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Assessment and Countermeasures of the Impact of Travel Patterns on Obesity Problems of Urban Residents

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KEYWORDS

Obesity,
Travel Patterns,
Urban Transportation,
GWR Model,
OLS Model

ABSTRACT

This study examines the relationship between travel modes and residents' obesity in Wuhan, using data from 93 streets. Travel modes (walking, cycling, public transit, and car travel) were analyzed alongside BMI as an indicator of obesity. Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models revealed the following: (1) Walking, cycling, and public transit distances were negatively correlated with obesity, with walking and cycling having stronger effects than public transit, while car travel showed a positive correlation. (2) Public transit station density was positively correlated with obesity and influenced the relationship between travel modes and obesity. Areas with higher station density showed stronger correlations with public transit and car travel distances, while lower station density areas emphasized walking and cycling. (3) Obesity levels varied significantly across regions. Further research is needed to validate these findings and explore the complex dynamics of urban travel and obesity.

1. Introduction

Obesity is the main cause of illness and premature death worldwide (Finkelstein et al., 2009; Friedenberg, 2002; Goldner, 1956), even considered as global epidemic and recognized as a multi-system public health issue (Su et al., 2017). Obesity increases the risk of various chronic diseases such as type 2 diabetes, hypertension, dyslipidemia, coronary heart disease, and certain types of cancer. As of 2010, it was estimated that overweight and obesity caused 3.4 million deaths globally, accounting for 3.9% of years of life lost and 3.8% of disability-adjusted life years. Due to established health risks and increased prevalence of obesity-related diseases, obesity has become a major global health concern. The World Health Organization has developed the "Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020," which includes strategies to curb the rising global obesity rates and bring them back to the levels of 2010 ("Global NCD Action Plan | WHO FCTC," n.d.). Data shows that by 2023, the number of obese individuals in China has already exceeded 250 million. The proportion of overweight adults in China is approximately 20%-30%, and in large cities, due to improved living standards, this proportion has reached 35%-40%. There has been a

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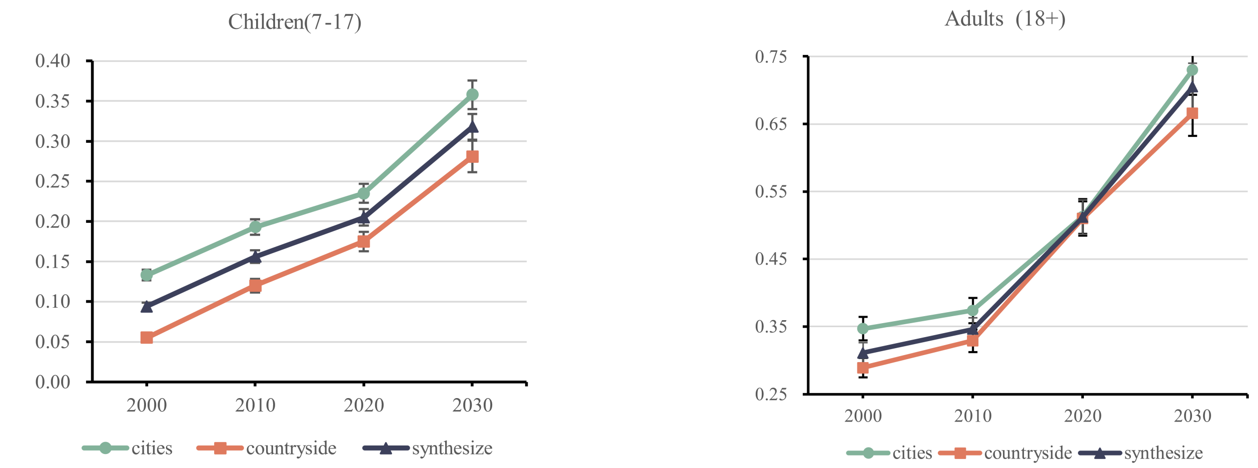

Figure 1 | Obesity rates by age (with projections)

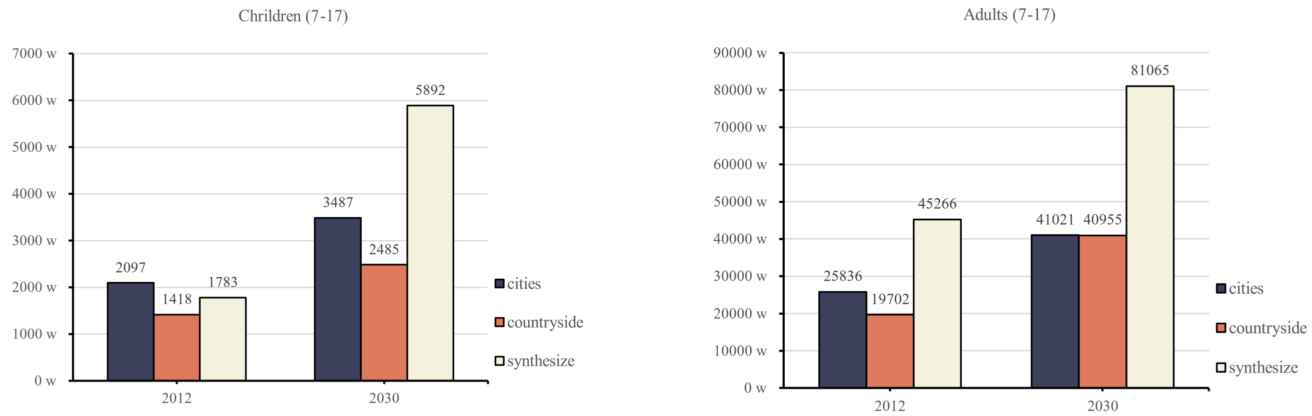

Figure 2 | Prevalence map of obese people in China (with projections)

surge in chronic diseases such as hypertension, fatty liver, diabetes, and cardiovascular diseases caused by obesity, making it an invisible killer of public health in China.

The following are predictions of obesity rates and incidence rates for residents of different age groups in rural and urban areas, as shown in Figure 1. It can be observed that patients with obesity account for a large proportion in both adult and children's populations, with urban residents having significantly higher obesity rates than rural residents, and the proportion of obese individuals is increasing year by year. Figure 2 shows the number of obese individuals in China with corresponding disease incidence, indicating that the disease incidence among urban obese individuals remains higher than that of rural areas, and it is expected to continue rising in the future. Therefore, it is worth studying and exploring prevention and control measures for the societal health issue of obesity. In this context, our team takes residents' daily commuting patterns as a starting point to study the relationship between commuting patterns and obesity issues, and based on this, propose relevant recommendations to provide a theoretical basis for the effective control of global obesity problems.

2. Literature Review

Researchers have conducted extensive studies on the factors influencing obesity. Foster et al. (2018) investigated the impact of transportation noise on obesity and metabolic disorders, finding that long-term exposure to road traffic noise increases the risk of obesity. Similarly, Mundorf et al. (2018) argued that targeted communication can encourage different population groups to adopt active and sustainable transportation modes, helping to mitigate rising obesity rates. An et al. (2020) reviewed evidence linking economic globalization to obesity, evaluating this relationship at the national level using longitudinal and cross-sectional research designs. Li Xin et al. (2022) examined the risk of ischemic heart disease, a major obesity-related condition, by analyzing multiple data sources in Wuhan and assessing the built environment of communities. Squalli (2017) explored the link between obesity and greenhouse gas emissions, emphasizing the role of transportation patterns in reducing environmental impact. Additionally, Glazier et al. (2014) highlighted the importance of walkable urban environments in addressing physical inactivity, overweight, and obesity, underscoring the role of urban planning in promoting public health.

With extensive research on obesity, scholars have been analyzing and assessing the relationship between obesity and various influencing factors from different perspectives. The relationship between transportation and obesity has emerged as a research hotspot. Scholars have considered that changing commuting patterns to increase daily energy expenditure can help alleviate obesity (Howell and Booth, 2022). Amir Samimi et al. (2009) developed a model to examine the impact of transportation and other variables on overall health and obesity among residents. Their findings indicate that developments centered around public transportation have a significant positive effect on both overall health and obesity reduction. Furthermore, reducing car usage by 1% can lead to a 0.4% reduction in obesity; Douglas M. King et al. concluded that there is an increasing amount of evidence suggesting that commuting through public transportation may be a potential measure to intervene in obesity (King and Jacobson, 2017); Martin Lindström explores the correlation between commuting modes and overweight/obesity, the study concludes that individuals who walk or bike to work have a significantly lower occurrence of overweight and obesity compared to the reference category of car driving (Lindström, 2008).

Additionally, researchers have also examined the relationship between transportation and diseases associated with obesity. For example, Kim et al. studied the effects of switching from private car commuting to public transportation on cardiovascular function and adiposity factors (Yae-Young et al., 2016). The findings suggest that a change in transportation mode contributes to improved cardiovascular function and obesity variables. Increasing physical activity through using public transportation can help prevent cardiovascular diseases and obesity. With further research and the introduction of the concept of active transportation, many scholars have conducted more in-depth studies on the relationship between the same mode of transportation and obesity in different scenarios. Green and Ferrari et al. explored the relationship between active transportation modes and obesity indicators (Ferrari et al., 2022; Green and Klein, 2011). Bassett et al. (2008) examined the association between active transportation and obesity rates across different countries, finding that nations with higher levels of active transportation generally have lower obesity rates. Similarly, Flint et al. (2014) evaluated whether active commuting is independently linked to objective biological markers of obesity and concluded that promoting active travel is an effective strategy for obesity prevention. Andersen (2016) and Laverty and Millett (2014) also emphasized that active transportation is a simple yet effective way to improve health and alleviate obesity-related issues. Additionally, Bell et al. (2002) suggested that reliance on motorized transportation may contribute to the global obesity epidemic, highlighting the promotion of active transportation as a potential preventive measure. Numerous scholars in their research have recognized that active transportation modes play a role in improving obesity-related issues.

These scholars have employed various models and experimental methods to delve into and confirm the factors influencing obesity, Mohamed utilized an OLS model to analyze the significant predictive factors of obesity related to transportation usage (Mohamed, 2018); Seliske et al. conducted a multilevel logistic regression to examine the correlation between urban sprawl, active transportation, moderate physical activity, and overweight/obesity (Seliske et al., 2012). Their findings indicated that urban sprawl is associated with active transportation but unrelated to obesity and overweight; She et al. assessed the impact of public transportation usage on obesity incidence at the county level in the United States, evaluating the potential of public transportation as an intervention for obesity (She et al., 2017). Regression analysis revealed that for every 1% increase in public transportation usage among the county population, the obesity incidence decreased by 0.221%.

This suggests that public transportation usage has the potential to contribute to reducing obesity rates among county populations. Based on the analysis of the literature, it is evident that there is still a lack of specific research on the correlation between obesity and transportation modes. The spatial correlation and clustering of obesity and transportation modes remain understudied areas, which are the focus of this study. Building upon existing research, this study aims to conduct a more in-depth investigation by utilizing

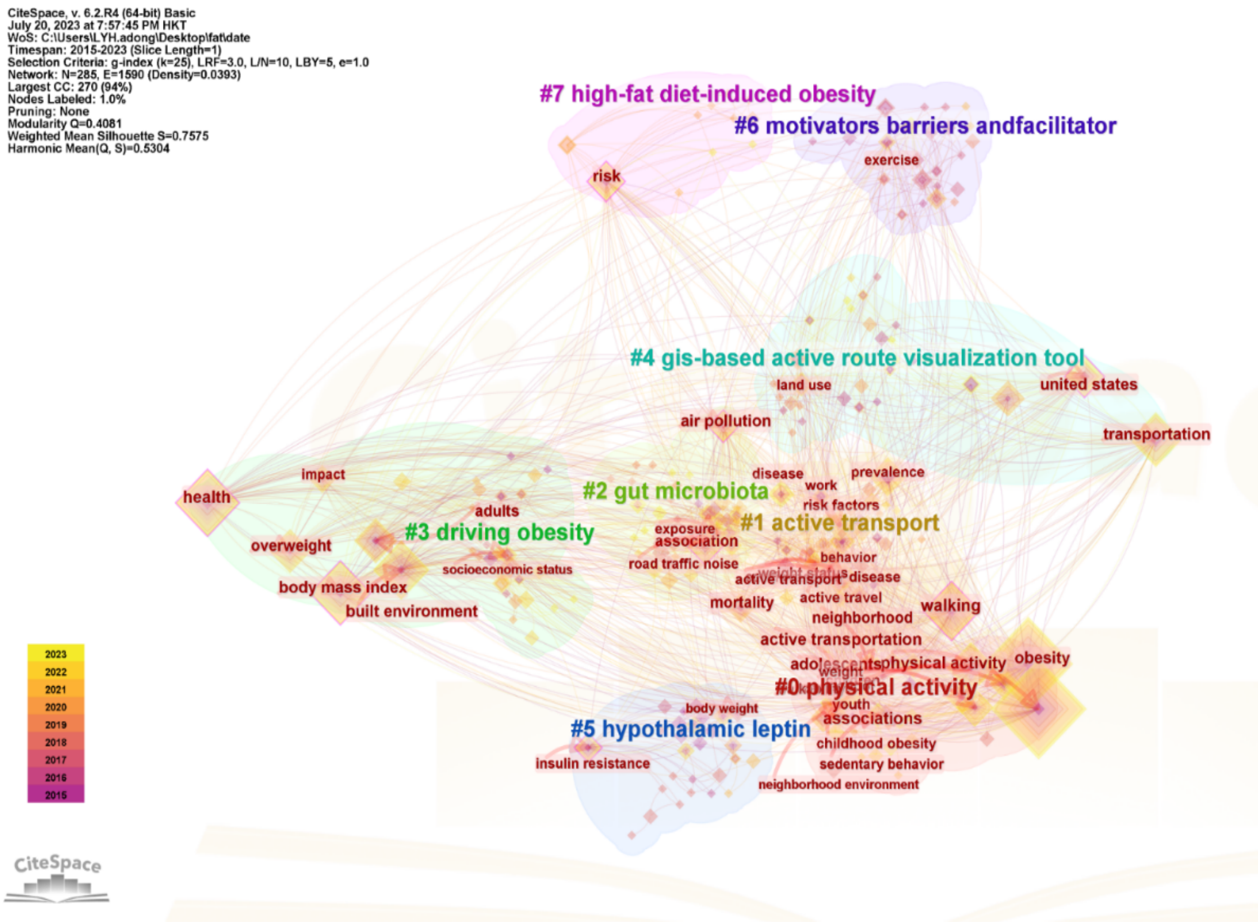

Figure 3 I Cluster analysis chart of 1281 literature on obesity and transportation

OLS and GWR models to statistically examine the impact characteristics of four transportation modes on obesity and overweight issues among urban residents. Additionally, it explores the spatial correlation and clustering of obesity and overweight levels among residents. By investigating the relationship between transportation modes and obesity from different perspectives, this study aims to provide new insights and recommendations for effectively alleviating the global obesity problem. Moreover, it seeks to fill the research gap in this area and provide a theoretical foundation for future studies in this direction.

Using CiteSpace, we analyzed 1,281 Web of Science articles on obesity and transportation, identifying key trends through keyword co-occurrence and clustering (Figure 3). Research has shifted from surface-level topics like "interventions" and "road traffic noise" to deeper issues such as "access," "food environment," and "cells" (Table 1), highlighting transportation's critical role in obesity. Scholars have explored factors like physical activity, driving behaviors, and motivational influences. Further studies on access and food environments could inform targeted policies. Advancing this field will enhance our understanding of the transportation-obesity link and support effective public health strategies.

As the world's second-largest economy, China has achieved remarkable growth, but this has also reshaped lifestyles, contributing to rising obesity and related chronic diseases. National data from 2015 showed that 43% of adults in China were overweight or obese (Wang et al., 2007). According to various surveys and research by the China, the average BMI of all age groups in China is increasing. The "Report on Nutrition and Chronic Diseases among Chinese Residents (2020)" provides comparisons of overweight and obesity rates among different age groups from 2015 to 2019 (Figure 4). It reveals that over half of Chinese adults are already overweight or obese, along with one-fifth of adolescents aged 6-17 and one-tenth of children under the age of 6. Calculated based on the absolute population, there are already 600 million people in China who are overweight or obese, ranking first globally. The fact that China has a population of 600 million people facing this health issue underscores the seriousness of overweight and obesity in the country.

Table 1 | Top 10 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2015 - 2023
prevalence	2015	3	2015	2015	
interventions	2016	2.7	2016	2018	
road traffic noise	2017	1.94	2017	2018	
time	2018	2.15	2018	2018	
cancer	2020	2.59	2020	2021	
transportation	2015	2.41	2021	2021	
sedentary behavior	2019	1.94	2021	2023	
access	2015	3.13	2022	2023	
food environment	2022	2.25	2022	2023	
cells	2022	2.02	2022	2023	

Over the past 30 years, the prevalence of overweightedness and obesity has increased by an average of around 2.5 times across all age groups, indicating that this health issue persists and continues to expand. The urgency to conduct research and find relevant measures to address this problem is evident. In October 2016, China introduced the "Healthy China 2030 Plan," which aims to integrate health throughout the entire process of urban and rural planning, construction, and governance. Our team focuses on studying the relationship between residents' transportation patterns and overweight and obesity, aiming to identify the impact of different transportation modes on the issue.

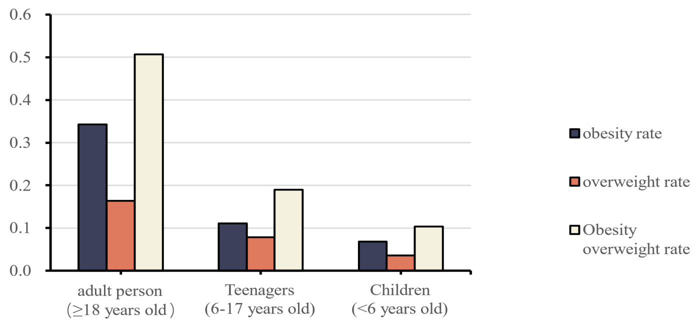

Figure 4 | Comparison of Overweight, Obesity Rates of Chinese Residents by Age Group, 2015-2019

(Source: Report on Nutrition and Chronic Disease Status of Chinese Residents,2020)

3. Data Sources and Research Methodology

3.1. Data Sources

In this study, Wuhan City is selected as the research object, with seven central urban districts including Jianghan District, Wuchang District, Qiaokou District, Qingshan District, Jiang'an District, Hongshan District, and Hanyang District (Figure 5) chosen as the study areas. A questionnaire survey was conducted to collect data on the health status, travel patterns, and economic conditions of residents in each district. The overall area covered by the study is approximately 860 km², with a population of 6.4 million. Such a survey scope and population size are considered sufficient to provide an adequate sample for subsequent research and to draw more convincing conclusions. In total, our team collected 10,328 questionnaires through a combination of online and offline methods.

3.2. Preliminary Data Analysis

The Body Mass Index (BMI) is a health indicator proposed by the World Health Organization (WHO) and recognized as a risk indicator for diseases. It is defined as an individual's weight in kilograms divided by the square of their height in meters. To assess the health status of the respondents, their BMI was calculated based on their height and weight, and the classification of adult body weight in "Standards for the Health Industry in the People's Republic of China" (Table 2) was referenced. The study found that 36% of the respondents had an abnormal health status, with 26% of them being overweight or obese. Fur-

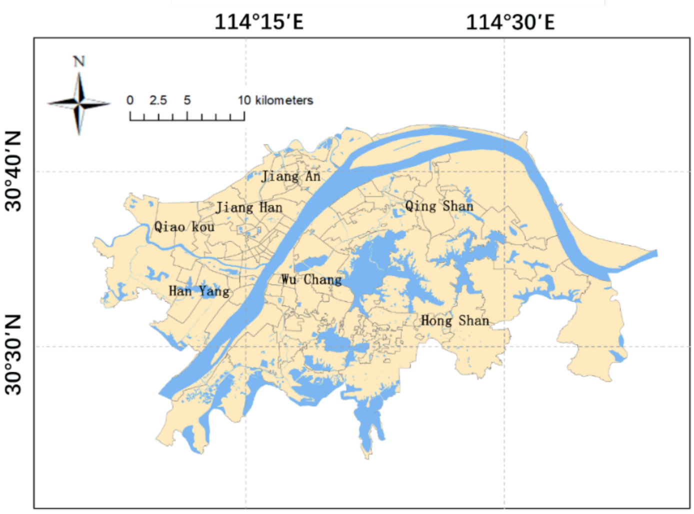

Figure 5 | The scope of the survey on the urban center of Wuhan

thermore, it was observed that among this large proportion of unhealthy individuals, 73% of the respondents were not familiar with the meaning of BMI, and 61% had little or no understanding of the risks associated with obesity and overweight issues (Figure 6). Therefore, based on these findings, this study aims to conduct in-depth research on urban residents with a BMI equal to or greater than 18.5, using BMI as an indicator of obesity and overweight levels among the population.

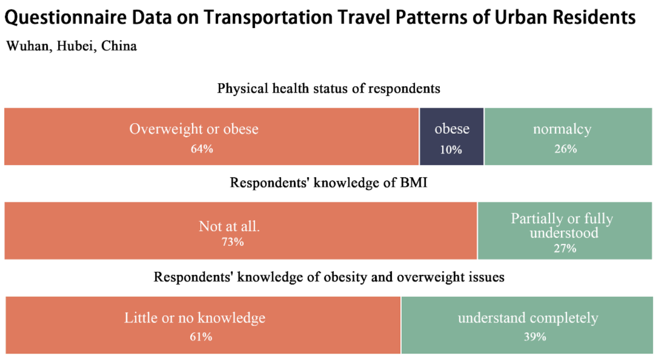

Figure 6 | Preliminary analysis of research data

Based on the questionnaire responses regarding modes of transportation, our team categorized the respondents' transportation modes into four categories: walking, cycling, public transportation, and car usage. Based on this classification (as shown in Figure 7), it was found that walking had the highest number of participants, with a significantly high proportion of healthy individuals at 72%. Cycling followed closely behind at 68%, public transportation at 64%, and car usage at 59%. These findings suggest that the impact of transportation modes on obesity and overweight issues among residents is ranked as walking > cycling > public transportation > car usage. It is worth noting that the majority of residents' travel distances are concentrated within 0-2 kilometers. Therefore, when analyzing the relationship between transportation modes and obesity/overweight issues among residents, we will control the spatial unit at the street level to obtain more accurate conclusions.

3.3. Selection and Treatment of Transportation Travel Modes

The study variables consisted of four modes of transportation, namely walking, cycling, public transportation, and car usage, among residents in the central urban area of Wuhan. The coordinates of the respondents' origin and destination were derived from the geographic information provided in the question-

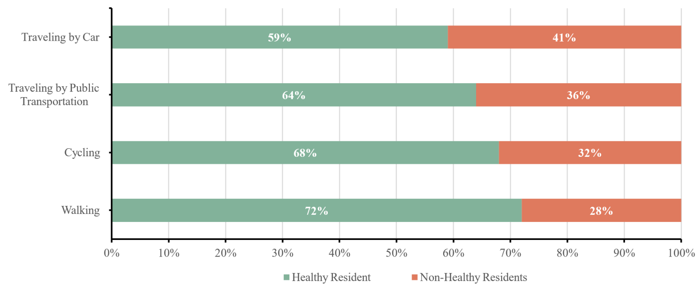

Figure 7 | Percentage of healthy residents choosing all modes of travel

Table 2 | Classification of adult body weight according to the "Health Industry Standard of the People's Republic of China"

Categorization	BMI（kg/m²）
obese	BMI≥28
overweight	24≤BMI＜28
Normal weight.	18.5≤BMI＜24
underweight	BMI＜18.5

naire. The Baidu API was utilized to obtain OD (Origin-Destination) path data for all survey samples, which enabled the calculation of the actual distances for each transportation mode. In these distance calculations, the distances for walking and cycling were determined based on the shortest non-motorized road routes. The distance for public transportation comprised the fixed distance of the public transportation route plus the connecting distance between the origin/destination and the public transportation station. As for car usage, the distance was calculated based on the shortest motorized road route (Figure 8).

3.4. Research Methodology

$$y_i = \beta_0(U_i, V_i)x_{ik}(U_i, V_i) + \varepsilon_i \# \quad (2)$$

In this study, both the OLS (Ordinary Least Squares) model and GWR (Geographically Weighted Regression) model were employed to statistically test the impact characteristics of walking, cycling, public transportation, and car travel on obesity and overweight issues among urban residents, as described earlier. The OLS model was primarily used to analyze the relationship between a single dependent variable and multiple independent variables. It provides estimates of parameters on an average or global sense, allowing for factor selection based on the estimation results. On the other hand, the GWR model, an extension of the OLS model proposed by Brunsdon et al.(Brunsdon et al., 1999), incorporates the spatial locations of independent variable occurrence points into regression parameters. This allows the relationships between variables to vary with spatial location, accounting for spatial correlation and heterogeneity

$$W_{ij} = exp\left(-\frac{d_{ij}^2}{h^2}\right) \# \quad (3)$$

by assigning weights based on the decay function between each sample spatial location. Considering that the independent variables, such as walking, cycling, public transportation, and car travel, as well as the dependent variable, BMI (Body Mass Index) of residents, are presented in coordinate data form and exhibit spatial attributes, applying the GWR model enables better linear regression analysis of variable spatial heterogeneity. However, due to the sensitivity of the GWR model to multicollinearity among variables, it is advisable to include a limited number of

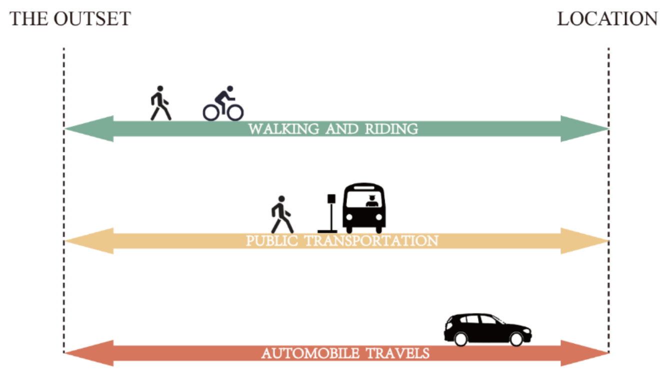

Figure 8 I Three modes of travel division

variables to ensure the accuracy of the GWR analysis. Therefore, it is common practice to conduct re-

$$y_i = \beta_0 + \sum_{k=1}^{n} \beta_k x_{ik} + \varepsilon_i \#(1)$$

gression analysis using the OLS model before performing GWR analysis to eliminate confounding factors.

The expressions of the OLS model (Equation 1) and the GWR model (Equation 2) are as follows:

The y_i is the dependent variable of the ith sample, β_0 is the intercept of the linear regression equation, β_k is the regression coefficient of the kth independent variable, x_{ik} is the value of the kth independent variable on i, and ε_i is the algorithm residual.

Therein $\beta_0(U_i,\ V_i)$ is the GWR intercept at $(U_i,\ V_i)$ spatial location, $\beta_k(U_i,\ V_i)$ is the weighted regression coefficient of the kth independent variable at$(U_i,\ V_i)$ spatial location, $x_{ik}(U_i,\ V_i)$ is the value of the kth independent variable at $(U_i,\ V_i)$,and ε_i is the algorithm residuals.

The key to the GWR model lies in the setting of the spatial weight matrix. In this study, ArcGIS 10.7 was used to select the Gaussian function as the kernel function of GWR analysis, with the kernel type being fixed. The expression of the kernel function is as follows:

In this case, $d_{ij}$is the spatial distance between sample i and sample j, and h is the optimal bandwidth. The GWR model is sensitive to the choice of bandwidth, and either too large or too small bandwidth may have an impact on the model fitting accuracy. Thus, based on the ArcGIS analysis platform, the Akaile Information Criterion (AIC) method is cho-

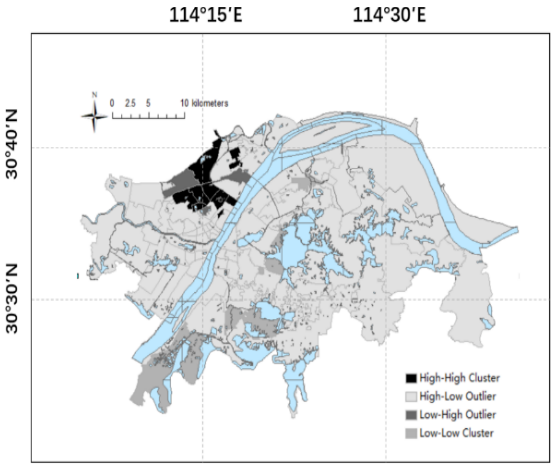

Figure 9 I Wuhan Localized Moran Index

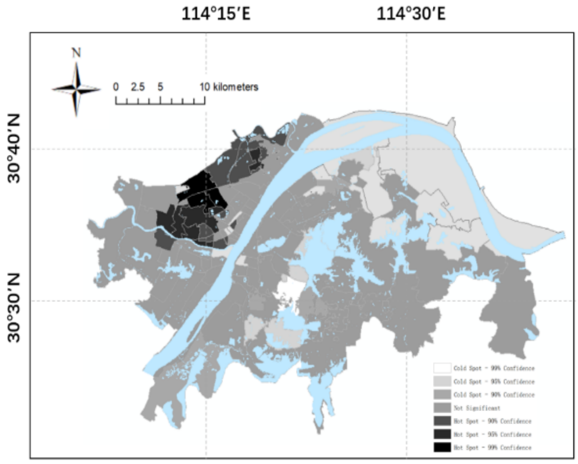

Figure 10 Analysis of localized hotspots in Wuhan

sen to determine the optimal bandwidth, and the optimal bandwidth can be determined when the AICc value of the model is the smallest.

4. Analysis of Results

4.1. Spatial Correlation Validation

Through the global statistical analysis of spatial correlation and the corresponding local statistical analysis, this paper examines the spatial correlation and degree of agglomeration of the degree of obesity and overweight among Wuhan residents.

The global statistical analysis of spatial correlation includes spatial autocorrelation analysis and high/low clustering analysis, the results of which (Table 3) rejected the hypothesis that the BMI values of the residents of Wuhan streets are not spatially correlated. In the spatial autocorrelation analysis, the global Moran's index was 0.261, indicating that there was a positive spatial correlation between the BMIs of Wuhan streets, while the z-value of 2.931 for the high/low clustering analysis indicated that this spatial correlation was more pronounced in the areas with higher BMIs.

In the local statistical analysis, firstly, three types of residents' obesity and overweight degree of high - high clustering, low - high anomaly and low - low clustering existed in Wuhan's central city streets through the local Moran's index analysis (Figure 9). High-high concentration is primarily found in the core areas of Hankou, Wuchang, and Hanyang along the river, Wuhan's traditional center, characterized by a dense population and well-developed transportation. Low-low concentration appears in the northeastern part of Wuhan, where heavy industries such as iron and steel and chemical enterprises dominate. This region has a self-contained social structure, leading to lower inter-regional travel demand, and its distance from Wuhan's center further limits outbound travel. Low-high anomalies are mainly observed in the streets of central Wuhan.

The low-high anomaly mainly occurs in the area within the second ring road of Wuhan, and is interspersed with the high-high agglomeration, which is also a more populated and conveniently located area in Wuhan. In addition, hotspot analysis was further utilized to identify the spatial clustering of areas with high and low values of statistical significance, respectively, thus validating the previously described characteristics of the distribution of the degree of overweight and obesity of the residents of each street (Figure 10). The above validation results only show that the spatial correlation of the degree of obesity and overweight is more significant in Wuhan city center, but the specific influence of different modes of transport on the residents' BMI is not yet clear, which is further analyzed by introducing the OLS model and the GWR model in this paper.

4.2. OLS Model Analysis

After standardizing the data of the variables, the results of the OLS model analysis are shown in Table 4, which shows that the VIF values of the variables as urban transport travel modes are lower than 7.5, so there is no redundancy in the variables. Among the variables, walking trip distance A_k, cycling trip distance B_k and car trip distance S_k passed the significance test with a robust p-value ≤ 0.05. Among them, the regression coefficients of walking travel distance, cycling travel distance and public transport travel distance are negative, especially the regression coefficient of walking travel distance reaches 0.3718, which is the highest value among the effective variables, and it also indicates that among the various types of transport modes described in this paper, walking travel distance has the greatest influence on the degree of obesity and overweight of Wuhan residents.

In order to compare the analytical validity of the OLS model and the GWR model, this paper will compare the adjusted R^2 and the Akaike information criterion of these two models. The R^2 value in the OLS diagnostic is 0.368, while the adjusted R^2 value is 0.267, which indicates that the OLS model is able to fit and explain about 26.7% of the total variance of the dependent variable, and furthermore the optimal bandwidth of the OLS model is determined in ArcGIS10.7 based on Gaussian function as well as the cross-validation method with a post-AICc value of 1087.26 The above diagnostics can be used to compare the analytical validity of the OLS model with the GWR model in the following section. for analytical validity comparison.

4.3. GWR Model Analysis

In the identification of travel modes influencing residents' obesity and overweight issues in various streets of Wuhan, the Geographically Weighted Regression (GWR) model demonstrates higher stability with an R^2 value of 0.675, which is an 83.42% improvement compared to the R^2 value of the Ordinary Least Squares (OLS) model. Additionally, the GWR model in this study has an AICc value of 1083.13, indicating a decrease of 4.13 compared to the AICc value of the OLS model. Normally, a decrease of 3.00 in AICc value suggests a significant improvement in the effectiveness of the model analysis. Hence, it can be observed that the GWR model yields higher effectiveness in analysis compared to the OLS model. Consequently, the subsequent analysis will be based on the GWR model to examine the impact characteristics of various transportation drivers on residents' obesity and overweight issues.

In the GWR model, standardized residuals following a random distribution indicate the effectiveness of the model. Based on the distribution of standardized residuals (Figure 11), it can be observed that none of the streets in Wuhan have standardized residuals exceeding 2.5 times the standardized residual, indicating that the residual test has been passed. Additionally, the model extension test based on the Moran's I index (Table 5) shows that the standardized residual

Table 3 | Global statistical results of spatial correlation of BMI distribution of Wuhan residents

Test items	exponents	Z-value	P-value	variance
High/Low Cluster Analysis	0.00011	3.52121	0.00021	<0.00001
Spatial autocorrelation analysis	0.26105	5.12252	0.00005	0.000576

Table 4 | Results of OLS model analysis of BMI distribution of Wuhan residents

Transportation travel patterns	regression coefficient	standard error	VIF	Robust t-value	Stable p-value
walking distance	-0.3718	0.1263	5.162	-2.944	0.042
cycling distance	-0.3165	0.24097	3.745	-1.313	0.031
public transportation distance	-0.1568	0.25982	2.965	-0.603	0.045
car travel distance	0.3566	0.38091	3.233	0.936	0.012

* $p<0.05$

confidence of this GWR model is greater than 99%. This suggests the absence of spatial clustering or dispersion, aligning with the characteristics of a random distribution.

The regression coefficients for walking distance A_k, cycling distance B_k, public transportation distance D_k, and car travel distance S_k are shown in Table 6. It can be observed that in geographically weighted regression analysis, the walking and cycling distances in different streets of Wuhan still exhibit a negative correlation with BMI values, while the car travel distance continues to show a positive correlation. This indicates that walking and cycling as modes of transportation clearly hinder the increase in BMI values, especially the walking distance, which has a high regression coefficient of 0.325 in the GWR model, suggesting a strong correlation with obesity and overweight issues among residents. In the GWR model, car travel distance shows a positive correlation with the prevalence of obesity and overweight among residents, indicating that the adoption of non-public transportation methods significantly reduces the physical exertion associated with travel, thereby making residents more susceptible to obesity and overweight issues. It should be noted that the above inferences are based on the provided information and regression coefficients. Further research and validation are required to accurately assess the relationship between walking, cycling, public transportation, car travel distances, and the prevalence of obesity and overweight among residents.

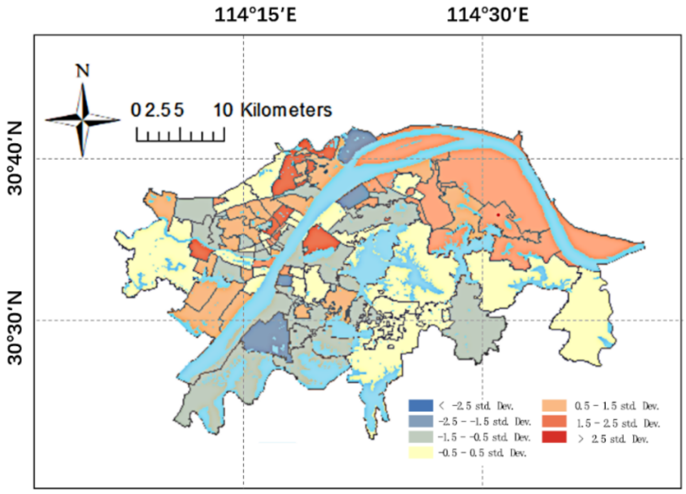

Figure 11 l Standardized Residual Distribution Plot

The GWR regression coefficient distributions of walking, cycling, and public transportation distances in each street of Wuhan are shown in Figures 12, 13, and 14. The regressions coefficients for all 93 streets in the study area were found to be negative, indicating a negative correlation between the distances of walking, cycling, and public transportation trips and the prevalence of obesity and overweight among residents. Furthermore, these coefficients were mainly concentrated in the southeast corner, with relatively lower values in the core urban areas and the lowest values in relatively remote areas. Contrasting with the distribution of public transportation in Wuhan (Figure

Table 5 l Standardized Residual Moran's Index Test for GWR Models

Test item	Numerical value
Moran Index	0.156
Z-score	4.375
P-value	<0.01

Table 6 l GWR modeling results

Transportation travel patterns	regression coefficient	Lower limit of regression coefficient	Upper limit of regression coefficient	standard error
walking distance	-0.325	-0.3258	-0.3247	0.106
cycling distance	-0.273	-0.2736	-0.2725	0.223
public transportation distance	-0.115	-0.1158	-0.1139	0.204
car travel distance	0.269	0.2681	0.2703	0.327

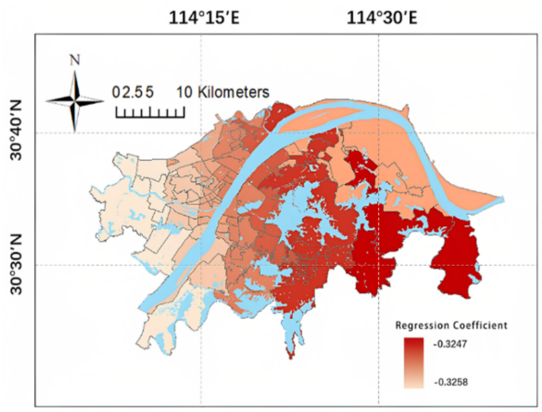

Figure 12 | Distribution of GWR Regression Coefficients (Walking Travel Distance) by Street in Wuhan

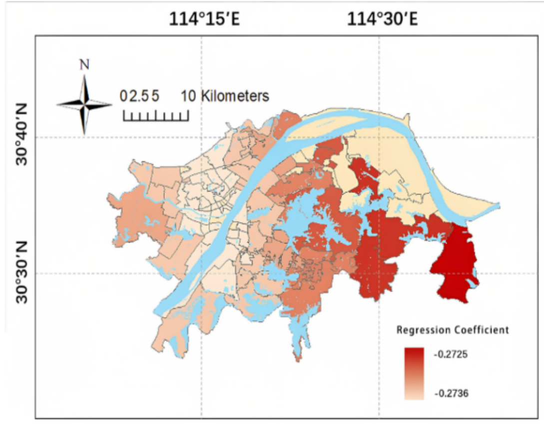

Figure 13 | Distribution of GWR regression coefficients (cycling trip distance) by streets in Wuhan

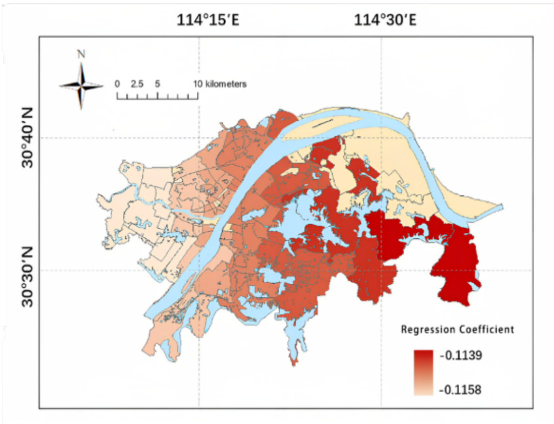

Figure 14 | Distribution of GWR regression coefficients (distance traveled by public transportation) by street in Wuhan

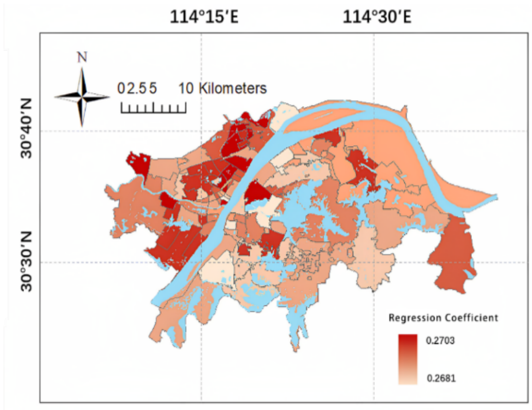

Figure 15 | Distribution of GWR regression coefficients (distance traveled by car) by street in Wuhan

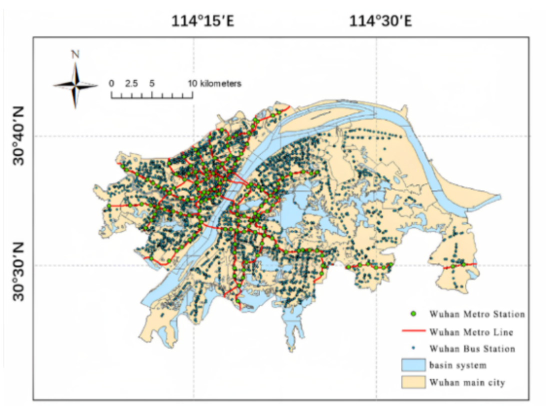

Figure 16 | Wuhan Public Transportation Map

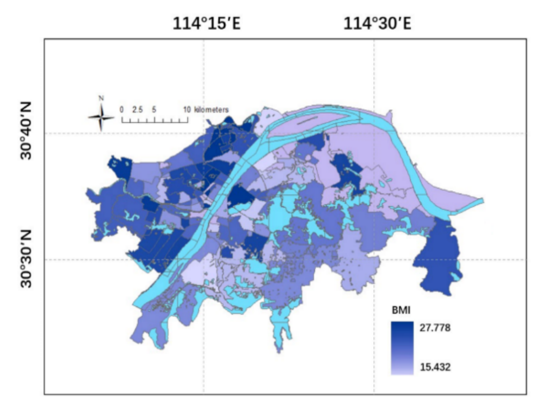

Figure 17 | Distribution of obesity and overweight in Wuhan

15), the areas near the main axis of the Yangtze River belong to densely populated residential areas with high public transportation coverage. In such cases, residents are more likely to choose walking or cycling as a mode of transport, thereby partially alleviating the issue of obesity and overweight.

In contrast, Figure 15 presents the GWR regression coefficient distribution of car travel distances among residents in each street of Wuhan. The regression coefficients for all 93 streets were found to be positive, indicating a positive correlation between car travel distances and the prevalence of obesity and overweight among residents. Compared to Figure 16, it can be observed that in areas with high public transportation coverage, there is a stronger relationship between car travel distances and obesity and overweight. This suggests that even when public transportation coverage is high, residents still tend to choose car travel over public transportation or other non-motorized modes of transport, thereby exacerbating the problem of obesity and overweight.

According to the distribution map of obesity and overweight among residents in Wuhan (Figure 17), it can be observed that areas such as Jiang'an District, the western part of Qiaokou District, the southern part of Hanyang District, and the southeastern part of Hongshan District have a more serious problem of obesity and overweight among residents. By comparing it with the distribution map of public transportation in Wuhan, it can be inferred that there is a positive correlation between the density of public transportation stations and the issue of obesity and overweight among residents. This may be because areas with high coverage of public transportation stations belong to the most developed areas of Wuhan. Due to the availability of comprehensive facilities and a self-sustaining social life system, residents in these areas have shorter daily travel distances. Therefore, urban residents are more likely to choose walking or cycling as a mode of transport. Compared to walking or cycling, using public transportation requires less physical effort.

5. Conclusions and Recommendations

5.1. Conclusions

From an overall perspective, 26% of the respondents in the sample were overweight or obese, and 73% of the respondents were not familiar with the meaning of BMI. Additionally, 61% of the respondents had little or no understanding of the health risks associated with obesity and overweight. From these findings, it can be inferred that residents have a low level of awareness and concern regarding obesity and overweight issues. The current situation of obesity and overweight among residents is not optimistic.

Based on the analysis of specific questionnaire items, we further explored the factors influencing obesity and overweight issues among urban residents in different modes of transportation. The following conclusions were drawn:

1) Among the four typical modes of transportation, namely walking, cycling, public transportation, and car use, there is a negative correlation between the distance of walking, cycling, and public transportation and the prevalence of obesity and overweight among residents. However, the negative correlation is least significant for public transportation distance, while there is a positive correlation between car use distance and the prevalence of obesity and overweight.
2) The density of public transportation stops is positively correlated with the degree of obesity and overweight among residents. Moreover, the density of public transportation stops also affects the correlation between transportation modes and obesity and overweight issues. In areas with high coverage of public transportation stops, both public transportation and car use distances have a stronger correlation with obesity and overweight. In areas with low coverage of public transportation stops, the correlation between walking, cycling distances, and obesity and overweight is more pronounced.
3) There are significant variations in the distribution of obesity levels among residents in different regions of Wuhan. For instance, obesity and overweight are more severe in areas such as Jiang'an District, the western part of Qiaokou District, the southern part of Hanyang District, and the southeastern part of Hongshan District.

5.2. Recommendations

Based on the analysis above, it can be inferred that residents' choices of walking, cycling, and public transportation can improve obesity issues. Encouraging and facilitating the use of these three modes of transportation is an effective measure to reduce obesity among residents. Firstly, optimizing the slow transportation system and constructing urban greenways are crucial. For example, Wuhan's slow transportation system has a serious issue of "acquired deformity", mainly characterized by the absence of dedicated bicycle lanes on many roads and the obstruction of pedestrian pathways or bicycle lanes by barriers or random parking. These problems directly discourage residents from choosing walking or cycling as their daily modes of transportation, thus affecting the obesity and overweight issues among residents.

Therefore, Wuhan needs to optimize its slow transportation system by constructing a more comprehensive independent network for motorized and non-motorized vehicles, establishing dedicated bicycle lanes, and strictly prohibiting motor vehicles from entering these lanes. Secondly, benefiting from its unique natural environment, Wuhan has built over 350 "pocket parks" and greenways extending over 2,000 kilometers as of October 2022. Wuhan needs to maintain the efficiency of greenway construction and continue improving the grid structure of greenways while connecting them with other service systems in line with the city's development pattern. The optimization of the slow transportation system and the construction of urban greenways provide residents with convenient and safe walking and cycling environments, thereby increasing their inclination to choose non-motorized modes of transportation. This will help alleviate the obesity and overweight issues among Wuhan residents. In addition, you can also optimize the public transport and shared transport planning layout, combined with the regional distribution of obese overweight residents of Wuhan in this paper and the distribution of public transport can be proposed for the city managers. For example, in areas such as Jiangan District and Qiaokou District in the west with broad public transport coverage and a significant problem of obesity and overweight among residents, a centralized placement of public transport stations and shared bicycles can be implemented to create a travel system that combines public transport and bike-sharing. This can help to alleviate the issue of obesity and overweight among residents. In the southeastern part of Hongshan District and other public transportation station coverage is small and the problem of obesity and overweight residents is serious in the region for decentralized placement, expanding the density of shared bicycle coverage, and prompting the residents to non-motorized travel, thereby improving the problem of obesity and overweight.

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