	78.6	77.3 to 79.7
Poor	1036	21.4	20.3 to 22.7
Sleep quality			
Good	2574	53.3	51.7 to 54.6
Poor	2259	46.7	45.4 to 48.3
Physical inactivity			
Yes	2472	51.1	49.8 to 52.6
No	2361	48.9	47.4 to 50.2
Obesity			
Yes	321	6.6	5.9 to 7.4
No	4512	93.4	92.6 to 94.1
Central obesity			
Yes	2551	52.8	51.3 to 54.2
No	2282	47.2	45.8 to 48.7
Family history of hypertension			
Yes	738	15.3	14.2 to 16.3
No	4095	84.7	83.7 to 85.8
Diabetes			
Yes	494	10.2	9.3 to 11.2
No	4339	89.8	88.8 to 90.7
Total	4833	100.0	

Table 2 presents the prevalence of hypertension among rural adults in Yunnan Province aged ≥ 60 years by socioeconomic and lifestyle factors. The overall prevalence of hypertension was 50.6%. Older adults aged ≥ 60 years with poor household assets, poor access to medical services, poor sleep quality, physical inactivity, and family history of hypertension had higher prevalence of hypertension than their counterparts, otherwise older adults aged ≥ 60 years with obese, including central obesity, and diabetic older adults had higher prevalence of hypertension than their counterparts ($P < 0.01$).

Table 2 Prevalence of hypertension among rural adults aged ≥ 60 years by socioeconomic and lifestyle factors in Yunnan Province, China

Variables	n	%	95% CI	P Value
Gender				<i>0.001</i>
Male	1047	47.6	45.5 to 49.7	
Female	1400	53.1	51.2 to 54.9	
Age Group				<i>0.001</i>
60-64 years	591	44.6	42.0 to 47.3	
65-69 years	649	50.5	47.8 to 53.3	
70-74 years	562	53.7	50.9 to 56.7	
≥ 75 years	645	54.8	52.2 to 57.6	
Ethnicity				<i>0.015</i>
Han	2007	49.9	48.4 to 51.3	
Minority	440	54.5	51.1 to 57.8	
Educational level				<i>0.220</i>
Illiterate	876	51.8	49.4 to 54.3	
Primary (grade 1-6) or higher	1571	50.0	48.3 to 51.8	
Household assets				<i>0.004</i>
Good	1703	49.3	47.6 to 50.9	
Poor	744	53.9	51.2 to 56.6	
Access to medical service				<i>0.013</i>
Good	1887	49.7	48.1 to 51.2	
Poor	560	54.1	50.9 to 57.1	
Sleep quality				<i>0.001</i>
Good	1191	46.3	44.3 to 48.2	
Poor	1256	55.6	53.5 to 57.6	
Physical inactivity				<i>0.001</i>
Yes	1349	54.6	52.6 to 56.6	
No	1098	46.5	44.5 to 48.6	
Obesity				<i>0.001</i>
Yes	224	69.8	64.8 to 74.6	
No	2223	49.3	47.8 to 50.8	
Central obesity				<i>0.001</i>
Yes	1500	58.8	56.9 to 60.7	
No	947	41.5	39.5 to 43.5	
Family history of hypertension				<i>0.001</i>
Yes	501	67.9	64.7 to 71.1	
No	1946	47.5	46.0 to 49.2	
Diabetes				<i>0.001</i>
Yes	318	64.4	60.2 to 68.6	
No	2129	49.1	47.5 to 50.4	
Total	2447	50.6		

The result of PCA indicated satisfactory reliability, Kaiser-Meyer-Olkin (KMO)=0.529, and the Bartlett test of sphericity was statistically significant ($P<0.001$). The three variances associated with SEP accounted for 39.0% of total variances. As shown in Table 3, the final model reached the model fit indices which are generally considered to be a reasonable model fit to the data, including RMSEA, GFI, CFI, TLI, and WRMR.. The following changes were made to the basic model to create the final one. First, we dropped age and ethnicity from the basic model as the modification indices revealed the path was not statistically significant ($P\geq 0.05$). Second, we dropped the direct effect of gender on diabetes, and hypertension and of physical inactivity on body composition based on the fit of model according to the goodness-of-fit index. .

Table 3 Goodness-of-fit index of the structure equation modeling

Goodness-of-fit	Reference value	Value
root mean square error of approximation (RMSEA)	<0.05	0.024
coefficient of determination (GFI)	>0.90	0.995
comparative fit index (CFI)	>0.90	0.945
Tacker-Lewis index (TLI)	>0.90	0.927
weighted root mean square residual (WRMR)	<0.05	0.004

Figure 2 shows the final SEM model of associated factors of hypertension. Whereas gender (female=1, male=0) had a negative relationship with sleep quality (-0.14, $P<0.001$), it had a positive relationship with body composition (0.30, $P<0.001$) and physical inactivity (0.11, $P<0.001$). Higher socioeconomic status had a negative association with hypertension (-0.08, $P=0.001$) and a positive relationship with body composition (0.09, $P=0.008$). The effect of body composition was greater on hypertension (0.20, $P<0.001$) than diabetes (0.14, $P<0.001$). Family history of hypertension had similar effects on hypertension (0.12, $P<0.001$) and body composition (0.11, $P<0.001$). Diabetes (0.06, $P<0.001$) and physical inactivity (0.06, $P<0.001$) had the same positive relationship with hypertension, while sleep quality (-0.07, $P<0.001$) had a negative effect on hypertension.

Table 4 presents the direct, indirect, and total effect of the studied variables on hypertension. Overall, body composition had the greatest total effect on hypertension (0.21), followed by family history of hypertension (0.14), gender (0.08), sleep quality (-0.07), SEP (-0.06), physical inactivity (0.06), and diabetes (0.06). Figure 3 showed that gender solely had an indirect effect on hypertension through mediators, including physical inactivity, sleep quality, and body composition.

Table 4 Direct, indirect, and total effects of variables on hypertension

Variables	Direct	Indirect	Total
Family history of hypertension	0.12	0.02	0.14
Physical inactivity	0.06	No path	0.06
Diabetes	0.06	No path	0.06
SEP	-0.08	0.02	-0.06
Gender	No path	0.08	0.08
Sleep quality	-0.07	No path	-0.07
Body composition	0.20	0.01	0.21

Discussion

To our knowledge, this is the first study to use SEM to examine the direct and indirect effects of socioeconomic and lifestyle determinants on hypertension in China. The findings indicate that body composition, SEP, and family history of hypertension have both direct and indirect effects on hypertension, while physical inactivity, diabetes, and sleep quality are directly associated with hypertension and gender is indirectly associated with hypertension.

Our study indicated noticeably higher prevalence rates of physical inactivity and poor sleep quality among older adults aged ≥ 60 years in rural southwest China. Prevalence of physical inactivity in our participant population was also higher than the 27.5% globally^[20]. Further, prevalence of poor sleep quality was higher than that observed in previous studies in China ^[23]. These high prevalence rates may result from the demographic transition caused by economic development currently underway in China as well as lack of awareness of the impact of lifestyle choices on chronic

disease among older adults aged ≥ 60 years in rural Yunnan Province. Correspondingly, as these central determinants of blood pressure lead to a higher prevalence of hypertension among the studied population, hypertension prevalence was similarly with the reported prevalence rate of 44.6%-60.1% in China Hypertension Survey^[24], and coincident with the worldwide prevalence of 33-59% among age ranged from 40-79years^[25].

SEM was used as a powerful tools to construct a complex theoretical model which presented approaching reality. The study indicated that body composition was the most important risk factor that directly affected development of hypertension in our study. Further, the high prevalence of obesity and central obesity directly contributed to the occurrence of hypertension, consistent with WHO report^[3]. Body composition also indirectly affected hypertension via diabetes. This may be due to the alterations at hormonal, inflammatory, and endothelial levels which result from obesity and central obesity ^[26]. The findings suggest that, especially for older adults with diabetes, obesity and central obesity are key opportunity points for hypertension control.

The study established that high SEP was a protective factor which directly affected hypertension. This finding is inconsistent with studies conducted in Sudan^[27] and South Africa ^[28]. This may result from the fact that older adults with better SEP had better health awareness and more opportunities to prevent, diagnosis, treat, and manage hypertension in Yunnan Province compared with Sudan and South Africa. SEP also indirectly affected hypertension through body composition. Thus, the findings indicate that older adults with lower SEP need more effective prevention and intervention programs for hypertension prevention.

The present study also found that poor sleep quality had a direct effect on the prevalence of hypertension. The contribution of sleep quality to the development of hypertension has been established in previous research ^[29]. Poor sleep quality is common in older populations, and our results of high prevalence of poor sleep quality

were similar to a cross-section survey conducted in Iran ^[30]. Given this finding, improving sleep quality among Yunnan residents could have a positive effect on prevention of hypertension.

Physical inactivity was positively and directly associated with prevalence of hypertension in our study. This finding aligns with previous studies in China ^[31], Greece^[32], and the UK ^[33]. Our study suggested that increasing moderate and vigorous physical activity as well as reducing sitting time is important for the prevention of hypertension among rural older adults. Moreover, we found family history of hypertension also directly affected the prevalence of hypertension, a result consistent with previous research ^[34]. This study thus indicates that those with a family history of hypertension should have regular screenings for hypertension and undergo lifestyle interventions for hypertension prevention.

In our study, diabetes had a positive, direct effect on the prevalence of hypertension. In the basic model of our study, diabetes was also affected by gender, age, ethnicity, and body composition. Finally, age, gender, and ethnicity were eliminated from the model because the paths were not significant. This is consistent with previous research that found the prevalence of diabetes and hypertension was associated with similar risk factors ^[35]. This finding also suggests that maintaining proper body composition promotes hypertension and diabetes prevention.

Our study also showed that the effect of gender on hypertension was mediated by body composition, physical inactivity, and sleep quality. This was contrary to a previous study in China ^[36]. The precise reason for this discrepancy requires further exploration.

The following limitations of the present study should be noted. First, hemoglobin A1C was not measured and the diagnosis of diabetes was solely based on FBG tests or self-reported. This may underestimate the prevalence of diabetes among the study

population. Second, physical exercise records were participant-reported in the study questionnaire, which could introduce inaccuracies as they are subject to participant recall. Objective measures of physical activity should be taken in the future to strengthen the results of our analysis. Third, data on participants' diets, mental factors and lipid parameters were not included in the present study, and they are important factors in the development of hypertension. Finally, the findings were based on a study of three counties, which could limit the ability to generalize the results to the entire province.

In sum, based on the findings that SEP, body composition, physical inactivity, diabetes, and sleep quality have significant influences on prevalence of hypertension, future interventions to prevent and control hypertension among rural Chinese older adults should focus on those with low SEP while interventions to control diabetes should focus on body composition and increasing physical activity levels and improving quality of sleep.

Abbreviations

SEP:Socioeconomic position; SEM:Structure equation modeling; GDP:Gross domestic product; PPS:Probability proportional to size; BP:Blood pressure; FBG:fasting blood glucose; BMI:Body mass index ; WHO:World Health Organization; PSQI:Pittsburgh Sleep Quality Index; PCA:Principal component analysis; RMSEA:Root mean square error of approximation; GFI:goodness-of-fit index; CFI:Comparative fit index, TLI:Tacker-Lewis index ; WRMR:weighted root mean square residual (WRMR); KMO:Kaiser-Meyer-Olkin.

Ethical approval and consent to participate

This study was approved by the Ethics Committee of Kunming Medical University prior to the commencement of research. Written informed consent was obtained from the participants.

Consent for publication

Not applicable.

Competing interests

None declared.

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Availability of data and material

The datasets used and/or analysed during the current study is available from the corresponding author on reasonable request.

Contributors

CL was involved in the studies design. WGY, FLM, CWL, LYN and SJR collected the data. LX performed the statistical analysis. LX and ARG wrote the paper. All authors reviewed and approved the final version of the paper.

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Figure 1 Basic Structural Equation Modeling model of our study

Figure 2 Final Structural Equation Modeling model of associated factors of hypertension among rural adults aged ≥ 60 years in Yunnan Province, China

Figure 3 Indirect effects of associated factors of hypertension based on Structural Equation Modeling model among rural adults aged ≥ 60 years in Yunnan Province, China

Figures

Figure 1
Basic Structural Equation Modeling model of our study

Figure 2

Final Structural Equation Modeling model of associated factors of hypertension among rural adults aged ≥60 years in Yunnan Province, China

Figure 3

Indirect effects of associated factors of hypertension based on Structural Equation Modeling model among rural adults aged ≥ 60 years in Yunnan Province, China