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Neighborhood Built Environment and Self-Rated Health among Community-Dwelling Adults: The Mediating Role of Sleep Quality and the Moderating Role of Socioeconomic Status

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Abstract

Background: Built environments are recognized as essential factors influencing health outcomes among older adults. However, the extent to which such environments can further enhance health outcomes by promoting sleep quality remains unclear. This study explored whether sleep quality mediates the relationship between neighborhood-built environment and self-rated health among community-dwelling adults in Sichuan, China, and examined the conditional effects of socioeconomic status (SES) and residency.

Methods: A cross-sectional survey was conducted among 422 residents in Gaoping District, Nanchong. Moderated mediation analysis was applied using regression-based models to examine direct, indirect, and conditional pathways.

Results: Analysis revealed a negative correlation between the built environment and sleep quality ($p < 0.001$). Sleep quality serves as a significant mediator in the relationship between the built environment and self-rated health across all measured dimensions. The aesthetics and traffic safety dimension exhibited the strongest overall total effect (β=0.372, P<0.05) and direct effect (β=0.270, P<0.05). The analysis confirmed that this mediation is highly conditional: the strongest indirect effect was found among urban residents with high socioeconomic status (β=0.219, P<0.05), whereas the pathway was non-significant for rural residents with low socioeconomic status. Furthermore, the impact of poor sleep on health was significantly strongest in the high socioeconomic status group (β=-0.411, P<0.05).

Conclusion: Improving the built environment, particularly the aesthetics and traffic safety, contributes to enhancing adults' health outcomes by promoting better sleep quality. Interventions may yield the greatest benefits for urban populations with higher socioeconomic status.

Keywords: Neighborhood Built Environment, Self-Rated Health, Sleep Quality, Socioeconomic Status

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1. Introduction

Research indicates that supportive community environments enhance population health by reducing environmental hazards.(1) Active elderly people have better sleep quality than inactive elderly people(2). In both urban and rural areas, people who are more physically active have better sleep quality(1,3). Improving the level of physical activity can be one of the best options to increase the quality of sleep and the health of the elderly(4). Nonetheless, the extent to which these environments can improve health outcomes by promoting proactive health behaviors and enhancing physiological recovery, particularly sleep quality, remains ambiguous(5,6). While the established protective role of the environment is well-documented, its capacity to enhance well-being through specific behavioral and biological pathways necessitates further investigation(7).

Self-rated health (SRH) is a widely used global indicator that reflects individuals' overall perceptions of their physical, psychological, and social well-being(8,9). It has been consistently shown to predict morbidity, functional decline, and mortality across various populations (10). Despite notable advancements in healthcare and living standards, the prevalence of fair or poor SRH among middle-aged and older adults has been widely recorded (11). Identifying its determinants of SRH is thus acknowledged as a crucial step in tackling the health issues of ageing populations.

An increasing number of studies have emphasized the impact of the neighborhood-built environment on residents' health and well-being (12,13). The built environment, encompassing living convenience, road and street conditions, aesthetics and traffic safety, and public security, influences opportunities for physical activity, social interaction, and psychological comfort (14). Supportive neighborhoods can improve health by promoting mobility, reducing stressors, and promoting a sense of safety, whereas unsafe or inadequately maintained environments may lead to health decline and impaired sleep quality (8,14). While many studies have established a connection between neighborhood environments and objective health outcomes, research linking environmental characteristics to subjective health perceptions is still relatively scarce (15). The mediating role of sleep quality, encompassing physiological recovery and environmental comfort, remains insufficiently examined in community-based populations.

China is experiencing rapid population ageing, with Sichuan Province being one of the regions most impacted by this demographic transition(16–18). The Seventh National Population Census (2020) indicates that Nanchong City has a permanent population of approximately 5.6 million, with 26% of individuals aged 60 years and older, surpassing the national average(19,20). Gaoping District, as a typical urban area of Nanchong, represents medium-sized inland cities characterized by high residential density, limited community resources, and uneven infrastructure development. Environmental and social disparities may affect residents' daily activities and their perceived health status.

This research investigates the relationship between the community-built environment and self-rated health among community-dwelling adults in Gaoping District, Nanchong, Sichuan Province, while also assessing the role of sleep quality as a mediating factor in this association. This study, based on the Health Ecological Model,

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seeks to: (1) identify the relationships between critical aspects of the built environment and self-rated health (SRH); and (2) assess whether sleep quality serves as a mediator in these relationships.

2. Methods

2.1 Study Setting and Design

A cross-sectional study was conducted in Gaoping District, Sichuan Province, between July 2023 and August 2024. Ethical Approval was obtained from the Institutional Review Board of Management and Science University and the Institutional Review Board of North Sichuan Medical College (No.2024019). Written informed consent was obtained from all participants before data collection.

A multi-stage cluster random sampling method was utilized. Three townships and two sub-districts were randomly chosen, followed by the random selection of five village or community committees within each unit, totaling 25 committees. Following data screening, 422 valid responses were included for the final analysis based on data completeness. Moderated mediation analysis was applied.

2.2 Participants

A total of 422 community-dwelling adults were chosen from the sampling frame based on the completeness of data regarding the built environment, sleep quality, and self-rated health factors for the present study.

Participants were included if they met the following criteria: (1) age ranging from 22 to 85 years; (2) residency in the designated neighborhood for a minimum of 6 months; and (3) capability to complete the questionnaire independently or with limited assistance. Participants were excluded if they exhibited significant cognitive impairment, substantial psychiatric problems, or serious physical conditions that could undermine the reliability of self-reported data.

2.3 Built Environment

The neighborhood-built environment was evaluated using the validated Chinese version of the Neighborhood Environment Walkability Scale–Abbreviated (NEWS-A)(4,21). It comprises 17 items categorized into four dimensions: living convenience, road and street conditions, aesthetics and traffic safety, and public security.

Responses were coded on a 5-point Likert scale, and higher scores indicated more supportive environments. Each item is evaluated on a scale from 1 to 5, where 1 indicates strong agreement (very good) to 5 denotes strong disagreement (very bad).

2.4 Self-Rated Health

Self-rated health was assessed by the General Health (GH) subscale of the Chinese version of the 36-Item Short Form Health Survey (SF-36), validated in Chinese populations(22). GH quantifies an individual's self-evaluation of health status and its trends, with elevated scores reflecting superior health and lower scores indicating poorer health. Items were recorded so that higher scores consistently reflect better health and then summed to yield a total GH score ranging from 5 to 25, with higher scores indicating better perceived health.

2.5 Sleep Quality

Sleep quality was measured with the Insomnia Severity Index (ISI) (3,23,24). It is a five-item tool that evaluates the perceived severity and daytime effects of insomnia symptoms experienced over the preceding two

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weeks. Total scores range from 0-28, categorized as follows: scores of 0–7 indicate no clinically significant insomnia, 8–14 represent subthreshold insomnia, 15–21 denote moderate clinical insomnia, and 22–28 signify severe clinical insomnia.

2.6 Sociodemographic Characteristics and Related Variables

Sociodemographic characteristics such as age, gender, marital status, education level and residential area. Additional household variables, such as family income, number of family members and, as well as subject-related variables such as family income, family members. Family economic status was classified into three levels: low, medium, and high, based on the participants' self-assessment criteria. Individual interviews were conducted with patients and their caregivers to ensure their privacy and confidentiality during the data collection process.

2.7 Study Procedure and Data Collection

The initial survey sample size was calculated based on the formula: $n = \frac{Z^2_{1-\alpha/2} p(1-p)}{d^2}$. Sample size was calculated using the single proportion formula with a 95% confidence level (Z=1.96), p is the estimated proportion, and d is the allowable margin of error. A multi-stage cluster random sampling method was employed to select participants. The survey was conducted in Gaoping District, where three townships and two sub-districts were randomly chosen, followed by the selection of five village or community committees within each unit.

A total of 422 community-dwelling adults completed the survey and provided valid data for all variables of interest (built environment, sleep quality, and self-rated health). According to the requirements for moderated mediation analysis using bias-corrected bootstrap resampling (10,000 iterations), this sample size (N=422) is sufficient to ensure estimation stability and detect significant indirect effects.

2.8 Statistical Analysis

Analyses were performed utilizing R (version 4.5.0) (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics summarized the characteristics of the participants. Continuous variables were reported as median and interquartile range, while categorical variables were expressed as frequencies and percentages. Group differences were assessed through the application of t-tests or chi-squared tests, as suitable. Statistical significance was established at $p < 0.05$ (two-tailed).

Spearman rank correlation analysis was utilized to investigate the relationships between the neighborhood-built environment (NE), sleep quality (ISI), and self-rated health (SRH).

A three-step mediation analysis was conducted to evaluate the proposed mediating role of sleep quality, utilizing the following equations:

Path a (Effect of NE on ISI): $M = \alpha_0 + axe + e_m$

Path b and c′ (Effect of ISI and NE on SRH): $Y = \beta_0 + c'X + bM + e_\gamma$

Path c (Total effect of NE on SRH): $Y = \gamma_0 + cX + e_\gamma$

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X represents the built environment, M indicates sleep quality, and Y signifies self-rated health. The indirect effect was determined as the product ab, while the total effect was confirmed by the equation $c \approx c' + ab$. Bias-corrected bootstrap resampling (5,000 iterations) was employed to assess the significance of mediation, where a 95% confidence interval that does not include zero signifies a significant mediation effect. Models were controlled for age, sex, marital status, educational attainment, and household income. Results were presented as standardized coefficients (β), accompanied by p-values and confidence intervals.

2.9 Mediation Mode Analysis

The mediation analysis investigated the role of sleep quality (ISI) as a mediator in the relationship between neighborhood-built environment (NE) and self-rated health (SRH) (shown in Figure 1). Four dimensions of the built environment, living convenience (NE1), road and street conditions (NE2), aesthetics (NE3), and public safety (NE4), were evaluated individually, along with the overall built environment score.

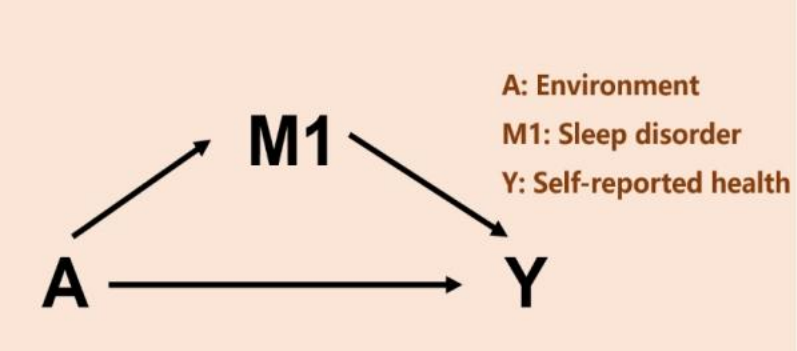

Figure 1. Mediating Mode

Each model adhered to the structure depicted in Figure 1, which includes: (1) Path a - the influence of NE on ISI; (2) Path b - the influence of ISI on SRH; (3) Path c′ - the direct influence of NE on SRH while controlling for ISI; and (4) Path c - the overall influence of NE on SRH.

We further extended the mediation model to a moderated mediation framework to investigate if the built environment's influence was conditional. Specifically, we tested if the relationship between neighborhood-built environment (NE) and sleep quality (ISI) was moderated by residence area (K), and if the relationship between sleep quality (ISI) and self-rated health (SRH) was moderated by family economic status (L).

The conditional indirect effects were derived using the Delta method and assessed via Bias-corrected bootstrap resampling (10,000 iterations). Conditional indirect effects were calculated for each subgroup, representing the X→M→Y pathway under specific moderator levels. The conditional indirect effect was categorized into 6 subgroups based on the levels of residence area and family economic status. Statistical significance was determined when the 95% confidence interval did not include zero. Mediation is categorized as partial when both ab and c′ are significant, and as complete when ab is significant while c′ is not. Analyses accounted for sociodemographic covariates, presenting results as standardized coefficients along with corresponding p-values.

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3. Results

3.1 Descriptive analyses

A total sample of 422 community-dwelling adults were included in the analysis. The participants consisted of 175 males (41.4%) and 247 females (58.6%), with a mean self-rated health (SRH) score of 11.52 ± 4.02, as indicated in Table 1. Approximately 49.2% of the respondents were aged 40 years or younger, while 32.9% were aged between 41 and 50 years. The majority of participants were married (78.7%), were of Han ethnicity (99.1%), and primarily lived in urban areas (66.3%). In terms of educational attainment, 62.0% had completed high school or technical college, while 28.1% possessed a bachelor's degree or higher. Approximately 73.2% indicated the average economic condition of their families.

INSERT TABLE 1

The descriptive statistics of the four neighborhood-built environment dimensions are shown in Table 2. Among these, road and street conditions showed the highest mean score (18.44 ± 4.87), indicating that most respondents perceived their community infrastructure to be satisfactory and well-maintained. Conversely, public security recorded the lowest mean score (11.91 ± 2.83), reflecting certain safety and neighborhood protection concerns.

INSERT TABLE 2

Table 3 presents the Spearman rank correlations among the community-built environment, sleep quality, and self-rated health. All four dimensions of the built environment and self-rated health exhibited significant negative correlations with sleep quality (ρ = –0.20 to –0.40, $p < 0.001$, ρ = –0.439, $p < 0.001$). There was a positive correlation between the all built environment and self-rated health (ρ = 0.173-0.302, $p < 0.001$), suggesting that lower sleep quality is linked to worse perceived health among community-dwelling middle-aged to older adults.

INSERT TABLE 3

Table 4 revealed a significant mediating role for sleep quality across all measured built environment dimensions. Aesthetics and traffic safety were the strongest predictors, yielding the largest indirect effect(β=0.102, P<0.05) and the most substantial total effect (β=0.372, P<0.05). Crucially, all four individual dimensions demonstrated significantly larger total effects compared to the composite score(β=0.270, P<0.05).In contrast, public security was the only dimension exhibiting near complete mediation, where the indirect effect (β=0.087, P<0.05) was nearly equal to the direct effect(β=0.106, P<0.05), highlighting its distinct mechanism of action primarily through sleep quality.

INSERT TABLE 4

Description of Figure 2: Figure 2 illustrates the path analysis results. In the unconditional model, a better built environment was significantly associated with better sleep quality (lower ISI scores) (β=*-0.099*, P<0.001). Subsequently, better sleep quality exerted a significant positive influence on self-rated health (β=*-0.269*, P < 0.001). The significant indirect effect (β= 0.027, $p < 0.001$) confirmed that a better built environment contributes

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to better health via improved sleep, while the direct effect remained significant (β = 0.052, p < 0.001).

Crucially, the moderated mediation model revealed that these pathways are highly conditional on the residential setting. While the built environment significantly improved sleep quality in both groups, this beneficial effect was significantly stronger for rural residents (β = -0.153, p < 0.001) compared to urban residents (β = -0.080, p < 0.05$). Furthermore, the association between poor sleep quality and SRH was significantly moderated by family economic status. Interestingly, the strongest negative association was observed in the high economic status group (β = -0.411, p < 0.001), suggesting that the perceived health of this group is the most sensitive to sleep disturbances.

Figure 2 Comparison of Unconditional and Conditional Mediation Effects on the Overall Built Environment

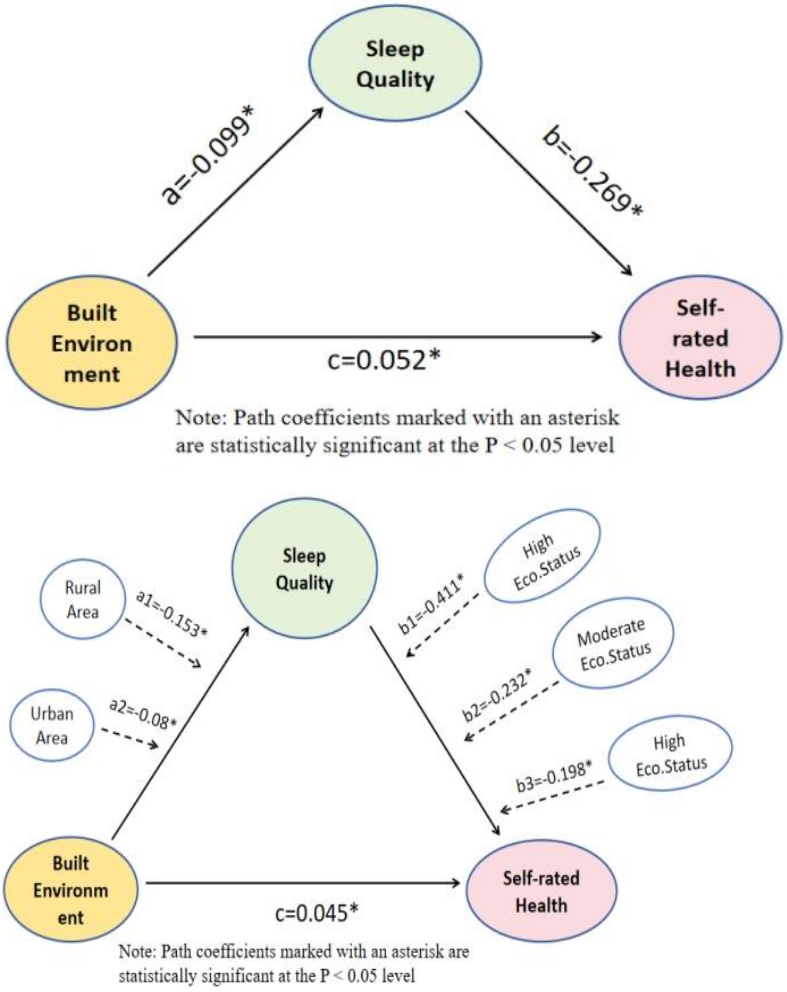

Table 5 revealed distinct mechanisms across the built environment dimensions. The strongest overall mediation pathway was universally observed in urban residents with high socioeconomic status across all four dimensions, peaking with aesthetics and traffic safety(β=0.219, P<0.05), and closely followed by living convenience (β=0.178, P<0.05) and public security (β=0.178, P<0.05). Conversely, the indirect effect was generally weakest and non-significant for rural residents with low socioeconomic status across three

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dimensions(NE1 β=0.032, NE2 β=0.038, NE4 β=0.084). A notable exception was aesthetics and traffic safety, where the mediation pathway proved highly robust: the lowest significant indirect effect was observed in the rural, middle socioeconomic status group (β=0.070, P<0.05), demonstrating that the benefit of aesthetic quality on health via sleep is the most resilient to socioeconomic and residential barriers.

INSERT TABLE 5

4. Discussion

The current study investigated the relationship between the neighborhood-built environment and self-rated health (SRH) among community-dwelling adults in Gaoping District, Sichuan. Consistent with our hypotheses, residents living in more supportive, accessible, and safer neighbourhoods exhibited superior sleep quality and, consequently, higher SRH. A key finding of this study is the mediating role of sleep quality: it partially mediated the impact of living convenience, road conditions, and aesthetics on SRH, while public security exhibited a near-complete mediation effect. The current study investigated the perceived health status quo among community-dwelling adults in Gaoping District, Sichuan. We found that a total of 422 valid respondents were included in our study, with a mean self-rated health (SRH) score of 11.52 ± 4.02.

In accordance with our assumptions, people residing in more supportive, accessible, and safer neighbourhoods exhibited superior sleep quality and elevated SRH. The quality of sleep slightly mediated the impact of living convenience, road and street conditions, and aesthetics on SRH, whereas public safety exhibited a nearly perfect mediation effect.

Previous research has widely recognized the role of neighbourhood environment in shaping residents' physical and psychological health. Since 2016, the Chinese government has consistently implemented the "15-Minute Living Circle" project across communities nationwide (1,25,26). The execution of the "15-Minute Living Circle" initiative concept has enhanced community health services by offering older persons vital exercise amenities, accessible daily requirements, and improved healthcare resources. This comprehensive strategy has successfully addressed the requirements of older adults and subsequently improved their subjective assessment of physical health. In areas with enhanced medical service accessibility, older folks are more inclined to sustain superior physical health owing to improved and dependable access to vital health-related resources(21,27,28). The proximity of fresh food and healthcare facilities diminishes physical exertion and logistical obstacles, facilitating individuals' daily health management. This convenience likely improves inhabitants' physical well-being and leads to more favourable self-rated health status among community-dwelling middle aged and older adults.

Our findings align with existing studies showing that favourable built environments, which characterized by safety, greenery, accessibility, and walkability, are positively associated with health and well-being(13,29,30). A key finding of this study is the mediating role of sleep quality: it partially mediated the impact of living convenience, road conditions, and aesthetics on SRH, while public security exhibited a near-complete mediation effect. A study conducted in Guangzhou similarly reported that neighbourhood safety and environmental

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aesthetics were strong predictors of sleep satisfaction among older adults (31). The mediation effect of sleep observed in the present study supports emerging evidence that environmental noise, lighting, and safety conditions influence sleep quality, which subsequently affects subjective health perception(32,33). In contrast, few studies in inland or medium-sized Chinese cities have empirically tested these indirect pathways, making our findings an important contribution to the literature on community health in under-studied regions.

The mechanisms underlying these associations may involve both behavioural and psychosocial pathways. A supportive built environment can promote outdoor activities, social participation, and psychological comfort while reducing exposure to stressors such as traffic hazards and insecurity. Improved environmental quality enhances residents' sense of control and safety, leading to more stable sleep patterns and better emotional recovery. In turn, good sleep quality has been linked to improved immune function, reduced depressive symptoms, and higher overall life satisfaction, all of which contribute to positive self-rated health (11,14). The near-complete mediation observed for public safety underscores the crucial role of perceived security in daily life: individuals who feel protected and free from environmental threats may sleep better and, consequently, perceive themselves as healthier. This finding highlights that public safety, beyond its physical aspect, also carries psychological meaning that affects well-being.

The results also have practical implications for community planning and public health promotion in ageing urban settings. The findings highlight that improvements in neighbourhood aesthetics, accessibility, and safety could yield substantial benefits for residents' sleep and perceived health. Local governments and community planners may prioritise the development of age-friendly environments through safe pedestrian networks, well-lit streets, green spaces, and quiet residential zones. Integrating environmental design with community-based health promotion programs can create sustainable conditions for healthy ageing. In the context of a deep-ageing society such as Sichuan, where the proportion of older adults continues to increase, such interventions are especially pertinent for maintaining quality of life and reducing health inequalities.

A crucial and nuanced finding from our moderated mediation analysis is the heterogeneity based on residential context. While the built environment significantly improved sleep quality in both settings, the beneficial effect was significantly weaker for urban residents (β = -0.080) compared to rural residents (β = -0.153). This contrasts with previous assumptions that urban infrastructure always yields higher health returns. We propose that this attenuation in urban areas may be attributed to unmeasured urban stressors, such as noise pollution, artificial lighting at night, and higher population density. These factors likely counteract the positive effects of improved infrastructure, creating a "cancellation effect" that prevents urban residents from deriving the full sleep benefits experienced by their rural counterparts. In contrast, rural settings, being inherently quieter and less congested, may allow the benefits of infrastructure upgrades (like better roads or aesthetics) to translate more directly into improved sleep.

Furthermore, our study revealed that family economic status significantly moderates the impact of sleep on health. Interestingly, the high socioeconomic status group exhibited the strongest negative association (β = -

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0.411), indicating that they are the most sensitive to sleep disturbances. Several mechanisms may explain this "paradox of affluence." First, individuals with higher SES often hold more cognitively demanding jobs and may face higher psychological stress, making restorative sleep more critical for their daily functioning. Second, this group typically possesses higher health literacy and expectations; therefore, they may perceive symptoms of insomnia as a more severe deviation from their "health norm," leading to a sharper decline in their self-rated health scores compared to lower SES groups, who might normalize poor health due to chronic exposure to adversity.

These findings have targeted implications for urban planning in aging societies. Planners should not only focus on "hard" infrastructure (accessibility) but also on "soft" environmental quality (noise reduction, lighting control) to mitigate the stressors that currently dampen the health benefits of urban living. Given its complete mediation role, enhancing community safety (e.g., lighting, patrols, surveillance) is the most cost-effective intervention to improve sleep-dependent health outcomes. Since high SES individuals are highly sensitive to sleep loss, and rural residents benefit most from environmental upgrades, differentiated public health policies are needed. Integrating environmental design with community-based sleep hygiene programs could be a vital strategy for healthy aging in Sichuan.

This study has certain limitations that should be acknowledged. The initial aspect concerns generalizability. Although the study utilized a cluster random sampling method, its focus was confined to a specific community in Sichuan Province, China, thus undermining the generalizability of the results. Secondly, the cross-sectional design complicates causal inference. Although mediation paths were statistically supported, the temporal ordering of these associations remains uncertain. Third, only sleep quality was examined as a mediator, future research should address more mediators by employing structural equation modelling (SEM) to test more complex interrelationships among environmental, behavioral, and psychological variables. Despite these drawbacks, this research contributes to the evidence on perceived health status among community-dwelling middle-aged to older adults in China and the significance of aging healthy society in China.

5. Conclusions

This study strongly suggests that sleep quality mediates the association between the built environment and self-rated health in community-dwelling older persons. We found significant heterogeneity in this association based on dwelling context: urban residents' built environment had an unexpected inhibitory (negative) effect on health, likely due to unmeasured urban stressors like noise and pollution overriding positive perceptions. Non-urban settings showed a considerable favourable influence. Family economic position also buffers the negative effects of poor sleep quality on self-rated health. Implementing differentiated urban design policies that prioritise the mitigation of environmental stressors and enhance economic support for vulnerable groups may strengthen the psychological resilience of older adults, thereby improving their self-rated health and quality of life.

Additionally, family economic status plays a critical moderating role; notably, individuals with higher economic status demonstrated greater health sensitivity to sleep quality, wherein poor sleep exerted a stronger

detrimental impact on their self-rated health compared to other groups. Consequently, urban planning policies should not only prioritize infrastructure upgrades but also focus on mitigating environmental stressors. Simultaneously, health interventions should be differentiated, providing targeted psychological and sleep support to vulnerable groups to enhance their resilience and quality of life.

Abbreviations

NE: Neighborhood Environment

SRH: Self-Rated Health

ISI: Insomnia Severity Index

SEM: Structural Equation Modelling

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Management and Science University and the Institutional Review Board of North Sichuan Medical College (No.2024019). The data underlying this article are available in the School of Public Health in the North Sichuan Medical College. All participants were informed of the purpose and procedures of the survey, and written consent was obtained prior to participation. The questionnaire survey was conducted in community settings and workplaces under the supervision of trained investigator.

Consent for publication

Not applicable.

Availability of data and materials

According to the Institutional Review Board of North Sichuan Medical College, the data of this study are not available for online access. If the readers need to gain access to the data, they have to apply for the consent of the Institutional Review Board of North Sichuan Medical College and authors with the necessary reasons. This is a requirement mandated for this research study by our Institutional Review Board of North Sichuan Medical College.

Competing interests

The authors declare no competing interests.

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Authors' contributions

All authors were involved in the study design, provided scientific oversight throughout the project, detailed comments on the paper across several drafts, and edited the paper. L.Y designed the study and wrote the

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manuscript. L.Y collected the data. L.Y and L.Y designed the data analysis and revised the data study. X.T. assumed the corresponding author and revised the study finally. L.Y, J.T, and X.T re-viewed and edited the final version of the manuscript.

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TABLES

Table 1 Socio-demographic Characteristics and Self-rated Health Status among Community-dwelling Participants (N=422)

Variables	n (%)	SRH scores	t/F	*P*
	422	11.52±4.02		
Gender			0.672	0.502
Male	175(41.4)	11.68±4.14		
Female	247(58.5)	11.41±3.94		
Age			2.420	<0.05
≤ 40 years	208(49.2)	11.33±3.91		
41-50 years	139(32.9)	11.35±4.12		
51-60 years	64(15.1)	12.72±4.03		
≥ 61 years	11(2.6)	10.45±4.01		
Ethnicity			-1.995	<0.05
Han	418(99.1)	11.49±4.01		
Others	4(0.9)	15.50±3.51		
Education Level			2.022	0.110
≤ Junior middle school	41(9.6)	12.61±3.48		
High school/college	262(62.0)	11.31±4.06		
≥Bachelor's degree	119(28.1)	11.63±4.06		
Marriage Status			1.166	0.313
Unmarried	72(17.1)	11.00±3.84		
Married	332(78.7)	11.68±4.00		

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Others	18(4.3)	11.68±4.00		
Occupation			1.080	0.366
Mental work	244(57.8)	11.51±4.04		
Manual work	63(14.9)	11.05±3.95		
Retired	53(12.5)	11.15±4.20		
Unemployed	14(3.3)	12.07±3.38		
Both mental & manual	48(11.3)	12.48±3.94		
Place of Residence			0.276	0.759
Rural	52(12.3)	11.27±3.76		
Township	90(21.3)	11.77±3.95		
Urban	280(66.3)	11.49±4.10		
Family Economic Status			7.698	<0.01
Very Poor	33(7.8)	9.09±4.04		
Poor	41(9.7)	10.63±3.77		
Average	309(73.2)	11.59±3.87		
Good	35(8.2)	14.09±4.00		
VeryGood	4(0.9)	13.00±5.42		

Note: SRH means self-rated health. Categorical variables as n (%). Reverse-scored items have been adjusted. For the comparison of the two groups, the t-test was used. For the comparisons of three or more groups, ANOVA was employed, with F.

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Table 2 Descriptive Statistics of Neighborhood-Built Environment Dimensions (N=422)

Dimensions of Built Environment	Mean±SD
Living Convenience	14.91±4.21
Road and street conditions	18.44±4.87
Aesthetics and traffic safety	17.58±3.53
Public security	11.91±2.83

Note: Higher scores indicate better perceived neighborhood conditions. Reverse-scored items were recorded so that higher values consistently represent a more supportive environment

Table 3 Correlations among Built Environment, Sleep Quality, and Self-Rated Health (N=422)

Variable	Sleep Quality	Self-rated Health	Living Convenience	Road and street condition	Aesthetics and traffic safety	Public security	Total built environment
Sleep quality	1.00						
Self-rated health	-0.439***	1.00					
Living Convenience	-0.198***	0.201***	1.00				
Road and street condition	-0.234***	0.221***	0.613***	1.00			
Aesthetics and traffic safety	-0.247***	0.302***	0.544***	0.721***	1.00		

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Public security	-0.208***	0.173***	0.553***	0.704***	0.617***	1.00	
Total built environment	-0.264***	0.266***	0.816***	0.903***	0.836***	0.808***	1.00

Note: Values are Spearman rank correlation coefficients (ρ). Only the lower triangle is shown; main diagonal = 1.00. N = 422. Significance: * p < 0.05; ** p < 0.01; *** p < 0.001.

Table 4. Decomposition of Direct and Indirect Effects for Mediation Models

Path	Indirect Effect (ab)	Direct Effect(c′)	Total Effect(c)	Mediation Type
NE1→ISI→SRH	0.061*	0.114*	0.175*	Partial Mediation
NE2→ISI→SRH	0.063*	0.105*	0.168*	Partial Mediation
NE3→ISI→SRH	0.102*	0.270*	0.372*	Partial Mediation
NE4→ISI→SRH	0.087*	0.106*	0.193*	Near-complete Mediation
NE Total→ISI→SRH	0.027*	0.052*	0.079*	Partial Mediation

Notes: Values represent standardized regression coefficients (β). NE = Neighbourhood Environment; ISI = Insomnia Severity Index; SRH = self-rated health

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Table 5. Decomposition of Conditional Direct and Indirect Effects Based on Residence Setting and Family Economic Status

Path	Subpopulations	Indirect Effect (ab)	Direct Effect(c′)	Total Effect(c)	Mediation Type
NE1→ISI→SRH	Urban residents	0.086*	0.083*	0.169*	Partial Mediation
	3				
	2	0.102*	-	0.185*	
	1	0.178*	-	0.261*	
	Rural Residents	0.032	-	0.115*	
	3				
	2	0.038	-	0.121*	
	1	0.066	-	0.149*	
NE2→ISI→SRH	Urban residents	0.066	0.093*	0.159*	Partial Mediation
	3				
	2	0.080*	-	0.174*	
	1	0.143*	-	0.236*	
	Rural Residents	0.038	-	0.131*	
	3				
	2	0.046*	-	0.139*	
	1	0.081*	-	0.174*	
NE3→ISI→SRH	Urban residents	0.105*	0.253*	0.358*	Partial Mediation
	3				
	2	0.121*	-	0.374*	
	1	0.219*	-	0.472*	
	Rural Residents	0.126*	-	0.313*	

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	3				
	2	0.070*	-	0.323*	
	1	0.126*	-	0.379*	
NE4→ISI→SRH	Urban residents	0.084	0.079	0.163	Near-complete Mediation
	3				
	2	0.099*	-	0.179*	
	1	0.178*	-	0.257*	
	Rural Residents	0.055	-	0.134	
	3				
	2	0.065	-	0.145	
	1	0.117	-	0.196*	
NE Total→ISI→ SRH	Urban residents	0.030*	0.045*	0.075*	Partial Mediation
	3				
	2	0.036*	-	0.081*	
	1	0.063*	-	0.108*	
	Rural Residents	0.016	-	0.061*	
	3				
	2	0.019*	-	0.064*	
	1	0.033*	-	0.078*	

Notes: Values represent standardized regression coefficients (β). NE = Neighbourhood Environment; ISI = Insomnia Severity Index; SRH = self-rated health
3=low socioeconomic status 2=middle scioeconomic status 1= high socioeconomic status