Research Paper

Urban Child-Friendly Spaces: A Study on the Mechanism of the Multi-Pathway Influence of the Commuting-to-School Environment on Children's Mental Health Across Age Groups†

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Abstract

Urbanization has profoundly reshaped human living spaces and daily behaviors, impacting all age groups, especially school-age children, who are vulnerable to environmental changes. In recent years, children's commuting-to-school environments and travel modes have undergone significant transformation. The proportion of motorized journeys has risen, while independent travel has declined, exposing children to higher levels of traffic, noise, and safety risks. These shifts, closely linked to urbanization, have introduced new sources of psychological stress on children. As a result, concerns regarding children's mental health have grown worldwide, with rising rates of anxiety, depression and stress-related symptoms becoming increasingly evident.

The commuting-to-school environment functions as a vital link between home and school, representing the urban space where children spend the most time and encounter the greatest variety of experiences. This setting has a direct effect on their emotional state, social interactions, and perception of well-being. However, current educational and urban planning practices tend to emphasize physical health, often overlooking the crucial role of mental health. Furthermore, children's perceptions of their environments, as well as their needs, vary considerably across different stages of development.

In response to this gap, the study explores how the urban commuting-to-school environment affects the mental health of children at different age levels and investigates the pathways and mechanisms through which these effects occur. This study takes Harbin City as a case study, and employs a combination of literature review, child-friendly questionnaires, and cognitive mapping

to build a comprehensive model describing the relationship between commuting environment and children's mental health. The study identifies four key dimensions of the commuting environment (safety, comfort, convenience, and variety). Three categories of mediator are considered: stress perception, experience of autonomy, and sense of social connectedness. Children's mental health is measured using self-reported scores from the MHS-CA Children's Mental Health Scale self-scores.

A total of 900 students, equally divided among primary (ages 6-10), middle (ages 11-14), and high (ages 15-18) school group in Harbin City, were randomly selected, and 886 valid questionnaires were returned. After preprocessing the data, structural equation modeling was applied to analyze multiple mediation effects, while group comparisons assessed differences across age groups.

The results demonstrate that all four dimensions are positively correlated with children's mental health. Among these, perceived stress and sense of social connectedness act as mediators, especially in the safety and variety, whereas autonomy experiences mediate the influence of security, comfort, and convenience on psychological well-being. Age group analysis reveals distinct patterns: for primary school children, the pathway from safety through stress perception to mental health is most pronounced, indicating that lack of safety leads to heightened stress and poorer mental health; Middle school students show the strongest mediating role of autonomy, likely due to increased psychological sensitivity period; While for high school students, the link between convenience, stress perception, and mental health is most significant, indicating that ease of school access at this stage greatly influences their psychological state.

This study systematically uncovers how different features of the urban commuting-to-school environment affect children's mental health at various developmental stages. It highlights the need to pay attention to children who are in a disadvantageous position in urban planning decision-making, and helps to make up for the neglect of mental health in the current research related to child-friendly cities, improve urban inclusiveness, and promote the development of urban design refinement.

Keywords

Commuting-to-school environment; Child-friendly city; Children's mental health; Structural equation modeling

1. Introduction

In recent years, children's mental health has received increasing attention from the international academic community and the government. According to the statistics from World Health Organization (WHO) and UNICEF, there are 13 percents of children and adolescents aged 10–19 experiencing a mental health problem. These mental disorders not only directly affect children's academic performance and social adaptation but may also have a long-term impact on children's social functioning in adulthood. It has been found empirically that children's mental health is closely related to their cognitive ability and achievement, peer group and friendship, and self-identity as the basis for social development (Nakajima *et al.*, 2024a).

The influences on children's mental health are multidimensional and complicated. Apart from family and school, the role of urban environment has attracted more and more attentions as an external factor. With the rapid urbanization, the urban environment has remoulded the living environment and behaviour of people every day. And school-aged children, as an especially vulnerable group, have experienced

significant changes in the school commuting environment. These changes may act as invisible stressors and affect children's mental states through multiple paths.

Due to their developmental characteristics, children are more likely to be affected by the negative impact of invisible stress. As the spatial link between home and school, the school travel environment is the urban space that school-aged children interact with the most and most often. It directly affects children's emotional experiences, social interactions and subjective well-being.

Under such circumstances, this study attempts to explore how the urban school travel environment affects the mental health of school-aged children through multiple paths. Taking structural equation modelling (SEM) into use, this study explores the age-specific differences in the above-mentioned paths.

2. Framework

2.1. Basis for Model Construction

The characteristics of the urban environment encountered by children during travel play a decisive role in their travel experiences. Based on environmental psychology theory, individuals' evaluations of environmental characteristics will influence their emotional arousal and cognitive load (Li, Wang and Zhou, 2023). According to the above theoretical basis and empirical studies, this research classifies the school travel environment into four dimensions—safety, comfort, convenience, and diversity—and discusses their possible mechanisms affecting mental health.

Safety is the basic condition to realize the independent travel of children. Existing studies have found that low traffic safety perceptions will directly reduce children's willingness to travel independently and limit their activity space (Vlaar *et al.*, 2019). At the same time, social and economic differences, discrimination, and even the sensory environment of the urban environment are all linked to a higher risk of mental health problems (McCay, 2019). Children who live in areas with perceived unsafe conditions will experience more anxiety and psychological stress (Bouter *et al.*, 2023). In contrast, positive interactions between neighbours and cohesive communities can help alleviate stress and improve mental health (Alderton *et al.*, 2019).

A comfortable physical commuting environment is also very important for mental health. Existing studies have found that smooth and safe roads and sidewalks not only affect travel safety but also affect physical activity and outdoor experience, which in turn affect mental health (Arif and Ullah, 2025). In addition, urban noise is strongly associated with poor sleep, increased psychological stress, and other health problems (Rudolph *et al.*, 2019). If the urban environment is not suitable for children, it will bring burden and reduce the willingness to commute actively (Clemens, Von Hirschhausen and Fegert, 2022).

Commuting conditions in terms of convenience facilitate children's autonomy and sense of control over their environment. Commuting convenience has been associated with not only more opportunities for physical activity but also spatial cognitive development, greater environmental familiarity, and mental health (Költő *et al.*, 2021). In addition, the convenience of public transportation during commuting directly affect travel experiences (Vlaar *et al.*, 2019).

Diversity indicates the range of children's exposure to city resources. Natural environment has been proven to positively affect mental health through facilitating physical activity, recovering emotions, and improving cognitive health (Mavoa *et al.*, 2019; Poulain *et al.*, 2020a; Nigg *et al.*, 2022). Meanwhile, diverse activity spaces in cities provide possibilities for play and exercise, serve as significant contexts for social cooperation, skill training, and interest cultivation (Teeuwen, Psyllidis and Bozzon, 2023). Diversity and

clarity of informational signage help children to interpret urban structure, reduce the uncertainty and anxiety of getting lost, and increase their sense of belonging to the city (Gong *et al.*, 2019).

2.2. Effects of School Travel Environments on Children's Spatial Experience

Mental health includes two aspects: short-term emotional symptoms and long-term psychological health. Perceived stress represents the emotional appraisals in the short run. Persistent or repeated high levels of stress may lead to emotional exhaustion, anxiety, or sleep disturbance. Autonomous experiences include freedom, competence, and control, which contribute to better coping and emotional regulation. Social connectedness refers to receiving emotional support, information resources, and ways to share problems. Strong social ties have been found to decrease the risk of developing depression and anxiety and to increase positive affect (Lin and Yu, 2011).

First, perceived stress reflects whether the environment is threatening and whether it consumes emotional and cognitive resources (Varas-Julca, Palacios-Serna and Santana-Mora, 2024). Second, autonomy experiences are believed to be essential for self-efficacy and mental development. Daily experiences of exploration and control make children feel good emotionally in the short term and enhance their self-esteem in the long term (Chen *et al.*, 2025). Third, social connectedness refers to the quality of interactions with peers, neighbours, or adults. Peer companionship, brief interactions with neighbours, and a sense of community among residents near school entrances provide social support and reduce feelings of loneliness (Fallavollita and Lyons, 2023).

2.3 Research Hypotheses

Most studies focus on a single environmental factor, rather than exploring the joint impact of multiple factors, which may blur the links between the two. It is also possible that perceived stress, autonomy, and social connectedness are the key mediators between the travel environment and children's mental health.

Therefore, to explore the process of how the travel environment affects children's mental health, this study develops a moderated mediation model in which perceived stress, autonomy experiences, and social connectedness are proposed as mediators. In turn, SEM is used to explore the relationships among variables and test the paths between environmental satisfaction and mental health. The hypotheses are:

H1: Perceived stress has a direct effect on mental health.

H2: Autonomy experiences have a direct effect on mental health.

H3: Social connectedness has a direct effect on mental health.

H4: Environmental satisfaction, containing safety, comfort, convenience, and diversity, indirectly affects mental health through perceived stress, autonomy experiences, and social connectedness.

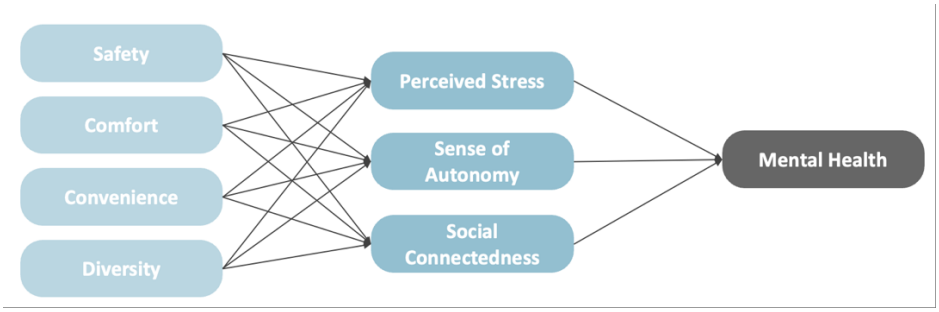


Figure 1. Path Hypothesis. Source: By the author

3. Methods

3.1. Study Sample and Questionnaire Design

This study was conducted in Harbin, a major city in Heilongjiang Province in northeastern China and the second-largest urban centre in the region. School-aged children were classified into three groups based on their educational stage: primary school students (ages 6–10), middle school students (ages 11–14), and high school students (ages 15–18). A random sample of 300 students was drawn from each age group, resulting in 900 distributed questionnaires. After data cleaning, 886 questionnaires were deemed valid.

The questionnaire used in this study consisted of six sections. The first section collected basic information, including sociodemographic characteristics (age and gender) and commuting-related variables. The second section measured satisfaction with the school travel environment and included four dimensions: safety, convenience, comfort, and diversity. Each dimension consisted of three items, and all items were rated on a five-point Likert scale. Participants rated 12 items from 1 (strongly disagree) to 5 (strongly agree) based on their subjective perceptions of the statements in the questionnaire.

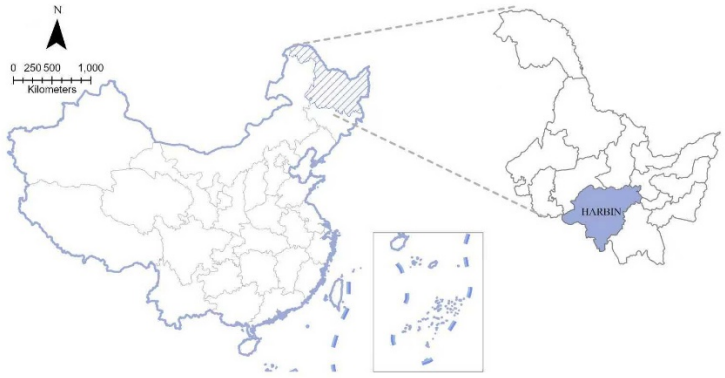


Figure 2. Research Area. Source: By the author

Table 1 Questionnaire items

	Items	Range
Basic Information	Age	-
	Gender	-
	Travel Time	-
	Travel Mode	-
Satisfaction with Commuting-to-school Environment	Safety	5 points
	Comfort	5 points
	Convenience	5 points
	Diversity	5 points
Stress Perception	Perception of Environmental Stressors	5 points
	Sources of Environmental Anxiety	5 points
Autonomy	Sense of Choice and Control	5 points
	Perceived Competence	5 points

Social Conductedness	Opportunities for Exploration and Interest	5 points
	Quality of Peer Interaction	5 points
	Feelings of Community Belonging	5 points
	Perceived Supportiveness of Social Spaces	5 points
Mental Health	Anxiety Experience	7 points
	Pleasant Experience	7 points
	Emotional Response	7 points

Table 2 Environmental Satisfaction Questionnaire

Dimension	Variable	Corresponding descriptions (1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree)
Safety	Traffic Safety	I feel safe crossing the street because vehicles and bicycles yield to me.
	Public Security	On the road, I don't worry about encountering dangerous individuals or strange incidents.
	Atmosphere of the Environment	The overall journey to school makes me feel comfortable and happy.
Comfort	Road Conditions	The path I walk on is smooth, without potholes, so I don't need to worry about tripping.
	Heat Environment	In summer, it's not too sunny or hot while walking, and in winter, I don't feel particularly cold or bothered by the wind.
	Sound Environment	The sounds along the way are not noisy, and there are no persistent annoying noises (like constant honking).
Convenience	Accessibility of Public Transport	If I need to take a bus or train, the stations are conveniently close to both my home and school.
	Connectivity of the Street Network	The route to school is easy to find and straightforward, without needing to detour frequently.
	Degree of Crowding	During the commute to and from school, the path is not overcrowded, so I can walk comfortably.
Diversity	Landscape Diversity	The scenery along the way is pleasant, with green trees, small flowers, or interesting buildings, making it enjoyable.
	Activity Space Diversity	If I want to stop and chat with classmates or play for a while, there are suitable spots along the way.
	Signage Diversity	The road signs, maps, and traffic signals are clear and easy to understand, so I don't get lost.

The third to fifth sections assessed perceived stress, autonomy, and social connectedness. For perceived stress, participants were guided by two core questions, and responses were collected using two five-point scales ranging from 1 to 5. Autonomy was measured through three components. These feelings corresponded to three states: a sense of freedom or ease, a sense of control or self-direction, and a sense of excitement or curiosity. Social connectedness was evaluated through the quality of peer interaction, feelings of community belonging, and the perceived supportiveness of social spaces along the route. A social connectedness index was created by summing the scores from these three items.

Table 3 Questionnaire about Mediating Variables

Latent variables	Observed variables	Description

Perceived Stress	Perception of Environmental Stressors	How would you describe the level of stress you experience during your daily trips to and from school?
	Sources of Environmental Anxiety	Do you feel anxious on your way to or from school?
Autonomy	Sense of Choice and Control	How often do you feel a sense of freedom /unrestrained during your commute to school?
	Perceived Competence	How often do you feel a sense of control /autonomy during your commute to school?
	Opportunities for Exploration and Interest	How often do you feel a sense of excitement /curiosity during your commute to school?
Social Connectedness	Quality of Peer Interaction	I am able to communicate well with my peers on the way to and from school.
	Feelings of Community Belonging	My school commute gives me the peer contact and sense of community I need.
	Perceived Supportiveness of Social Spaces	The social spaces along my school route are what I hope for.

The sixth section assessed mental health using the self-report emotional status items from the Mental Health Scale for Children and Adolescents (MHS-CA). The MHS-CA is a standardized psychological assessment tool that evaluates five dimensions of mental functioning through a set of structured questions. Due to this study focuses specifically on the emotional aspect of school-aged children's mental health, only three items related to the emotional dimension were selected for evaluation.

Table4 Mental Health Assessment Dimensions and Their Corresponding Descriptions

Left Endpoint （1）	Aspect	Right Endpoint （7）
I experience unexplained anxiety or intense fear in certain situations throughout the day, which severely affects my life.	Anxiety Experience	I live a relatively relaxed and content life, never feeling tense.
I am unable to derive any pleasure from life and feel that existence is devoid of meaning.	Pleasant Experience	I feel particularly joyful and happy, and even when facing difficulties, I believe I can overcome them.
I struggle to control my emotions, often feeling irritable, sad, prone to crying, or easily emotionally affected.	Emotional Response	My emotions remain stable, my reactions are proportionate, and I am able to manage my emotions effectively.

3.2 Data Analysis

In the preliminary stage of data analysis, subjective responses from the questionnaire were examined using IBM SPSS Statistics Version 29. Structural equation modelling was then conducted in SPSS AMOS to perform a multiple-mediator path analysis.

As the main variables in this study were measured through rating scales, several data quality checks were performed to ensure the validity of subsequent analyses. Internal consistency for each dimension was assessed using Cronbach's alpha, with the results presented in the table below. A coefficient above 0.6 is generally considered acceptable, and all values in this study ranged between 0.8 and 1, indicating excellent internal consistency (Kenny and McCoach, 2003). Model fit was evaluated using common goodness-of-fit indices. Taken together, these findings demonstrate that the proposed model shows strong overall fit.

Building on this, we assessed the convergent validity (AVE) and composite reliability (CR) of each scale dimension. Standardized factor loadings for all measurement items were obtained from the structural model, and the AVE and CR values for each dimension were then calculated using their respective formulas. All AVE values exceeded 0.50 and all CR values were above 0.70, indicating strong convergent validity.

4. Results and Discussion

4.1 Descriptive Characteristics of the Sample

The distribution of participants' gender, age, travel time to school, and travel mode is summarized in the table 5. Overall, most students across age groups spent less than 30 minutes commuting to school, and the proportion of active travel remained relatively low. Travel time generally decreases with age, whereas the share of active travel increases among older students.

The comparison by gender shows no significant difference. With respect to age, students in the primary school group exhibit slightly higher average mental health scores compared with those in the middle and high school groups. An examination of commuting time reveals a clear pattern: mental health levels increase notably as commuting time decreases. The survey also indicates that students who commute actively show considerably better mental health than those who rely on passive modes of travel. These findings are highly consistent with those reported in previous research in Japan (Nakajima *et al.*, 2024b).

Table 5. Sample Description（n=886）

		Primary School Group	Middle School Group	High School Group	Average
	Number of Participants	295	295	296	/
	Male-to-female ratio	1.153	1.021	1.242	1.135
	Age	7.3	13.5	16.7	
Travel Time	**Less Than 10 mins**	43.70%	38.10%	58.20%	46.70%
	10 Minutes to Half an Hour	32.80%	46.90%	33.60%	37.80%
	More Than Half an Hour	23.50%	15%	8.20%	15.50%
	Active Commuting	22.80%	38.7	42.60%	34.70%

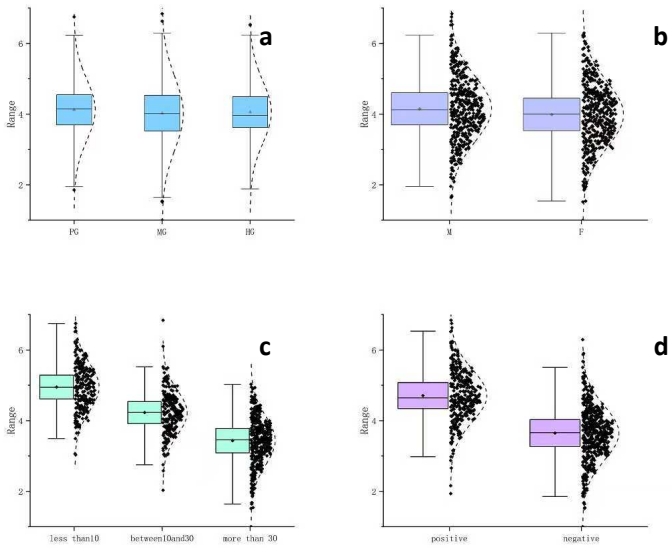


Figure 3 Comparison of Mental Health Scores Across Different Categories. Source: By the Author

4.2 Structural Equation Modelling Analysis

4.2.1 Overall Analysis

In this study, mental health was modelled as a latent variable, while the four dimensions of environmental satisfaction, perceived stress, autonomy experience, and social connectedness were specified as observed variables.

The overall model indicates that all four dimensions of environmental satisfaction exert significant indirect effects on mental health through the mediating variables. Specifically, safety shows a significant negative indirect effect on mental health through perceived stress. Autonomy experience plays a significant mediating role in the relationship between safety and mental health. Social connectedness demonstrates a significant mediating effect between diversity and mental health. Regarding perceived stress, the relative influence of the four environmental factors decreases in the following order: safety, convenience, comfort, and finally diversity.

Community security contributes most strongly to the perception of safety. Road surface conditions represent the most influential factor within the comfort dimension, which may be associated with the long winter season in Harbin where snow and ice frequently impair pavement quality, significantly affecting school commuting experiences. For convenience, the availability of public transportation is the most influential factor, aligning with findings from Pesola et al. (Pesola *et al.*, 2020). Landscape diversity exerts the greatest influence on overall environmental diversity, which is consistent with the observations of Poulain et al. (Poulain *et al.*, 2020b).

4.2.2 Structural Differences Across Age Groups

A multi-group analysis based on structural equation modelling was conducted to compare how commuting environments affect mental health across different age groups. The figure below illustrates the structural patterns through which the commuting environment influences mental health among school-aged children of varying ages.

The comparison of meaningful patterns presented in the structural differences between the overall model and age-specific models is shown below. For the younger group, the effect of perceived safety on stress is much stronger than that of the other factors. Moreover, the mediating effect of autonomous experience is relatively weak among 6–10-year-old children. In contrast, for the middle-age group, the most prominent paths from environmental comfort and convenience to autonomous experience are shown. For the oldest group, the strongest effect of environmental convenience on the perception of stress is shown. In addition, social connectedness plays a more important mediating role in this age group. Convenience and comfort also have a greater influence on mental health than safety or diversity. Within the younger group, public security is the most influential component of perceived safety, and traffic safety is the second most influential component. The convenience of public transportation was ranked as one of the most influential factors for the three age groups.

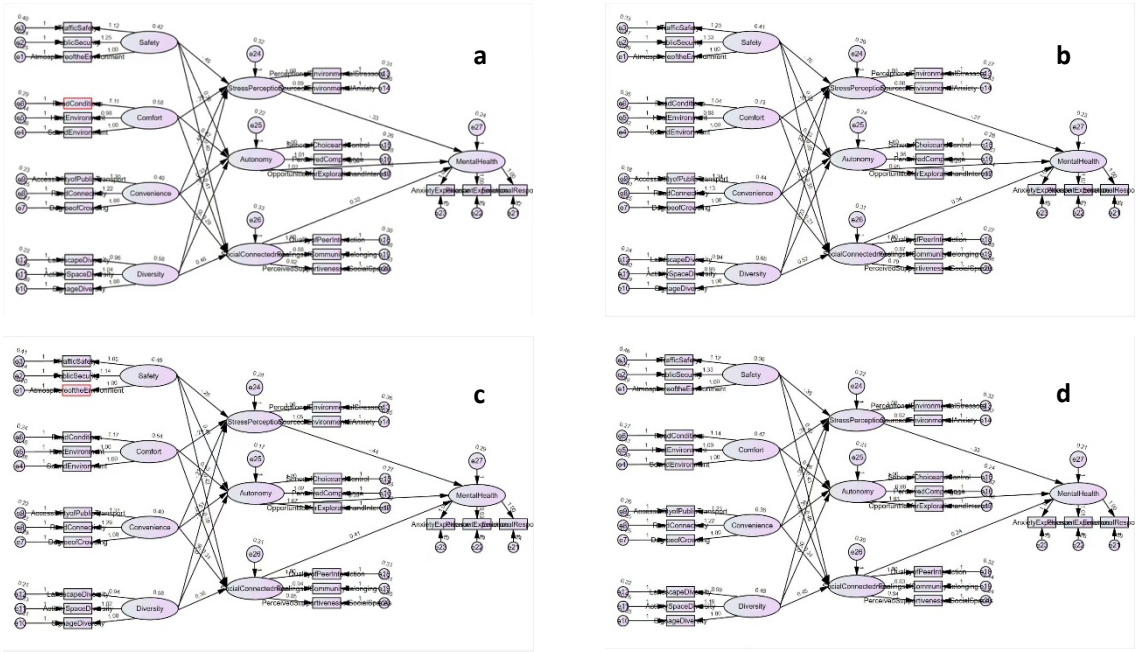


Figure 4 Structural Equation Model. Source: By the Author. a, Overall Structural Equation Model. **b,** Primary School Group. **c,** Middle School Group. **d,** High School Group**.**

5. Conclusion and Implications

This study aimed to clarify the structural relationships among the commuting environment, perceived stress, autonomous experience, social connectedness, and the mental health of school-aged children. By establishing a structural equation model, we found that the satisfaction of the four dimensions of the commuting environment have an indirect effect on mental health through perceived stress, autonomous experience, and social connectedness.

Age-stratified multi-group analyses showed that there were clear developmental differences in the mechanisms through which the commuting environment influenced mental health. For the primary school group, the path from "sense of safety - perceived stress - mental health" was most significant. For the middle school group, the path from "autonomous experience - perceived stress - mental health" was most significant. For the high school students, the path from "convenience - perceived stress - mental health" was most significant.

This study connected the satisfaction of the commuting environment with psychological well-being and perceptions of environmental use, thereby identifying which environmental elements have the greatest impact at different developmental stages, providing a basis for guidance for planners who wish to improve the commuting environment more accurately.

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