Research Article
Volume 10:2, 2022

Journal of Neurological Disorders

Research Article

Open Access

Sun, Sleep, and Satisfaction: Mediating Role of Depression and Source of Endogeneity among Middle-Aged and Older Adults in China

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Abstract

Purpose: To examine: (i) depression as a mediator in effects of sleep duration and quality on life satisfaction (LS), (ii) source of endogeneity in self-reported data on sleep, and (iii) predictive power of sleep duration and quality on LS.

Methods: Panel data of 22,674 observations from the China Health and Retirement Longitudinal Survey (2015 and 2018) was used. Sleep was assessed with self-reported duration and quality. Depression was measured by the 10-question version of the Center for Epidemiological Survey Depression. LS was rated by five scales. Fixed effects ordered logit models were used to determine the effect of sleep duration and quality on life satisfaction and the mediating role of depression. We used instrumental variable strategy to explore the source of endogeneity. Information value and random forest model were used to examine the predictive power of sleep measures duration and quality.

Results: Sleep duration and quality were found to improve life satisfaction via lower depression score. Non-agricultural employed population with urban hukou (household registration) accounted for the endogeneity, but the instrument variable sunset failed the weak instrument test. Sleep measures were found to predict life satisfaction, especially for the lower life satisfaction groups.

Conclusion: Our findings suggest the importance of sleep and the study of the associations between solar cues, social schedules, and sleep. Policy makers of social care of older adults might consider sleep intervention among this population.

Keywords: life satisfaction • Sleep • Sunset time • Mediation effect • Endogeneity

Introduction

Subjective well-being (SWB) is an important measure of quality of life. Compared with traditional economic indicators (for example, income, employment), it can better reflect subjective quality of life and is sensitive to social conditions, and thus increasingly favored by researchers [1].

The cognitive dimension of SWB, life satisfaction (LS), represents an individual's global evaluation of life [2]. LS itself is one of the pursuits of a happier life. Higher LS is positively associated with life events such as marriage and child birth, and negatively associated with job disruptions and divorce [3]. In Chinese adults, LS reduces mortality risk, mediates the protective effect of security on social trust, and is the only dimension of SWB that mediating the positive effect of social cohesion on physical health by improving it [4-6].

Sleep proves to be one of the effective interventions of SWB [7,8]. Short sleep duration and poor sleep quality are inversely related with life satisfaction, partially mediated by depression in elderly Chinese [9]. Sleep quality and variability of sleep duration, instead of sleep duration, is strongly associated with life satisfaction in Norwegian university students [10]. Moreover, growing prevalence of sleep deprivation may pose a threat to population health and bring significant burden to the healthcare system [11]. Therefore, it is meaningful to examine effects of sleep duration/quality on LS in middle aged and older adults.

On the other hand, the mediating role of depression might be explained by negative associations with sleep and LS. Depression can increase the risk of frequent sleep disruption and may be correlated with compromised quality of life and neuro-psychological functions among older adults [12-16].

However, these findings are mostly based on subjects in Europe and North America and may not be applicable to people in Asia. There is regional heterogeneity in associations between socioeconomic indicators and LS, sleep duration and LS. For example, one study in Asia found that the effects of gender and age on LS are insignificant except in Central and West Asia [17,18]. The best sleep duration was found to be around 8 hours in Germans for maximal LS, but the optimal sleep duration for LS might differ in Asian populations [17,19].

Sleep is usually self-reported in social surveys [17]. Such data, in contrast to objective sleep in a daily setting, have different psychological and biological correlates that could lead to inconsistent conclusions about sleep and well-being [20]. Objectively-measured sleep is related with executive functioning broadly and self-reported sleep with conceptual flexibility in particular [21]. Fixed-effects models may help eliminate the self-reported bias, but determining source of endogeneity requires instrumental variable, an econometric model. Sunset time has proved to be a candidate instrumental variable relevant among urban non-agricultural employed population [22].

Previous studies, if not cross-sectional, mostly did not control for individual fixed effects and self-reported bias that are detrimental for the elucidation of the causality between sleep and LS. Therefore, we conducted this fixed effects longitudinal analysis and used objectively measured data, sunset time, as the instrument variable.

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Received: 02-February-2022, **Manuscript No.** jnd-22-53262; **Editor assigned:** 04-February-2022, **PreQC No.** jnd-22-53262 **(PQ); Reviewed:** 18-February-2022, **QC No** jnd-22-53262; **Revised:** 23-February-2022, **Manuscript No.** jnd-22-53262 **(R); Published:** 02-March-2022, **DOI:**10.4172/2329-6895.10.2.265

Using the nationally representative data on sleep and LS of middle aged and older adults and the sunset time of the subjects' geographical location in China, this study aims to explore the effects of sleep duration/quality on life satisfaction, the possible mediating effect of depression, and the predictive power of sleep measures for LS.

Based on the literature, we proposed the following hypotheses:

H1. Duration and quality of sleep have a positive effect on LS.

H2. Depression mediates the effect of sleep on LS. Specifically, depression is negatively associated with sleep duration/quality and LS.

H3. Urban non-agricultural employed population accounts for endogeneity.

H4. Duration and quality of sleep predict LS, especially in identifying poor LS.

Methods

Data

Data from the third (2015) and fourth (2018) waves of the China Health and Retirement Longitudinal Survey (CHARLS) were used. CHARLS collected the data of demographics, economic and health status, family conditions, and social conditions at the community/city level of the participants. The baseline survey was conducted in 450 communities from 150 counties/districts in 28 provinces. For details of the survey, see the Survey website (http://charls.pku.edu.cn/) and relevant literature [23-25]. After deleting 1,273 observations with missing or extreme values of sleep duration in the two waves (37,620 observations in total), 7,376 observations for subjects aged outside of the 45-70 years range, 151 observations from Xinjiang (where a time different from other areas in China was used) and 6,146 observations inapplicable (due to incompleteness of data) to longitudinal analysis, 22,674 observations remained for details of subjects, see (Tables 1 and 2).

Table 1. Descriptive statistics of continuous variables.

	2015			2018		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Life Satisfaction	3.39	0.77	11,337	3.24	0.79	11,337
Sleep Hours	6.42	1.72	11,337	6.21	1.74	11,337
Napping Time	38.10	44.04	11,337	38.66	43.75	11,337
Sleep Quality	2.02	1.19	11,337	1.88	1.21	11,224
Schooling Years	5.76	4.21	11,337	5.64	4.17	11,337
PCE (logarithm)	9.73	0.94	11,337	10.03	0.91	11,326
Age	55.84	6.51	11,337	58.72	6.51	11,337
CESD	7.57	6.18	11,337	8.28	6.39	11,337
GDP (logarithm)	5.26	0.89	11,337	5.44	0.92	11,337
Population (logarithm)	8.51	0.58	11,337	8.52	0.59	11,337

Note: SD=standard deviation; PCE=per capita expenditure at household level; CESD=Center for Epidemiological Survey - Depression; GDP=gross domestic product at city level

Table 2. Descriptive statistics of categorical variables.

	2015		2018	
	%	**N**	**%**	**N**
Urban Hukou	19.3	2,191	20.3	2,301
Female	51.8	5,870	51.7	5,862
Married	92.5	10,483	90.6	10,269
Social Participation	57.3	6,499	57.3	6,499
Physical Disability	23.3	2,555	23.9	2,696
Employment				
Non-agricultural Employed	28.1	3,122	23.6	2,658
Self-employed	12.5	1,394	9.2	1,031
Farmer	40.0	4,446	38.9	4,373
No work	19.3	2,148	28.3	3,185
Terrain				
Plain	40.9	4,627	40.9	4,627
Hills	30.4	3,434	30.4	3,434
Mountainous Region	21.0	2,379	21.0	2,379

Plateau	4.5	514	4.5	514
Basin	3.1	351	3.1	351
Urbanicity type				
City	12.1	1,376	12.1	1,376
Combined Urban-Rural Areas	3.4	387	3.4	387
Town Center Areas	13.2	1,500	13.2	1,500
Combined Town-Township Areas	8.9	1,008	8.9	1,008
Special District	0.7	79	0.7	79
Township Center Areas	3.9	442	3.9	442
Village	57.7	6,545	57.7	6,545
Region				
Beijing-Tianjin-Hebei-Shandong	14.9	1,622	15.1	1,711
Yangtze River Delta	9.3	1,020	9.0	1,020
SouthEast	7.8	8,477	7.5	8,477
Central	29.9	3,264	28.8	3,264
SouthWest	21.2	2,320	23.4	2,649
NorthWest	9.2	1,002	8.8	1,002
NorthEast	7.7	844	7.4	844
Note: SD=standard deviation				

Life satisfaction

LS were collected by asking "Please think about your life as a whole. How satisfied are you with it?" and the response could be completely satisfied (LS=5), very satisfied, somewhat satisfied, not very satisfied, or not at all satisfied (LS=1).

Sleep

Respondents were asked about the hours of their actual sleep for one night (self-reported night time sleep duration) and duration of nap after lunch (self-reported afternoon napping time) during the past month, with truncation at 1% and 99% percentiles to eliminate outliers. Total sleep duration was obtained by summing up self-reported night time sleep duration and afternoon napping time. The subjects were asked to indicate the frequency for restlessness during sleep on a 4 item scale. If it happens most or all of the time, they got 4 for sleep quality (very poor). If it never happens, they got 1 for sleep quality (very good).

Depression

Depression was measured by the 10 question version of the Center for Epidemiological Survey Depression (CESD) [24]. The Cronbach's alpha of the CESD-10 was 0.791. CESD scores range from 0 to 30, with higher score indicating more severe depressive symptoms.

Sunset time

Sunset time was computed with the calculator provided by US National Oceanic and Atmospheric Administration. Annual average sunset time and month specific sunset time for each city were recoded so that the integer digit represented the hour, and decimal digits the minutes divided by one hour. Hence, its coefficient represents the marginal effect of the effect of one additional hour.

Covariates

Demographic covariates included age, gender, hukou, marital status (married or not), employment (non-agricultural employed, self-employed, agricultural, unemployed), years of schooling, households' per capita expenditure (PCE), social participation (yes or no for social activities in the past month), and physical disability. PCE was imputed with the mean value of PCE by province, hukou, and gender. Physical disability was quantified by having difficulty with activities of daily living (ADL) or instrumental activities of daily living (IADL). Community level covariates were terrain and urbanicity type; city level covariates were GDP and population. Region by economic development level was also used as a covariate.

Statistical analysis

To obtain the effect of sleep duration and quality on LS and mediation effect of depression in a stepwise way, we employed the Stata command feologit, a user developed command for fixed effects ordered logit model [26]. We computed direct and indirect effect of depression with bootstrap method on pooled data. Nonlinear relationships and heterogeneity were examined with feologit. For longitudinal analysis, time invariant controls were dropped, such as gender and control variables at community and higher levels. All standard errors were clustered at the city level.

To further determine the source of endogeneity, we used instrumental variable ordered probit model (IV-oprobit) with the Stata command cmp and annual average sunset time as the instrument of sleep by hukou and employment [22,27-29]. Causal mediation analysis was conducted for employed population with urban hukou, using average sunset time for a pooled baseline model and month specific sunset time for a fixed effects model exploring seasonal variations.

Finally, we used information value (binary dependent variable) and random forest (ordered dependent variable) for predictive power of sleep measures on life satisfaction with R × 64 4.0.3. Information value considers each variable's independent contribution to the outcome and could be used to compare the strength of continuous and categorical variables without creating dummy variables [30]. An information value great than 0.3 suggests strong predictive power by rule of thumb [31]. Because categorical variables and continuous variables coexist, we computed importance ranking by mean decrease in accuracy criterion for random forest model [32].

Results

Mediation, non-linear relationship, and heterogeneity analysis

(Table 3) shows effect of sleep duration and quality on LS and the mediating role of depression with fixed effects model. Effect of sleep hours on LS (B=0.057, SE=0.018, p<0.01) is insignificant (B=0.024, SE=0.018, p>0.05) after adding the mediator CESD (B=-0.081, SE=0.005, p<0.001) negatively associated with sleep hours (B=-0.682, SE=0.030, p<0.001). Significance of Effect of total sleep duration on LS (B=0.062, SE=0.015, p<0.001) decreases (B=0.032, SE=0.015, p<0.05) after adding the mediator CESD (B=-0.081, SE=0.005, p<0.001) negatively associated with total sleep duration (B=-0.597, SE=0.027, p<0.001). Effect of sleep quality on LS (B=0.153, SE=0.027, p<0.001) is insignificant (B=-0.049, SE=0.027, p>0.05) after adding the mediator CESD (B=-0.091, SE=0.005, p<0.001) negatively associated with sleep quality (B=-2.478, SE=0.044, p<0.001).

(Table 4) demonstrates mediation effect of depression in a pooled analysis. The indirect effect of sleep hours on LS is 0.032 (SE=0.001, p<0.001), while the direct effect is 0.012 (SE=0.003, p<0.001). For total sleep duration, indirect effect is 0.028 (SE=0.001, p<0.001) and the direct effect is 0.012 (SE=0.015, p<0.001). For sleep quality, indirect effect LS is 0.119 (SE=0.003, p<0.001) and direct effect is -0.018 (SE=0.005, p<0.001). Confidence interval of bias corrected bootstrapping (replications set at 5,000) for the above effects does not include zero. Therefore, the conducive effect of sleep hours, total sleep duration, and sleep quality on LS mediated by depression is 72.7%, 65.1%, 117.8%, respectively.

Table 3. Sleep measures, depression, and life satisfaction (fixed-effects).

	LS	CESD	LS	LS	CESD	LS	LS	CESD	LS
Sleep Hours	0.057**	-0.682***	0.024						
	(0.018	(0.030)	(0.018)						
Total Sleep Duration				0.062***	-0.597***	0.032*			
				(0.015)	(0.027)	(0.015)			
Sleep Quality							0.153***	-2.478***	-0.049
							(0.027)	(0.044)	(0.027)
CESD			-0.081***			-0.081***			-0.091***
			(0.005)			(0.005)			(0.005)
N	12,718	22,211	12,718	12,718	22,211	12,718	12,532	22,074	12,532
Pseudo R Squared	0.059		0.102	0.060		0.103	0.063		0.105

Note: Standard errors in parentheses, clustered at city level; LS=life satisfaction; CESD=Center for Epidemiological Survey - Depression. Controls include hukou, marital status, years of Note: Standard errors in parentheses, clustered at city level; LS=life satisfaction; CESD=Center for Epidemiological Survey - Depression. Controls include hukou, marital status, years of schooling, expenditure per capita within households, age and age squared, physical disability, social participation, GDP and population at city level, and interview time. *p<0.05, **p<0.01, ***p<0.001

Supplementary Table 1 displays nonlinear relationship by adding squared terms of sleep hours and total sleep duration. No significant quadratic relationship for sleep hours (B=-0.012, SE=0.006, p>0.05) or total sleep duration (B=-0.003, SE=0.005, p>0.05) was found.

Supplementary Table 2 presents gender and age heterogeneity. While no gender based difference was detected, effects of sleep hours (B=0.093, SE=0.032, p<0.01), total sleep duration (B=0.092, SE=0.030, p<0.01), and sleep quality (B=0.205, SE=0.051, p<0.001) are the most significant among people aged 53-61 years. Supplementary Table 3 presents educational heterogeneity. Effects of sleep hours (B=0.143, SE=0.046, p<0.01) and total

Table 4. Mediating effect of depression (pooled)

	Point Estimate	Product of Coefficient		Bootstrapping	
		SE	Z	Lower	Upper
Sleep Hours					
Indirect	0.032***	0.001	25.760	0.030	0.035
Direct	0.012***	0.003	4.004	0.006	0.018
Total Sleep Duration					
Indirect	0.028***	0.001	24.987	0.025	0.030
Direct	0.015***	0.003	5.590	0.010	0.020
Sleep Quality					
Indirect	0.119***	0.003	36.997	0.112	0.125

Direct	-0.018***	0.005	-3.744	-0.028	-0.009
Note: SE=standard error; bias-corrected (BC) bootstrap confidence interval; 5000 bootstrap replications, ***p<0.01					

sleep duration (B=0.140, SE=0.039, p<0.001) are most significant among those only completed primary school, while effect of sleep quality (B=0.192, SE=0.060, p<0.01) is the most significant among the illiterate population.

Instrumental variable strategy and source of endogeneity

(Tables 5 and 6) present endogeneity among non-agricultural employed, and self-employed population respectively. Endogeneity is evident only among non-agricultural employed population with urban hukou (sleep hours, atanhrho12=-1.530, SE=0.757, p<0.05; total sleep duration, atanhrho=-1.848, SE=0.915, p<0.05) and sleep measures significantly impact LS (sleep hours, B=0.708, SE=0.071, p<0.001; total sleep duration, B=0.642, SE=0.040, p<0.001), but the effect of sunset is insignificant (p>0.5). Instead, only among self-employed population with urban hukou, coefficients of sunset (sleep hours, B=1.217, SE=0.290, p<0.001; total sleep duration, B=1.155, SE=0.296, p<0.001) passed the weak instrument test (sleep hours, Z=4.19, F=17.6>10; total sleep duration, Z=3.91, F=15.3>10). Among the agricultural and the unemployed population Supplementary Tables 4 and 5, although no endogeneity or relevant instrument was discovered, sleep duration significantly impacts rural population (farmer, B=0.443, SE=0.166, p<0.01; no work, B=-0.507, SE=0.093, p<0.001). Supplementary Figures 1-8 portray binned scatter plots of sleep duration and sunset after controlling for employment, hukou, and survey wave. By observation, the direction of correlation between sleep hours and sunset changed for non-agricultural employed population (by survey wave), self-employed and farmer population (by hukou). Supplementary Tables 6 and 7 further investigate mediation effects with instrumental variable, but no significant effect was found (p>0.05).

Predictive power

(Table 7) summarizes predictions by sleep measures. LS levels from the first column are strongly distinguished from those in the second column, and the third column gives the number of strong predictors. By observation, sleep measures differentiated LS level 1 and 2, representing poor life satisfaction, from good life satisfaction. Detailed information values on all LS combinations are presented in Supplementary Table 8. Supplementary Table 9 shows random forest ranking of predictive power for all variables. Depression, city level GDP, and years of schooling ranked high, followed by city level population, sleep quality, and nighttime sleep duration.

Table 5. Endogeneity among Non-agricultural employed population (by hukou)

	Sleep Hours		Total Sleep Duration	
	Rural	**Urban**	**Rural**	**Urban**
LS				
Sleep Measures	0.121	0.708***	-0.405	0.642***
	(0.103)	(0.071)	(0.663)	(0.040)
Sleep Measures				
sunset	-0.030	-0.239	0.070	-0.196
	(0.152)	(0.193)	(0.192)	(0.209)
constant	14.737***	13.139*	12.888**	13.438*
	(3.372)	(5.390)	(4.217)	(6.150)
lnsigma	0.435***	0.314***	0.559***	0.438***
	(0.013)	(0.031)	(0.014)	(0.029)
atanhrho12	-0.108	-1.530*	1.012	-1.848*
	(0.160)	(0.757)	(2.539)	(0.915)
N	4,275	1,185	4,275	1,185
Note: Standard errors in parentheses, clustered at city level; LS=life satisfaction. Controls include hukou, gender, marital status, years of schooling, expenditure per capita within households, age and age squared, physical disability, social participation, terrain and urbanicity type at community level, GDP and population at city level, region, and interview time. *p<0.05, **p<0.01, ***p<0.001				

Table 6. Endogeneity among self-employed population (by hukou)

	Sleep Hours		Total Sleep Duration	
	Rural	**Urban**	**Rural**	**Urban**
LS				
Sleep Measures	0.525	-0.096	0.170	-0.100
	(0.642)	(0.194)	(0.635)	(0.196)
Sleep Measures				
sunset	-0.044	1.217***	-0.203	1.155***
	(0.204)	(0.290)	(0.306)	(0.296)
constant	11.694*	-8.596	14.962*	-5.056
	(5.752)	(7.940)	(7.340)	(8.231)

lnsigma	0.430***	0.379***	0.531***	0.505***
	(0.018)	(0.034)	(0.018)	(0.035)
atanhrho12	-0.987	0.343	-0.241	0.396
	(2.536)	(0.294)	(1.165)	(0.344)
Note: Standard errors in parentheses, clustered at city level; LS=life satisfaction. Controls include hukou, gender, marital status, years of schooling, expenditure per capita within households, age and age squared, physical disability, social participation, terrain and urbanicity type at community level, GDP and population at city level, region, and interview time. *p<0.05, **p<0.01, ***p<0.001.				

Table 7. Predictive power of sleep measures as information value.

Differentiated LS Levels		# of Strong Indicators
1	3	3
1	4	4
1	5	5
2	4	1
2	5	2
1	2, 3	3
1	2, 4	3
2	1, 4	1
1, 2	4	2
1	2, 5	2
1, 2	5	2
1	3, 4	3
1	3, 5	3
1	4, 5	4
2	4, 5	1
1	2, 3, 4	3
1, 2	3, 4	1
1	2, 3, 5	3
1	2, 4, 5	3
2	1, 4, 5	1
1, 2	4, 5	2
1	3, 4, 5	3
2	3, 4, 5	1
1	2, 3, 4, 5	3
1, 2	3, 4, 5	1
Note: LS=life satisfaction; information value >0.3 considered strong indicators by rule of thumb; the first two columns representing groups of life satisfaction levels able to be strongly predicted		

Discussion

Using the 2015 and 2018 wave data of CHARLS, we found the protective effect of sleep duration and sleep quality on LS, largely mediated by depression. Specifically, good sleep promotes mental health, which in turn contributes to LS. The source of endogeneity with self-reported sleep measures is non-agricultural employed population with urban hukou. Poor LS can be predicted by self-reported sleep measures.

Sleep, life satisfaction and depression as a mediator

After controlling individual and time fixed effects, we found positive effects of sleep hours, total sleep duration, and sleep quality on LS. H1 was therefore supported. This is consistent with previous research which report that better sleep is associated with higher level of LS and may constitute part of LS intervention program [7,10,19,33]. Nonlinear relationship was found to be insignificant in the study, inconsistent with the U shaped correlation reported in cross-sectional literature [9,34,35]. Respondents aged 53-61 years old with primary school education mainly contributed to the effect of sleep duration, while those illiterate accounted for the effect of sleep quality most.

Depression was found to mediate the effects of sleep hours and sleep quality on LS, while partially mediating the effect of total sleep duration; depression was negatively associated with sleep measures and LS. H2 was therefore supported. This finding is consistent with the cross sectional literature on the mediating role of depression, but our longitudinal analysis demonstrates that effects of sleep hours and sleep quality are fully mediated by depression [9]. Although one study confirmed sleep quality as outcome or mediator of the association between depression and LS, the cross sectional design could not determine the direction of association, which might also explain why sleep quality became negatively associated with LS in our pooled analysis of mediation effects [14,36]. While the mediation effect may be explained by sleep caused daytime tiredness and bidirectional relationship between poor sleep and lower LS, depression displayed full mediation in terms of sleep hours and sleep quality because our longitudinal model eliminated individual and time fixed effects [33,37-39]. As for total sleep duration, partial mediation was detected, possibly due to its complex correlation with other factors and complicated reasons for napping, which goes beyond the focus of our study [40-43].

Sunset and source of endogeneity

Endogeneity was found among non-agricultural employed population with urban hukou. H3 was therefore supported. This is consistent with the hypothesis in the literature [22,28,29]. Human bodies are inclined to sleep according to the environment because of the circadian rhythms, and later sunset time could lead to later darkness and thus postponed bedtime [44-46]. Employed people living in urban areas are faced with rigid social schedules, thus those with later sunset time may not be able to compensate for later bedtime by waking up later in the mornings. This gap between solar cues and social schedules means that a later sunset can have important effects on sleep duration [22]. Nevertheless, relevance of sunset time with sleep failed the weak instrument test, except for self-employed population with urban hukou. Supplementary figures supported the explanation that association of sunset time with sleep duration could be explained by covariates. After all, sunset time used in the literature barely passed weak instrument test [22]. The positive correlation found among urban self-employed population might not attribute to occupations responding to solar cues nor can social schedule, meaning these observations of working age subjects freely plan their daily schedule. Among farmer and those unemployed, sleep duration is significantly associated with rural Hukou despite no endogeneity or relevant instrument. One possible explanation is that they mainly respond to solar cues. Still, to our best knowledge, no study has covered associations between solar cues, social schedule, and sleep, except for the outcomes of rigid social schedule against solar cues [22].

Sleep predicting poor life satisfaction

Sleep duration/quality strongly predicted poor LS, ranking after CESD, city level indicators, and education. H4 was therefore supported. Previous studies focused on traditional indicators of objective and perceived socioeconomic status, health, mental well-being, and other conventional demographics [32,47]. Our findings revealed depression as one major predictor, but also highlighted the significance of broader indicators, such

as city level economic development. Moreover, sleep was found to be a useful predictor though neglected.

Limitations and Conclusion

There are several limitations that need to be acknowledged. First, sunset time were collected at city level, as we could not access data at community level, which might explain the weak relevance of the instrument variable. Second, although we determine the source of endogeneity as non-agricultural employed population with urban hukou, it remains unclear why other population demonstrated significant correlations with sunset under some circumstances. Relations between solar cues, social schedule, and sleep are needs further examination. Third, a considerable number of respondents reported both agricultural and non-agricultural occupations (4,383 of the total 5,780 non-agricultural employed participants also reported occupations as farmers), while we focused on main occupation. Future studies may consider a more specific classification of employment and the interaction between main occupation and other occupations.

Reliable findings on the relationship between sleep and LS require handling of the prevalent self-reported sleep measures in social surveys. In the current study, we confirmed the effect of sleep on life satisfaction with fixed effects model, which is mediated by depression and urban non-agricultural employed population as the source of endogeneity by instrumental variables. Researchers need to caution the differences between objectively measured and self-reported sleep measures. Although the predictive power of sleep measures did not rank high, they are useful in predicting poor life satisfaction. Policy makers may consider campaigns to promote healthy sleep habits and protection of mental health, while detecting the vulnerable population by sleep screening programs.

Acknowledgments

We thank the China Health and Retirement Longitudinal Study (CHARLS) for collecting data and Peking University School of Health Humanities for financing this study.

Financial Disclosure

This study was supported by Peking University School of Health Humanities as part of a program aimed at promoting original research for undergraduates [Dachuang-6 2020.10.20 http://shh.bjmu.edu.cn/tzgg2/215898.htm]. The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Non-financial Disclosure: none.

Conflicts of Interest

The authors declare that there is no conflict of interest with any financial organizations regarding the materials reported in this manuscript.

Availability of Data and Material

Data and related materials are available at official website of the China Health and Retirement Longitudinal Study (CHARLS): http://charls.pku.edu.cn/.

Code Availability

Stata/SE 16.0 and R × 64 4.0.3 were employed for data analysis.

Ethics Approval and Consent to Participate

This study used the data from the China Health and Retirement Longitudinal Study (CHARLS), which has obtained the ethics approval and subjects' consent to participate. Ethical approval for all CHARLS waves was granted from the Institutional Review Board at Peking University. The IRB approval number for the main household survey, including anthropometrics, is IRB00001052-11015; the IRB approval number for biomarker collection was IRB00001052-11014. We consulted the ethics committee office at Peking University and were informed that no ethical review was required since we used a public database for extracting our data and no personal information was revealed in the article. Therefore, we ask for waiving of the ethics approval and consent to participate.

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How to cite this article: Xiao Han and Jun Li."Sun, Sleep, and Satisfaction: Mediating Role of Depression and Source of Endogeneity among Middle-Aged and Older Adults in China." *J Neurol Disord10* (2022);265