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The Impact of the Neighborhood Built Environment on the Commuting Patterns and Health of Patients with Chronic Diseases: A Case Study of Changshu, China

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Abstract: The health of patients with chronic diseases is affected not only by factors such as eating and living habits, but also by the neighborhood built environment, and by travel conditions. Using 18 blocks in the main urban area of Changshu, China, we performed structural equation modelling, to explore the relationships between the neighborhood built environment, the commuting patterns of patients with chronic diseases, and patient health. We first divided the commuting patterns into four categories—walking/biking, public transportation, electric vehicles/motorcycles, and cars—and conducted a street-scale questionnaire survey. Secondly, we divided 'health' into three latent variables—physical health, mental health, and healthy behavior—and analyzed the factors influencing the street environment. Finally, we verified our theoretical framework through a mathematical statistical analysis model. We found that: (1) service facility, environmental quality, and community safety perception in the neighborhood built environment significantly impacted commuting patterns; (2) the patient's physical health was significantly correlated with healthy behaviors and daily commuting patterns; and (3) socioeconomic attributes directly affected neighborhood environmental satisfaction, and indirectly affected the patient's health. Neighborhood environmental satisfaction also directly affected the patient's health, and there was a cross-influence relationship between these factors. We propose strengthening the walkability and connectivity of the neighborhood built environment, and improving the health awareness of patients, and their willingness to participate in healthy behaviors.

Keywords: commuter patterns; neighborhood built environment; patients with chronic diseases; SEM; Changshu City

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1. Introduction

According to survey data, nearly 60% of all patients with chronic diseases in China are working people between the ages of 20 and 60. Commuting is an important part of daily transportation for urban employees, accounting for more than 50% of total daily trips in China [1]. In the current context of rapid national economic development, urban space is expanding, and the proportion of patients with chronic diseases who choose to commute by car is on the rise. The increasing number of car-commuting trips has led to tremendous pressure on urban traffic, causing traffic congestion and environmental pollution. Simultaneously, workers' over-reliance on car commuting also increases their sedentary time, leading to insufficient physical activity, greater mental stress, and negative emotions, which can cause various health problems [2–4].

At present, both patients and national governments are paying increasing attention to national health issues. In 2016, the State Council issued and implemented China's first medium-and-long-term strategic plan in the field of health, the 'Healthy China 2030' Plan

Outline. This reflected the importance that the Chinese government attaches to national health and living environment issues.

Several researchers have explored the relationship between the built environment and travel behavior, but these studies have mostly focused on the built environment at the macro-level, such as density [5–8], diversity [9–12], design [13–16], and destination accessibility [17,18]. Environmental satisfaction comprises people's subjective satisfaction with, and psychological judgement of, changes in the surrounding environment, and it is the psychological basis of people's behavior towards the environment [19]. It is subjective because even people living in areas with the same built environment may have different levels of satisfaction and behaviors relating to their environment, due to their personal experiences, attitudes, preferences, and individual socioeconomic attributes [20].

The International Health Organization defines 'chronic disease' as a general term for chronic non-communicable diseases, mainly referring to tumors and cardiovascular and cerebrovascular diseases caused by environmental pollution, dietary habits, lifestyle, and other factors [21,22]. This study focused on three types of chronic diseases: hypertension, hyperlipidemia, and diabetes. Chronic diseases are mostly concentrated in middle-aged and elderly people, and the duration of the disease is relatively long [23]. In general, chronic diseases arise without a specific source of infection, primarily occurring due to the combined influence of various factors, such as the patient's daily life environment, behavior, eating habits, and family genetics. Therefore, patients with chronic diseases are more sensitive to their living environment than are patients with other diseases. A safe, convenient, open, and esthetically pleasing neighborhood built environment helps promote active physical activity among chronically ill patients, thereby improving their physical and mental health [24–26].

However, few studies have analyzed the relationship between commuting behavior and satisfaction with the built environment. The existing research also lacks a unified understanding of the measurement indicators for the built environment. The neighborhood environment identified in this paper refers to an area enclosed by natural boundaries or urban roads [27,28]. The land-use scale and population scale of the neighborhood environment are similar to the residential area. People in a neighborhood environment have the same sense of regional belonging and cultural identity. The built environment of the neighborhood refers to the artificially constructed physical environment within the living area of the residents. The content of the neighborhood built environment includes houses, schools, factories, parks, commercial areas, and roads. Among published studies, Humpel et al. propose that swift commute routes, subjectively identified by residents, are conducive to walking behavior [29]. Panter et al. found that an increased sense of danger when cycling or crossing the road is related to the proportion of car trips, and discourages walking behavior [30]. Others have indicated that different choices for commuting have different health effects [31–35]. In addition, some studies suggest that the choice of different commuting patterns among patients with chronic diseases will have different health effects [3,4,33–35]. The health status and health behavior of patients with chronic diseases may affect their choice of commuting pattern [36–40]. At present, scholars have focused on the impact of commuting behavior on residents' health; relatively few scholars have focused on the relationship between commuting behavior and the health status of patients with chronic diseases.

There is no consistent research conclusion on the impact of the neighborhood built environment on the choice of commuting pattern among patients with chronic diseases at home and abroad, and there is a lack of research on the correlation between the neighborhood built environment and the health status of patients with chronic diseases. Therefore, this study explored this relationship, taking Changshu City as a case study, and selecting factors such as the built-up environment of the streets at the micro-level, and the choice of commuting pattern of patients with chronic diseases. The results help expand existing research on the relationships among perceptions of the built environment, patient health, and commuting patterns. This study will help urban management departments formulate

targeted policies, and improve the health awareness of patients with chronic diseases, and their willingness to participate in healthy behaviors. It is hoped that the selection, by patients with chronic diseases, of healthy behaviors and commuting patterns, will help those patients to improve their own health.

2. Data and Methods

2.1. Data Collection

Changshu City is a county-level city in Jiangsu Province. Changshu City has 8 towns and 6 streets under its jurisdiction, with a total area of 1276.32 square kilometers. In 2020, the resident population of Changshu City was 1.677 million. With the increasing aging of the population, there were 339,200 chronic disease patients in Changshu in 2019, accounting for 20.23% of the permanent population. Changshu City has a relatively high economic level, and is at the forefront of China's county-level cities. In the past 10 years, the urban construction level of Changshu has developed rapidly. The roads and infrastructure of the city are relatively complete, and the people's living standards are generally high. The data used in this study come from the questionnaire survey on 'Physical Activity and Health Status of Chronic Disease Patients in Changshu City' conducted from December 2018 to January 2019. The survey randomly selected 18 typical communities in the main urban area of Changshu City, as case sites (Figure 1), and used random sampling to complete the questionnaire. The survey screened patients aged 18 and above, with chronic diseases, who were working full-time. The content mainly involved the patient's socioeconomic background, choice of daily commuting pattern, neighborhood built environment, and self-assessed personal health status (see Appendix A). A total of 1754 questionnaires were distributed; 1632 valid questionnaires were recovered, for an effective recovery rate of 93.04%. This study included 1632 valid responses in a regression model; Table 1 shows the socioeconomic attributes of the participants.

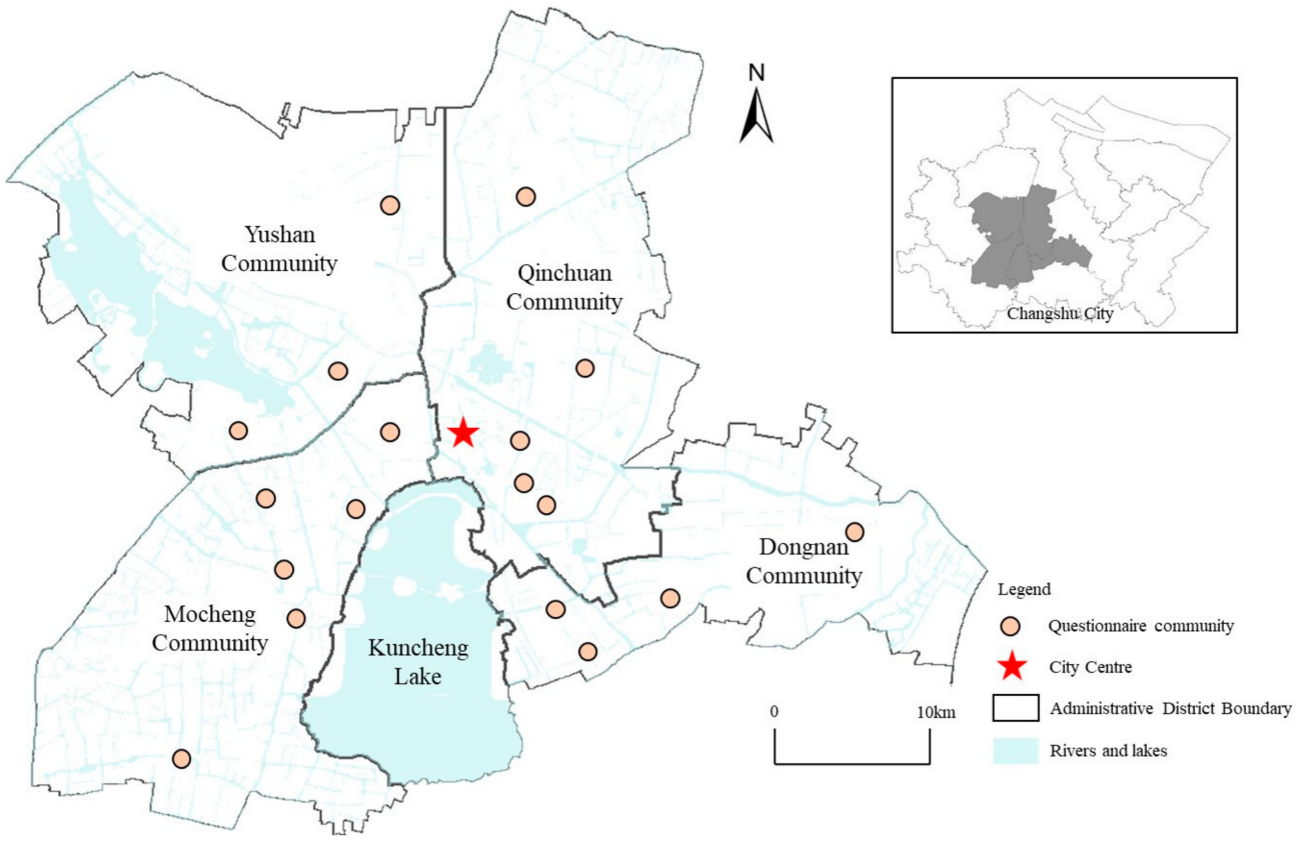

Figure 1. Distribution of the surveyed communities.

Table 1. Socioeconomic attributes of participants.

Variable	Symbol	*n* (%)	Describe	Variable	Symbol	*n* (%)	Describe
Sex	a1	972 (100)		10,001–15,000 yuan		120 (12.38)	6
Male		517 (53.22)	0	>15,000 yuan		119 (12.22)	7
Female		455 (46.78)	1	Car Owner	a4	972 (100)	
Age	a2	972 (100)	Range	No		345 (35.53)	0
Less than 31 yr		52 (5.4)	1	Yes		627 (64.47)	1
31–45 yr		230 (23.7)	2	Family population structure	a5	972 (100)	
45–60 yr		371 (38.2)	3	Less than 3		713 (73.31)	0
Above 60 yr		319 (32.7)	4	More than 4		259 (26.69)	1
Personal monthly income	a3	972 (100)	Range	Education	a6	972 (100)	
<2000 yuan		48(4.82)	1	High school/technical secondary school and below		216 (22.19)	0
2001–4000 yuan		180(18.49)	2	Bachelor/college and above		756 (77.81)	1
4001–6000 yuan		209(21.54)	3	Domicile	a7	972 (100)	
6001–8000 yuan		150 (15.43)	4	Outsider		280 (28.78)	0
8001–10,000 yuan		146 (15.11)	5	Local		692 (71.22)	1

In the process of designing the questionnaire, a number of medical ethics standards from relevant studies were used for reference [41]. These ethical standards put forward a series of requirements for the investigation of special populations. Therefore, we distributed 150 questionnaires for survey testing before the start of the survey phase. Specifically, a confidentiality option for patient privacy was added to the questionnaire content. The content of the questionnaire fully informed the respondents of the risks they faced, and of their rights. In addition, the research team conducted a full discussion before carrying out the questionnaire survey work. Possible private information included the name, age, disease type, and residential address of the patients with chronic diseases. For the content of the questionnaire, we solicited guidance and advice from medical ethics experts. In addition, the content of the questionnaire was also authorized and approved by the Changshu Health Ethics Review and Management Committee (Approval Code: 20190407001). We kept the above information strictly confidential, and promised to use it only for this research.

The participants consented to participate in a survey of their personal social and economic background and daily activity habits, and to assess their built environment. In particular, the questionnaire was anonymized, to protect the participants' privacy. This study generally examined the impact of social and economic background, and the built environment, on the medical choices of the patients. We also obtained the basic attribute information of the residential areas of the respondents, using the internet. We used a geographic information system-mapping platform to gather the spatial location and attribute information. To further protect participant privacy, we actively deleted name attributes when we obtained data through the questionnaire. This study only explored the characteristics and mechanisms of group activity, and did not conduct a differential analysis of individual patients.

We set options in the questionnaire to distinguish patients with chronic diseases, and to obtain details such as their own attributes, subjective evaluations of the patients' neighborhood built environment, and daily commuting patterns. We asked the respondents to try their best to complete the questionnaire. We analyzed the daily commuting behavior and living environment of the patients who had similar attributes, through regression models. The activities were those performed by groups of patients with similar socioeconomic backgrounds, living environments, and behavioral habits.

2.2. Research Methods

A structural equation model (SEM) is a kind of multivariate data analysis tool that examines the relationship between variables based on a covariance matrix. It is actually an extension of the general linear model, which can analyze and process multiple dependent variables at the same time. We focused on the impact of the neighborhood built environment on commuting patterns and on the health of patients with chronic diseases. The model used the patient's health level as a dependent factor, and the built environment,

as well as commuting patterns, as mediating factors. The commuting patterns could be refined into four categorical variables. As the traditional, multiple regression method had difficulty supporting the analysis in this study, the SEM used to analyze the impact of the neighborhood built environment on the choice of commuting pattern and on the health of patients with chronic diseases was through the effect size. Specifically, effects could be decomposed into direct, indirect, and total effects, each of which could explain different effects between variables [42,43].

3. Variable Selection and Theoretical Model

3.1. Variable Selection

3.1.1. Classification of Commuting Patterns

This study divided commuting patterns into four categories displayed in Table 2, based on the amount of physical activity undertaken by patients with chronic diseases. The modes of walking and bicycling produced the most physical activity, and are recognized herein as the unified commuting pattern category 'walking/bicycling'. The mode 'public transportation' involved a combination of different commuting patterns that included walking, bicycling, and using public transit, all of which include some amount of physical activity. 'Electric vehicles and motorcycles' comprised a motorized transportation mode that is most commonly used for short-distance travel, while 'automobiles' (car commuting) included the use of private cars, taxis, and unit shuttles. People who commute via automobile mode typically sit quietly during their commutes, and this mode involves the least physical activity [44–46].

Table 2. Descriptive statistics of commuting pattern variable (t). N = 972.

Commuting Pattern	Sample Size (%)	Classification
Walking/bicycling	300 (30.87)	1
Public transit	305 (31.35)	2
Electric car/motorcycle	103 (10.61)	3
Automobile	264 (27.17)	4
Total	972 (100)	

3.1.2. Exploratory Analysis of Neighborhood Built Environment Variables

The neighborhood built environment data came from a questionnaire survey, and several questions were set, for chronically ill patients' feelings about the neighborhood environment. The questionnaire options were set using a 5-point Likert scale, with 1 representing 'strongly disagree' and 5 representing 'strongly agree'. This study used SPSS 20.0 software to generate the data which reflected the built environment of the patients' locations in Changshu City. The generation ensured that the data were credible. The overall Cronbach's alpha value of the survey data on the neighborhood built environment for chronically ill patients in Changshu City was 0.676, compared with 0.695 for the standardized group.

The data showed that each item in the neighborhood built environment questionnaire was independent and acceptable. The results in Table 3 show that the Cronbach's Alpha values of the neighborhood built environment in the questionnaire were mostly less than 0.695. Thus, the data validity of each item in the neighborhood built environment questionnaire was good. To determine the feasibility of each observation variable in the neighborhood built environment, the model conducted exploratory factor analysis on the 18 indicators of the neighborhood built environment in the questionnaire. To avoid the problem of collinearity among the selected influencing factors, this study conducted Kaiser–Meyer–Olkin (KMO) and Bartlett tests on 18 variables of the neighborhood built environment. In the test results, the KMO was 0.777, and Bartlett's sphericity test value was significant at 0.000. These indicator values indicated that the differences between the options were large, and suitable for factor analysis (Table 4).

Table 3. Validity test of built environment survey data on streets where patients with chronic diseases were living.

Neighborhood Environment Satisfaction Questionnaire (Yes/No)	Symbol	Cronbach's Alpha
I can walk to the closest hypermarket or shopping mall easily and conveniently	D1	0.632
My community is surrounded by more walking roads around my community	D2	0.672
My community has more pedestrian pavement	D3	0.631
The natural landscapes around my community are attractive	D4	0.619
The cultural landscapes around my community are attractive	D5	0.623
My community suffered lots of fast-driving cars	D6	0.615
There are frequent traffic accidents around my community	D7	0.692
There are lots of obstructions around my community (such as motor vehicles occupying pavements, etc.)	D8	0.701
I can walk to the closest bus stop easily and conveniently	D9	0.655
I can walk to the closest park or street green space easily and conveniently	D11	0.621
My community is surrounded by lots of intersections	D12	0.634
My community is surrounded by lots of different roads	D13	0.639
Sanitation of roads around my community	D14	0.612
Lighting situation of roads around my community at night	D15	0.635
The streets around my community are flat	D16	0.624
My community is very safe	D17	0.615
The security of my community is very good at night	D18	0.617

Table 4. KMO and Bartlett's test.

Kaiser–Meyer–Olkin Value		0.761
Bartlett's sphere test	Approximate chi-square test	2782.433
	df	172
	Sig.	0.000

To improve the studied factors and make them more credible, we used the maximum variance method to rotate each factor orthogonally; the five common factors had a cumulative variance contribution rate of 58.22%. We further employed the rotation component matrix for data analysis (Table 5); the five common factors were respectively defined as service facility, environmental quality, road condition, traffic safety, and community safety satisfaction. They were combined together in the SEM as the latent variables of neighborhood environment satisfaction.

Table 5. Rotation component matrix of neighborhood built environment factor.

	Component Factor				
	1	2	3	4	5
D1	0.543				
D2	0.632				
D3	0.625				
D5	0.527				
D6	0.653				
D4		0.694			
D12		0.707			
D13		0.735			
D7			0.523		
D8			0.575		
D9			0.618		
D10			0.754		
D11			0.719		
D14				0.736	
D15				0.638	
D16				0.672	
D17					0.854
D18					0.848

Notes: Quantitative Model: principal component; rotation method: orthogonal rotation method with Kaiser standardization.

The model was used to analyze the perception effect, on patients with chronic diseases, of the neighborhood built environment. The mean deviation, standard deviation, and standard error of latent and observed variables are shown in Table 6. Among the five latent variables, the community safety satisfaction evaluation score was the highest, with an average value of 3.835, followed by the service facility and road condition satisfaction scores, with average values of 3.785 and 3.623, respectively. The average traffic safety satisfaction score was low, at only 2.927, while the environmental quality satisfaction score was the lowest, at just 2.683. The results showed that patients with chronic diseases in Changshu had a good perception of community safety, community service facilities, and road conditions around the community, but a poor perception of environmental quality and traffic safety.

Table 6. Mean deviation, standard deviation, and standard error of latent variables and observed variables of neighborhood environmental satisfaction.

Neighborhood Environment Satisfaction Latent Variables (Variable Symbols)	Measured Indicators of Neighborhood Environment Satisfaction	*n*	Mean	SD	SEM
Service facility satisfaction		972	3.623	0.618	0.021
	D1	972	3.572	1.072	0.036
	D2	972	4.089	0.694	0.027
	D3	972	3.272	1.089	0.032
	D5	972	3.588	0.733	0.031
	D6	972	3.762	0.757	0.029
Environmental quality satisfaction		972	2.489	0.836	0.035
	D4	972	2.978	1.082	0.049
	D12	972	2.377	1.137	0.047
	D13	972	2.186	1.089	0.028
Road situation satisfaction		972	3.389	0.478	0.01
	D7	972	3.176	0.882	0.028
	D8	972	3.279	0.807	0.027
	D9	972	3.408	0.815	0.029
	D10	972	3.532	1.017	0.032
	D11	972	3.726	0.693	0.018
Traffic safety satisfaction		972	2.845	0.752	0.027
	D14	972	3.276	1.072	0.035
	D15	972	2.163	0.836	0.031
	D16	972	2.988	1.072	0.033
Community safety satisfaction		972	3.572	0.672	0.022
	D17	972	3.581	0.754	0.018
	D18	972	3.772	0.763	0.027

3.1.3. Selection of Personal Health Variables

Related research results show that residents' choice of daily travel transportation mode is related to mental health, physical health, and body mass index (BMI) [36]. Particularly, Hansson suggests that patients with chronic diseases may not be willing or may not continue to choose walking or bicycling to commute [37]. Existing research has concluded that there is no uniform standard for the selection of patients' health variables: mental and physical health are frequently included, but studies generally lack attention to healthy behaviors [45]. Regarding the definition of the concept of health proposed by the World Health Organisation, we considered 'being healthy' primarily as being in good physical and mental condition, and having the ability to actively adapt to the social environment [47]. Therefore, we divided the patient's health into three categories—mental health, physical health, and healthy behavior—which constituted three latent variables of a comprehensive evaluation of the patient's health.

The concept of good mental health generally refers to a person's mental, emotional, and conscious aspects; good mental health is characterized by being energetic, and having positive self-esteem and good interpersonal relationships [47]. Therefore, our survey examined the participants' mental health from four aspects, to evaluate: (1) whether they

were tired; (2) whether they were inattentive and slow to respond; (3) their self-evaluation of health; and (4) whether they had good neighborhood relationships.

The latent variables of physical health included three aspects: (1) the patient's BMI; (2) whether the patient had a chronic disease; and (3) the patient's current sleep quality. BMI was calculated, in order to determine whether the participating residents were obese or overweight. 'Chronic diseases' specifically referred to typical chronic conditions, such as diabetes, hyperlipidemia, hypertension, stroke, and coronary heart disease; 'poor sleep quality' was reflected by sleep factors, such as frequent insomnia and dreams.

We also measured four aspects of healthy living behaviors: sleep time; exercise and fitness; housework; and going for a walk. Research has revealed that length of sleep will directly affect the patient's physical and mental health, and that insufficient sleep time will increase the patient's BMI value [48], which also has an indirect impact on the patient's choices of commuting methods. A patient's daily physical activity level and health perception can be measured from three aspects: daily walking; fitness exercise; and housework activities. These factors may also influence the choice of daily transportation and commuting patterns. The descriptive statistical results of the patients' personal health variables are shown in Table 7.

Table 7. Descriptive statistics of the patients' health variables.

Personal Health Latent Variable	Personal Health Observed Variables	Symbol	Sample Size (%)	Variable Description
Mental health	Fatigued and easily tired	b1	972 (100)	Logical
	No		831 (85.53)	0
	Yes		141 (14.47)	1
	Inattention and slow reaction	b2	972 (100)	Logical
	No		867 (89.23)	0
	Yes		105 (10.77)	1
	Self-rated health satisfaction	b3	972 (100)	Grade
	not good		35 (3.70)	1
	normal		344 (35.37)	2
	good		463 (47.59)	3
	very good		130 (13.34)	4
	Neighborhood relations	b4	972 (100)	Grade
	poor		18 (1.77)	1
	fine		608 (62.54)	2
	good		306 (31.51)	3
	very good (close)		40 (4.18)	4
Physical health	BMI [a]	b5	972 (100)	Grade
	lean or normal weight		614 (63.18)	1
	overweight		289 (29.74)	2
	obesity		69 (7.07)	3
	Suffering from chronic diseases	b6	972 (100)	Logical
	no		853 (87.78)	0
	yes		119 (12.22)	1
	Poor sleep quality	b7	972 (100)	Logical
	no		791 (81.35)	0
	Yes		181 (18.65)	1
Healthy daily habits	Sleeping time	b8	972 (100)	Continuous
	Work out	b9	972 (100)	Logical
	no		727 (74.76)	0
	yes		245 (25.24)	1
	Does housework	b10	972 (100)	Logical
	no		322 (33.12)	0
	yes		650 (66.88)	1
	Daily walk	b11	972 (100)	Logical
	no		589 (60.61)	0
	yes		383 (39.39)	1

Notes: According to 'Management Measures for Nutrition Improvement Work (Health and Disease Control [2010] No. 73)', issued by the Ministry of Health in 2010, [a] BMI means body mass index, BMI = weight (kg)/height $(m)^2$, BMI scores indicate nutrition status related to obesity as *obesity*, ≥28; *overweight*, 24–28; *normal* 18.5–23; *underweight*, <18.5.

3.2. Theoretical Model

Due to the different life experiences, attitude preferences, and socioeconomic attributes of the patients, despite living in the same community, they chose different daily commuting patterns. Therefore, it was necessary to further explore the mechanism behind the patients' daily commuting patterns. Specifically, it was necessary to study the influence of individual patients' daily health behaviors and habits on their choice of transportation mode. Studies have found that social and economic attributes such as gender, age, income, education level, and car ownership have a significant impact on individuals' commuting patterns [5,49]. Therefore, it was necessary to consider the common influencing factors, including the patient's street environment satisfaction, the patient's healthy daily habits satisfaction, and other factors in the relevant models that may have influenced the patient's travel patterns.

In summary, the theoretical model framework proposed in this study is shown in Figure 2. The research assumed that socioeconomic attributes had a direct impact on transportation and commuting patterns. Socioeconomic attributes may have had a direct impact on the patient's satisfaction with the neighborhood environment, and an indirect impact on the patient's daily commuting pattern. At the same time, the patient's daily commuting pattern may also have had a direct impact on the patient's satisfaction with the neighborhood environment. In addition, the patient's satisfaction with the neighborhood environment had a direct impact on the patient's daily commuting pattern, and an indirect impact on the patient's physical and mental health. A structural equation model was constructed, to verify the above assumptions.

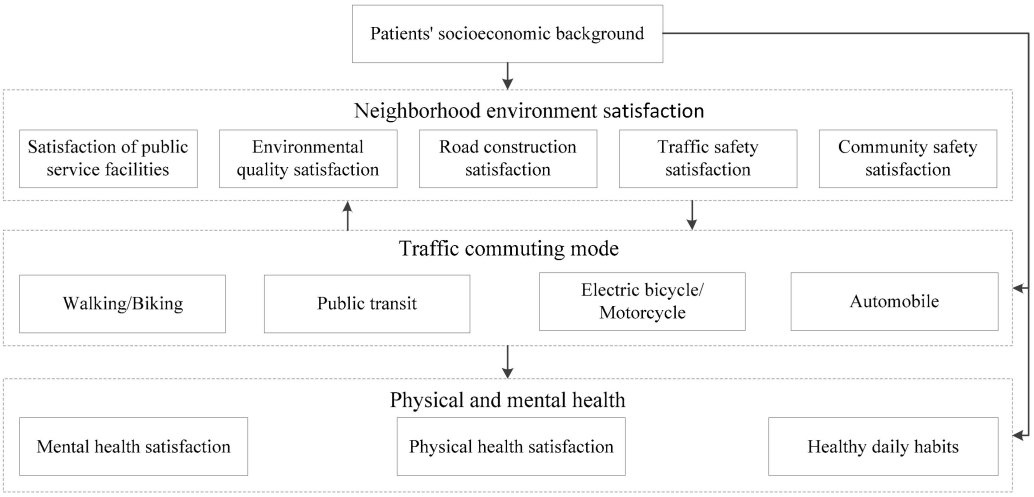

Figure 2. Model framework of the influence of neighborhood environment satisfaction on patients' daily commuting patterns and health.

4. Results and Discussion

4.1. SEM Fit Index

This study established the initial model through AMOS 20.0 software, used the maximum likelihood method to estimate the data, and obtained the final model after model evaluation and correction. The Chi-square value was 75.845, the degree of freedom was 55, and the *p*-value significance was 0.033, indicating that the final model was very close to the optimal model. When evaluating the SEM fitness index, we comprehensively considered three types of fitness indicators—absolute fitness, value-added fitness, and simplified fitness—and compared the model results with actual data. We also measured the consistency of data fitting [42]. Comparing the model fit index with the reference value (Table 8), we found that the fit effect of the model met the experimental expectations.

Table 8. Model fitness index.

Fit Index	Reference Value	Model Results
Absolute Fit Index	*p*	
χ^2	<0.05	0.33
RMR	<0.05	0.042
RMSEA	<0.05	0.031
GFI	>0.90	0.926
AGFI	>0.90	0.907
Value-added fitness index		
IFI	>0.90	0.897
NFI	>0.90	0.821
RFI	>0.90	0.808
TLI (NNFI)	>0.90	0.903
CFI	>0.90	0.911
Parsimonious fit index		
PGFI	>0.5	0.672
PNFI	>0.5	0.661
NC (χ^2 freedom ratio degree, CMIN/DF	1–3	1.512

4.2. Impact of Neighborhood Environmental Satisfaction on Daily Commuting Pattern and Personal Health

Neighborhood environmental satisfaction directly affected the patient's daily commuting pattern. It also indirectly affected the patient's health, by influencing the patient's daily commuting pattern (Table 9). We further analyzed the specific impact of neighborhood environment satisfaction on the patient's commuting pattern, and found that service facilities satisfaction had a significant negative correlation effect on the patient's commuting pattern. The results showed that when patients were satisfied with the service facilities in their living environment, they were more likely to choose walking/biking as their daily commuting pattern. The composition of good service facilities included commercial service facilities, leisure service facilities, street lighting, and other infrastructure in the neighborhood environment, as well as public transportation service facilities. Among them, commercial service facilities, leisure landscape service facilities, street lighting, and other infrastructure could help improve the travel environment for slow traffic, and could effectively improve the patient's willingness to walk/ride, and the patient's frequency of walking/riding. In addition to service facility satisfaction, the patient's daily commute pattern was also directly affected by the patient's level of environmental quality satisfaction. The model results show that when patients were satisfied with the level of their neighborhood environment, they were more likely to choose the walking/biking commute pattern. Community safety satisfaction had a significant positive direct effect on the patient's choice of commuting pattern. The higher the patient's recognition of the community as being safe, the more likely the patient was to choose the car for daily commuting. The level of the patient's satisfaction with the roads around the patient's residential area also had a significant positive and indirect effect on the patient's commuting pattern. Specifically, the greater the patient's satisfaction with road facilities, the more likely the patient was to choose commuting modes such as walking. However, traffic safety satisfaction did not significantly influence the patient's commuting pattern.

Moreover, the results showed that the patient's satisfaction with the neighborhood environment also significantly correlated with the patient's health status. Specifically, the quality of the living environment had a significant positive direct association with the patient's mental health and healthy behavior. The results showed that the higher the patient's satisfaction with the community's environmental quality, the higher the patient's mental health level. At the same time, the patient was more likely to engage in healthy behaviors, such as exercise, fitness, and walking. The patient's satisfaction with road conditions had a significant positive direct effect on the patient's mental health and physical health. The results showed that the more satisfied the patient was with the road conditions, the better was the patient's mental and physical health. In addition, the patient's perception of traffic safety also had a significant positive effect on the patient's

mental health. That is, the better the patient's perception of traffic safety, the better the patient's mental health. Studies have shown that patients who have a good perception of the safety of the community environment are healthier [19], but the impact of the perception of community safety on the health of the patients in this study was not significant.

Table 9. Direct, indirect, and total effects of neighborhood environmental satisfaction on commuting patterns and individual health.

Variable Symbol	Concrete Effect	Service	Environment	Road	Traffic	Community
t	Overall effect	−0.119 **	−0.047 *	−0.021	−0.016	0.042
	Direct effect	−0.121 **	−0.053 *	−0.042	−0.012	0.043 *
	Indirect effect	−0.003	−0.006	0.021 *	−0.006	−0.002
Physical	Overall effect	−0.03	0.025	0.097 *	0.017	0.003
	Direct effect	−0.03	0.025	0.097 *	0.017	0.003
	Indirect effect	–	–	–	–	–
Mental	Overall effect	−0.069	0.113 *	0.218 **	0.113 *	0.032
	Direct effect	−0.072	0.113 *	0.218 **	0.113 *	0.032
	Indirect effect	–	–	–	–	–
Behavioral	Overall effect	−0.058	0.100 *	0.011	−0.143	−0.032
	Direct effect	−0.058	0.100 *	0.011	−0.143	−0.032
	Indirect effect	–	–	–	–	–

Notes: The above values are all standardized values; * significant at the 10% confidence level; ** significant at the 5% confidence level; – indicates that there was no such relationship in the model.

4.3. Impact of Commuting Pattern on Patients' Health

The effects of daily commuting patterns on the health status of the patients with chronic disease is shown in Table 10, including a significant positive direct effect on their health behavior. The model analysis results show that the patients with chronic diseases who chose to commute by car were in better health. The possible reason was that the self-driving commute mode required the patient to have good sleep quality and stay energized. The patient could cope with the stress of traffic congestion and high-energy concentration during car commutes. Moreover, patients with chronic diseases who paid more attention to healthy behaviors were less likely to choose the car commute mode; a possible reason was that these patients could better integrate physical activity into their daily life by using walking and cycling to commute, without the need for a fixed time and place of exercise. In addition, the commuting patterns of chronically ill patients had no significant effect on their mental health.

Table 10. Total, direct, and indirect effects of patients' commuting patterns on health.

Variable Symbol	Concrete Effect	Mental	Physical	Behavioral
t	Overall effect	−0.037	0.118 *	0.042 **
	Direct effect	−0.037	0.118 *	0.042 **
	Indirect effect	...	...	...

* Significant at the 10% confidence level; ** significant at the 5% confidence level; ... indicates that there was no such relationship in the model.

4.4. Correlation Analysis of Patients' Socioeconomic Attributes with Neighborhood Environmental Satisfaction, Commuting Choices, and Health

The standardized correlation coefficient of path internal/external relationship is shown in Tables 11 and 12. From the model analysis results, it can be seen that factors such as patient gender, income level, and car ownership had a significant negative impact on neighborhood environmental satisfaction, while patient family income, education level, and family structure had a significant positive impact on neighborhood environmental satisfaction. Neighborhood environment satisfaction had a significant positive impact on walking/bicycle commuting patterns, and had a synergistic positive impact on the patient's physical health and healthy habits. Neighborhood environment satisfaction had a significant negative impact on bus travel mode, indicating that patients in a good neighborhood built environment were more inclined to choose walking/bicycle travel mode.

Table 11. Standardized correlation coefficient of path internal relationship.

Path Internal Relationship	Coefficient	Path Internal Relationship	Coefficient	Path Internal Relationship	Coefficient
Sex→Neighborhood environment satisfaction (e1)	−0.960	Neighborhood environment satisfaction→ Automobile (e8)	0.784	Public transit→Mental health (e15)	0.156
Car ownership→Neighborhood environment satisfaction (e2)	−0.518	Neighborhood environment satisfaction→ Public transit (e9)	−0.731	Walking/Biking→Physical health (e16)	0.834
Family structure→Neighborhood environment satisfaction (e3)	0.044	Walking/Biking→ Neighborhood environment satisfaction (e10)	0.791	Automobile→Physical health (e17)	0.672
Education level→Neighborhood environment satisfaction (e4)	0.394	Automobile→Neighborhood environment satisfaction (e11)	0.843	Public transit→Physical health (e18)	0.472
Monthly Income→Neighborhood environment satisfaction (e5)	−0.425	Public transit→Neighborhood environment satisfaction (e12)	0.672	Walking/Biking→Healthy daily habits (e18)	0.533
Household registration→Neighborhood environment satisfaction (e6)	0.195	Walking/Biking→Mental health (e13)	0.101	Automobile→Healthy daily habits (e19)	0.726
Neighborhood environment satisfaction→Walking/Biking (e7)	0.356	Automobile→Mental health (e14)	0.156	Public transit→Healthy daily habits (e20)	0.567

Table 12. Standardized correlation coefficient of path external relationship.

Path External Relationship	Coefficient	Path External Relationship	Coefficient	Path External Relationship	Coefficient
e7←→e10	0.408	e12←→e13	0.257	e17←→e18	−0.189
e8←→e11	0.367	e13←→e14	0.413	e18←→e19	−0.117
e9←→e12	0.353	e15←→e13	0.334	e18←→e16	−0.165
e10←→e13	0.272	e16←→e14	0.285	e16←→e20	−0.136

Table 13 reflects the direct, indirect, and overall effects of the patients' socioeconomic attributes on their commuting pattern, neighborhood environmental satisfaction, and personal health. Socioeconomic attributes directly affected the patients' choice of commuting pattern. Socioeconomic background affected the patients' satisfaction with their neighborhood environment, and indirectly affected their choice of daily commute mode, and their health. In addition, socioeconomic attributes, gender, car ownership, family population size, education level, and household registration all had significant direct effects on the choice of commuting pattern. Among these, gender had a significant negative effect on the commuting pattern, indicating that female patients were more willing to choose the walking/bicycle commuting pattern than male patients. Car ownership had a significant positive direct effect on the choice of commuting pattern. The patients who owned cars in their families were more inclined to choose the car as the mode of transportation for daily commute. The family population structure and the location of the household registration had a significant positive direct effect on the choice of commuting by car. It showed that the patients with larger families and local household registration were more willing to choose the car as their commuting pattern. The specific reason was that the larger the number of families, the greater the demand for car use. The patients with local household registration had better economic conditions, and could afford the cost of commuting by car. Those patients were therefore more likely to choose cars for commuting. In addition, the results showed that the patients with higher education were more likely to choose the car-commuting pattern. The interaction pattern is shown in Figure 3.

Table 13. Total, direct, and indirect effects of social and economic attributes on commuting patterns, neighborhood environmental satisfaction, and individual health.

Variable Symbol	Concrete Effect	a1	a2	a3	a4	a5	a6	a7
t	Overall effect	−0.157 ***	−0.012	0.053	0.201 ***	0.085 **	0.14 **	0.099 **
	Direct effect	−0.158 ***	−0.015	0.051	0.185 **	0.094 **	0.129 *	0.091 **
	Indirect effect	0.001	0.004	0.001	0.016	−0.006	0.011	0.009
Road	Overall effect	−0.117 **	−0.006	−0.105 **	0.115 **	−0.012	−0.089	0.002
	Direct effect	−0.117 **	−0.006	−0.105 **	0.115 **	−0.012	−0.089	0.002
	Indirect effect	…	…	…	…	…	…	…
Traffic	Overall effect	−0.017	0.172 **	0.037	−0.066	0.133 **	0.106 *	−0.036
	Direct effect	−0.017	0.172 **	0.037	−0.066	0.133 **	0.106 *	−0.036
	Indirect effect	…	…	…	…	…	…	…
Service	Overall effect	0.045	−0.003	−0.017	−0.064 *	0.014	−0.044	−0.032
	Direct effect	0.045	−0.003	−0.017	−0.064 *	0.014	−0.044	−0.032
	Indirect effect	…	…	…	…	…	…	…
Environment	Overall effect	0.131 ***	0.097 **	−0.01	0.01	−0.061	0.076	0.117 ***
	Direct effect	0.131 ***	0.097 **	−0.01	0.01	−0.061	0.076	0.117 ***
	Indirect effect	…	…	…	…	…	…	…
Community	Overall effect	−0.034	0.065	−0.065	0.175 ***	0	0.052	−0.044
	Direct effect	−0.034	0.065	−0.065	0.175 ***	0	0.052	−0.044
	Indirect effect	…	…	…	…	…	…	…
Mental	Overall effect	0.034 *	0.032 *	0.025	−0.026	0.008	0.045 **	0.010
	Direct effect	…	…	…	…	…	…	…
	Indirect effect	0.034 *	0.032 *	0.025	−0.026	0.008	0.045 **	0.010
Physical	Overall effect	−0.012	0.004	−0.007	0.011	−0.001	−0.003	0.003
	Direct effect	…	…	…	…	…	…	…
	Indirect effect	−0.012	0.004	−0.007	0.011	−0.001	−0.003	0.003
Behavioral	Overall effect	−0.011	−0.032 *	−0.001	0.005	−0.01	−0.02	−0.004
	Direct effect	…	…	…	…	…	…	…
	Indirect effect	−0.011	−0.032 *	−0.001	0.005	−0.01	−0.02	−0.004

Notes: The above values are all standardized values; * significant at the 10% confidence level; ** significant at the 5% confidence level, *** significant at the 1% confidence level; … indicates that there was no such relationship in the model.

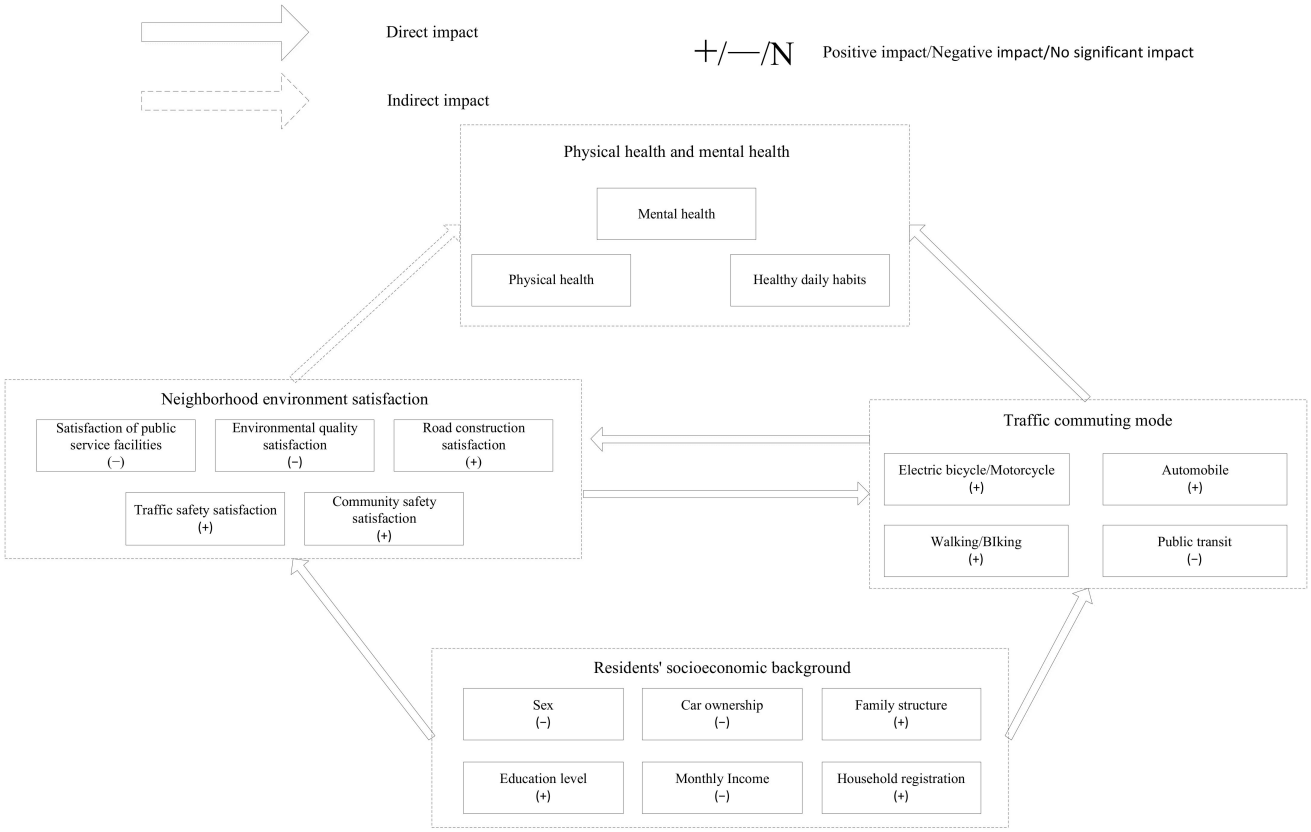

Figure 3. Interaction pattern diagram of social and economic attributes on commuting patterns, neighborhood environmental satisfaction, and individual health.

The patient's social and economic background affected the patient's satisfaction with the surrounding environment and choice of commuting pattern, thereby affecting personal health behaviors. Gender factors had a significant positive direct effect on the patient's neighborhood environmental satisfaction. There was a significant negative direct effect on satisfaction with road conditions: that is, female residents' satisfaction with environmental quality was better than that of male patients, and their satisfaction with road construction quality was worse than that of male patients. Age had a significant positive direct effect on the perception of environmental quality and traffic safety: the older the patient, the better the perception of environmental quality and traffic safety. The patient's monthly income had a significant negative direct effect on the perception of road conditions: the higher the patient's monthly income, the lower the patient's satisfaction with the street environment. There was a significant negative direct effect between car ownership rate and service facility satisfaction. The patients who owned cars had a relatively wider range of daily travel, and the types and choices of service facilities that could be used were wider. The patient's subjective evaluation of facilities near the community was correspondingly reduced.

In addition, socioeconomic attributes indirectly affected the health of the patients, by affecting their commuting patterns. This effect came from the patients' level of environmental perception, and the choice of commuting pattern. Gender had a significant positive direct effect on road environmental perception, and a significant negative direct effect on road conditions perception: that is, female patients with chronic diseases had a better perception of environmental quality than male patients. Women's perception of road conditions was worse than that of men with chronic diseases.

Age had a significant positive indirect effect on the patient's mental health. However, there was a significant negative indirect effect on the patient's daily healthy living habits, indicating that the older patients had better mental health levels than the younger patients, but less sleep and exercise; their frequency of healthy behaviors, such as fitness, was lower than that of the younger patients. In addition, the result showed that education level had a significant positive and indirect effect on the patient's mental health: that is, the mental health of the patients with high education was generally better than the mental health of the patients with low education.

The patient's monthly income had a significant negative direct effect on the patient's perception of road conditions—that is, the higher the patient's monthly income, the worse was the perception of road conditions, in patients with chronic diseases. Car ownership had a significant negative direct effect on the perception of service facilities: that is, the level of community service was perceived by patients with chronic diseases, who owned a car, to be worse. The possible reason was that chronically ill patients with cars had a wider range of daily travel space, could reach more high-level service facilities, and made a correspondingly lower evaluation of community-level infrastructure services. At the same time, there was a significant positive direct effect between car ownership and the patient's perception of road status and community safety. A possible explanation was that the street environment where families with cars were located was generally better, and their perception level was also better. Family demographics and higher education had significant positive direct effects on the patient's perception of traffic safety. The patients with chronic diseases, who had a larger family population and higher education, experienced better traffic safety. At the same time, household registration had a significant positive direct effect on the perception of environmental quality. The results show that the patients with chronic diseases who had local household registration had a better perception of environmental quality than those with non-local household registration.

5. Conclusions

5.1. Key Findings

In this study, we used the SEM to analyze the impact of neighborhood environment perception, personal health, and socioeconomic attributes, at the micro-level, on the daily

commuting patterns and health of patients in the city of Changshu. The following research conclusions were obtained:

(1) The patient's satisfaction with the neighborhood environment had a significant impact on the patient's choice of commuting pattern. Specifically, service facility satisfaction and environmental quality satisfaction in the neighborhood environment satisfaction measurement index had a significant negative direct effect on the patient's choice of commuting pattern. The patient's level of community safety satisfaction had a significant positive direct effect on the patient's commuting pattern. At the same time, the patient's daily commuting pattern also had a direct impact on the patient's satisfaction with the neighborhood environment.

(2) Among the health variables, the patient's physical health was significantly correlated with healthy behaviors and daily commuting patterns.

(3) Among the socioeconomic attributes, gender, car ownership, family population size, education level, and household registration had a significant influence on the patient's choice of commuting pattern.

(4) Socioeconomic attributes had a direct effect on neighborhood environmental satisfaction, and an indirect effect on the patient's health. Neighborhood environmental satisfaction also had a direct effect on the patient's health. In addition, the patient's satisfaction with the neighborhood environment had a direct impact on the patient's daily commuting pattern, and an indirect impact on the patient's physical and mental health. There was a cross-influence relationship between these influencing factors.

5.2. Implications

The results and discussion of the findings of this study show that the patients' commuting patterns had a significant impact on their health levels. Thus, we suggest that the relevant city management departments organize more health promotion activities and national fitness activities, to increase health awareness and patients' willingness to participate in health behaviors, and that they implement policies to guide more patients to actively choose the walking/bicycle commuting pattern.

Based on these research findings, we believe that a 'people-oriented' concept should be embodied in the planning and construction of the urban built environment. We need to improve patients' subjective perceptions of the built environment. Governments need to pay more attention to service facilities and environmental quality in the urban built environment. Patients' physical and mental health can be further improved by improving community service facilities, effectively improving patients' subjective feelings about the community environment, and attracting patients towards adopting a healthier and greener commuting pattern.

5.3. Limitations and Future Research Directions

Although the research yielded some meaningful findings, there were also some limitations. We measured three aspects of chronic disease patients' health: their mental health, physical health, and healthy behavior. However, due to the complexity of personal health measurement standards, the health indicators considered in this article were still not comprehensive enough. We intend to establish a more systematic and comprehensive indicator system for future research, to explore the causal relationship between the patient's own health and the patient's commuting pattern, in future.

In addition, this paper took 'residential quarters' as the survey unit. The physical spatial extent of these residential communities may not be consistent with the extent of the patient's living space. Therefore, this would lead to the occurrence of the Uncertain Geographical Environment Problem (UGCoP). Different spatial unit scales would lead to deviations in the correlation analysis results between the influencing factors. Therefore, we will conduct in-depth survey interviews, or use GPS devices, to record detailed trajectory data in the follow-up study. This kind of method can more accurately reflect the scope of daily life and the patient's activity trajectory. This refined survey method can help us

capture the extent of the patient's actual living environment, and the different elements of the neighborhood built environment. The fine-grained activity data will help us to find the mechanism of the neighborhood built environment, based on the commuting patterns and patients' health.

Based on past research, this paper looked deeply into the impact mechanism of the neighborhood built environment on daily traffic patterns and the health of patients with chronic disease. The research results of this paper enrich the related research in this field in China. On the one hand, when health geography studies the impact of the environment on people, it should pay more attention to the feelings of special groups of people, in regard to the environment, and consider the actual activities of people in time and space. On the other hand, this study also has a certain significance for community planning and management. Firstly, community-planning research needs to pay attention to the intervention effect of the environment on health, and incorporate public health into the decision-making factors of transportation and urban planning. Secondly, urban communities need to strengthen the construction of slow-moving transportation systems, provide more convenient transportation facilities for special groups of people who are sick, and promote their healthy behaviors: for example, by improving urban road design, improving the landscape comfort of slow-moving streets, and deploying more safety facilities on community streets. Improvements to the built environment of their neighborhoods can help encourage residents to travel in healthier ways. Thirdly, there is a need to promote the mutual communication of community residents, and to enhance the overall cohesion of the community. Relevant community party branches and neighborhood committees can hold voluntary services, cultural and sports activities, health education lectures, and other activities. These activities can promote the formation of a healthy and positive community spirit and culture among community members, in the long-term, and a frequent communication process.

In general, the health level of patients with chronic diseases is affected by a combination of factors. The patient's daily commuting patterns are also related to various factors, such as socioeconomic attributes and neighborhood environmental satisfaction. Factors such as the research time, the case location, the sample size, and social and cultural customs also had a direct or indirect impact on the results of this study. The survey period and the space environment limited the results.

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Appendix A. Questionnaire about Commuting Pattern for Chronic Disease

Dear Mr/Mrs,

Here is a questionnaire on daily commuting patterns and traffic behavior. We would like to thank you for your participation in this survey. Your active participation will help the investigation run smoothly. We assure you that the following survey results are only used for academic research and academic exchange activities. Our research results will not be used for commercial purposes. At the same time, the questionnaire data will not be disclosed to the public, and your personal information will be kept strictly confidential. Therefore, please be sure to fill in this questionnaire truthfully.

Thank you very much for your help with this investigation.

Section I Basic information

1. Please select your sex?
☐ Female ☐Male
2. Please select your age?
☐above 60 yr ☐45–60 yr ☐31–45 yr ☐Less than 31 yr
3. Please select your education level?
☐Bachelor degree and above ☐High school ☐Junior high school ☐Primary school and below
4. How many people living in your house?
☐Four and above ☐Three wo or below
5. How much is your personal monthly income (RMB)?
☐Below 2000 ☐2001–4000 ☐4001–6000 ☐6001–8000 ☐8001–10,000 ☐10,001–15,000 ☐15,000 and above
6. What type of transportation do you use for your daily commute?
☐Bus ☐Bicycle ☐Car ☐Walking ☐Others
7. Do you have a local account?
☐Yes ☐No
8. Would you willing to participate in our survey?
☐Yes ☐No

Section II Your satisfaction on neighborhood environment

9. Do you feel that there are sufficient supermarkets or shopping malls in the living area?
☐Yes ☐No
10. Do you feel convenient to walk to the nearest bus station?
☐Yes ☐No
11. Do you feel convenient to walk to the nearest street green space or park?
☐Yes ☐No
12. Are there many intersections around your community?
☐Yes ☐No
13. Are there many different roads around my community?
☐Yes ☐No
14. Are there many sanitation of roads around your community?
☐Yes ☐No
15. Do you satisfied with the lighting situation of roads around my community at night?
☐Yes ☐No
16. Are the streets around your community are flat?
☐Yes ☐No
17. Are there more walking roads around my community?
☐Yes ☐No
18. Are there more pedestrian crossing facilities around your community?
☐Yes ☐No
19. Are there attractive natural landscapes around your community?
☐Yes ☐No
20. Are there attractive cultural landscapes around your community?
☐Yes ☐No
21. Are there many fast-driving cars around your community?
☐Yes ☐No
22. Are there frequent traffic accidents around your community?
☐Yes ☐No
23. Do there have many road obstacles in your living environment that make you feel inconvenient to walk/riding?
☐Yes ☐No
24. Is the security around your community very good?
☐Yes ☐No
25. Do you think the law and order situation in the living area is good?
☐Yes ☐No

Section III Your satisfaction on individual health

26. Do you feel fatigued and tired easily for a long time?
☐Yes ☐No
27. Do you feel inattention and slow reaction?
☐Yes ☐No
28. What do you think of your individual health?
☐Not good ☐Normal ☐Good ☐Very good
29. How is your relationship with your neighbors?
☐Poor ☐Fine ☐Good ☐Very good(close)
30. How is your physical fitness index?
☐Lean or normal ☐Weight ☐Over weight ☐Obesity
31. Are you suffering from chronic diseases?
☐Yes ☐No

Section III Your satisfaction on individual health
32. What types of chronic diseases do you have? (multiple options)
☐Hypertension ☐Hyperlipidemia ☐ Diabetes ☐Cardiovascular disease ☐Other
33. Are you suffering from poor sleep quality?
☐Yes ☐No
34. Do you have the habit of regular exercise and fitness?
☐Yes ☐No
35. Do you have the habit of doing housework frequently?
☐Yes ☐No
36. Do you have the habit of taking regular walks?
☐Yes ☐No

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