보건교육건강증진학회지 제42권 제2호(2025. 6) pp.1-11
Korean J Health Educ Promot, Vol.42, No.2 (2025)
https://doi.org/10.14367/kjhep.2025.42.2.1

Environmental factors affecting obesity in urban residents in metropolitan area: Evidence from Seoul, South Korea

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Objectives: This study investigates the effects of urban physical activity and food environments on obesity. **Methods:** We analyzed data from the Korean Community Health Survey in Gangdong-gu, Seoul, from 2012 to 2016, using spatial logistic regression. The analyses were conducted to investigate the effects of proximity to and density of parks, road networks, convenience stores, pubs/barbecue restaurants, and snack bars on body mass index (BMI). The models were adjusted for age, sex, income, education, self-reported health status, and presence of chronic diseases. **Results:** Closer proximity to parks and higher road connectivity were inversely associated with BMI, with stronger effects observed in men. Food-environment associations were sex specific, i.e., men's BMI increased with shorter distances to convenience stores and higher snack-bar density, whereas women's BMI increased with the number of convenience stores and pubs/barbecue outlets. **Conclusion:** Green spaces and highly walkable streets protect against obesity, whereas food environments exert complex, sex-specific influences. Urban planning should prioritize park access, enhanced walkability, and zoning to regulate high-calorie food outlets and curb obesity in metropolitan populations.

Key words: built environment, urban environment, physical activity environment, food environment, obesity

Ⅰ. Introduction

Traditionally, cities and urbanization have been associated with prosperity and improved quality of life. Urban residents tend to exhibit healthier behaviors and better health outcomes than those living in non-urban environments (Matthews et al., 2017) due to higher education levels, better access to healthcare, and improved health literacy (Aljassim & Ostini, 2020; Liu, Qian, Chen, & He, 2020). This implies that inhabitants of urban areas are generally afforded greater opportunities including high-quality healthcare services and exposure to better environments. However, urban environments can also present significant health risks when resources are unequally distributed or when the urban built environment promotes sedentary lifestyles and unhealthy eating.

Meanwhile, urbanization encompasses a multifaceted array of dynamic processes including economic development, population movement, urban growth, and spatial expansion, characterized by four principal attributes: scale, density, diversity, and complexity (Vlahov, Boufford, Pearson, & Norris, 2010). Recent urban health concerns include not only infectious diseases such as COVID-19, but also chronic conditions such as obesity. Particularly, obesity is closely linked to urbanized lifestyles, particularly in megacities characterized by high population density, limited green space, and abundant access to energy-dense foods (Egger & Dixon, 2014;

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※ This paper was supported by Wonkwang University in 2024.
• Received: May 7, 2025 • Revised: June 13, 2025 • Accepted: June 22, 2025

McGuire, 2014).

Although these challenges are widely emphasized in global urban health literature, many districts in Seoul—despite being part of a megacity—report relatively lower obesity prevalence compared to rural areas. However, this overall trend does not reflect the substantial intra-urban disparities in access to health-promoting environments, which may influence obesity risk differently across neighborhoods. This discrepancy suggests that the relationship between urbanization and obesity is not uniform and may be shaped by local policy efforts and spatial characteristics.

Therefore, this study focused on the micro-level environmental factors—specifically, physical activity and food environments—to examine their association with obesity. As physical activity and food consumption are key determinants of obesity, previous efforts to control it have emphasized physical activities and healthy eating habits, including the reduction of high-calorie and high-sodium food consumption. However, these behaviors are often influenced by individual socioeconomic factors, such as income levels, education, and health literacy, emphasizing the need for health-promoting environments, particularly from a health equity perspective. While previous literature highlighted physical activity resources such as parks, open spaces, sports facilities, walkable streets, and public transit (Kipke et al., 2007; Papas et al., 2007; She, King, & Jacobson, 2017), as well as the distribution of food retailers (Sallis & Glanz, 2009), the spatial context in Seoul warrants close attention. In particular, the emergence of virtual foodscapes (e.g., delivery platforms) and changing dietary cultures introduced new complexities in understanding obesogenic environments (Yoon, Yoo, & Kwon, 2018).

Accordingly, this study hypothesized that individuals living in areas with lower access to environments that supported healthy behaviors were more likely to have higher body weights. We investigated spatial characteristics within 500-meter and 1,000-meter buffers surrounding individuals' residences to determine how the proximity and density of environmental factors are related to Body Mass Index (BMI). By doing so, we aimed to identify spatial health disparities and inform context-specific urban planning strategies that promote healthier environments in cities like Seoul.

Ⅱ. Methods

1. Participants

The data for this study were drawn from Gangdong-gu, a district located in the southeastern part of Seoul with a population of approximately 450,000. Gangdong-gu has actively participated in Healthy City initiatives and has been recognized for its efforts in public health promotion, including the expansion of parks and pedestrian-friendly streets. The district was selected not solely because of these activities, but rather because its urban characteristics exemplify both the challenges and potential solutions to obesity in metropolitan environments such as Seoul.

This study utilized data from the Korean Community Health Survey (KCHS), a nationwide, community-based survey conducted annually by the Korea Disease Control and Prevention Agency (KDCA). The KCHS employs stratified sampling by region and housing type to generate a representative sample of Korean adults aged 19 years and older. The survey includes questions on a wide range of health-related variables, including smoking, alcohol use, vaccination, disease morbidity and management, healthcare utilization, personal hygiene, and aspects of women's health.

The analysis included individuals residing in Gangdong-gu who had valid self-reported data on height and weight. A total of 4,378 participants from 2012 to 2016 were included in the final sample. The use of KCHS data for this study was approved by the Institutional Review Board (IRB) of the KDCA (No. 2016-10-01-P-A).

2. Variables

1) Dependent variable

The dependent variable was BMI, calculated from self-reported weight (kg) divided by height in meters squared (m^2). BMI was treated as a continuous variable to examine its association with urban environmental characteristics.

2) Independent variable

Independent variables were categorized into physical activity-related and food-related environmental factors. For the physical activity environment, we included: (1) the number and proximity of parks (Hobbs et al., 2017; Kipke et al., 2007); (2) distance to and density of public sports facilities, fitness centers (Kim, Shon, & Yi, 2017; Navalpotro et al., 2012), and golf driving ranges (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007); (3) distance to subway stations and the number of subway lines (Rundle et al., 2007; Xiao, Yang, & Chi, 2021); and (4) total road length and intersection density within the living radius (Ball, Lamb, Travaglini, & Ellaway, 2012; Lopez, 2007).

For the food environment, we examined the density per population and proximity of: (1) fast food outlets (Kipke et al., 2007); (2) pubs and Korean BBQ restaurants (Kim et al., 2017; Walker et al., 2020); (3) convenience stores (Morland, Diez Roux, & Wing, 2006; Yoon & Shon, 2020); and (4) snack bars/street food vendors (Collins, Pakiz, & Rock, 2008).

All environmental data except fast food restaurants were obtained from the Gangdong-gu Office as of the end of 2016. For fast food restaurants, data from the top five national franchises with the highest market share as of 2016 were included due to the absence of systematic monitoring data by the Seoul Metropolitan Government. All geographical information was used for analysis by generating coordinate values through geocoding based on real addresses (Lo & Yeung, 2006).

3) Control variables

Control variables known to influence BMI, such as sex, age, education, income, self-rated health status, and diagnosed chronic diseases were included in the analysis models. Self-rated health was assessed on a five-point Likert scale and categorized into two levels for analysis. Diagnosed chronic diseases included physician-confirmed hypertension and diabetes. These covariates helped account for individual-level variation in health status and socioeconomic background.

3. Statistical analysis

To investigate how environmental characteristics within the residential neighborhood affect BMI, we defined neighborhood buffers of 500 meters and 1,000 meters around each respondent's residence. These distances were based on prior research defining walkable neighborhood environments (Fan & Jin, 2014; Larsen, Cook, Stone, & Faulkner, 2015). Spatial logistic regression analyses were conducted using SAS 9.4 and ArcGIS software. Although the KCHS provides sampling weights, this study used unweighted analyses due to spatial linking constraints.

Ⅲ. Results

1. General characteristics of study population

A total of 4,378 participants were included in the analysis, consisting of 2,001 men (45.7%) and 2,377 women (54.3%). The mean age of the study population was 46.2 years. Participants aged 35-49 years were the largest proportion (30.9%), followed by those aged 50-64 years (30.1%) and 19-34 years (26.3%). Regarding monthly household income, the largest proportion of respondents (33.3%) reported an income between 1 million and 3 million Korean Won (KRW), followed by 3–5 million KRW (31.0%), ≥5 million KRW (28.0%), and 〈1 million KRW (7.6%).

Significant differences were observed between men and women in terms of educational level, self-rated health status, hypertension, diabetes, and BMI. Among all participants, 45.6% had attained a college degree or higher, with men showing significantly higher educational levels than women (p〈.001). In terms of self-rated health, 49.3% of men participants rated their health as good, compared to 38.1% of women participants (p〈.001). The prevalence of physician-diagnosed hypertension (p〈.001) and diabetes (p=.007) was also significantly higher among men. The mean BMI of all participants was 23.1 kg/m^2; however, the mean BMI was significantly higher in men (24.1 kg/m^2) than in women (22.3 kg/m^2) (p〈.001). Similarly, the prevalence of obesity (BMI≥25 kg/m^2) was significantly higher among men than among women (p〈.001).

2. Associations between urban physical environment and BMI

Several environmental factors were significantly associated with BMI. Among these, proximity to parks, number of parks, distance to fitness centers, number

〈Table 1〉 General characteristics of study population

Unit: n(%)

Variables	Categories	Men	Women	Total	t/χ^2 (p-value)
Age	(mean, SD)	46.0 (15.1)	46.4 (15.6)	46.2 (15.4)	-0.81 (.419)
	19-34	525 (26.2)	627 (26.4)	1,152 (26.3)	2.855 (.415)
	35-49	639 (31.9)	715 (30.1)	1,354 (30.9)	
	50-64	580 (29.0)	738 (31.0)	1,318 (30.1)	
	65 ≤	257 (12.8)	297 (12.5)	554 (12.7)	
Monthly income (10,000 Korean won)	〈 100	132 (6.7)	195 (8.4)	327 (7.6)	5.455 (.141)
	100-299	655 (33.3)	773 (33.3)	1,428 (33.3)	
	300-499	606 (30.8)	723 (31.2)	1,329 (31.0)	
	500 ≤	572 (29.1)	630 (27.1)	1,202 (28.0)	
Education	≤ Middle school	262 (13.1)	477 (20.1)	739 (16.9)	52.159 (〈.001)
	High school	723 (36.3)	911 (38.4)	1,634 (37.4)	
	College ≤	1,009 (50.6)	984 (41.5)	1,993 (45.6)	
Self-rated health	Unhealthy	1,014 (50.7)	1,471 (61.9)	2,485 (56.8)	55.628 (〈.001)
	Healthy	987 (49.3)	906 (38.1)	1,893 (43.2)	
Hypertension	None	1,572 (78.6)	1,988 (83.6)	3,560 (81.3)	18.411 (〈.001)
	Diagnosed	429 (21.4)	389 (16.4)	818 (18.7)	
Diabetes	None	1,842 (92.1)	2,237 (94.1)	4,079 (93.2)	7.219 (.007)
	Diagnosed	159 (7.9)	140 (5.9)	299 (6.8)	
BMI (body mass index)	(mean, SD)	24.1 (3.0)	22.3 (3.2)	23.1 (3.3)	19.39 (〈.001)
	〈 25	1,309 (65.4)	1,981 (83.3)	3,290 (75.1)	186.875 (〈.001)
	25 ≤	692 (34.6)	396 (16.7)	1,088 (24.9)	
Total		2,001 (45.7)	2,377 (54.3)	4,378 (100.0)	

of subway stations, and road length showed notable associations. For the 500-meter buffer, closer distance to parks was associated with lower BMI (p=.016), an effect that disappeared in the 1,000-meter buffer (p=.475), primarily driven by the male subgroup. Conversely, within the 1,000-meter buffer, a higher number of parks was associated with lower BMI (p=.030), also particularly among men. Among women, increased distance to indoor swimming pools within a 1,000-meter radius was associated with lower BMI (p=.028).

Increased road length within both 500-meter (p=.019) and 1,000-meter (p=.021) buffers was significantly associated with lower BMI, largely reflecting male patterns. Subway station accessibility showed limited associations: among men, a greater

〈Table 2〉 Association between urban physical activity environment and BMI in men

Variables	Environmental factors	500 m*				1,000 m*			
		Estimate	SE	t	p	Estimate	SE	t	p
Distance to	Parks	-0.0010	0.0004	-2.41	.016	-0.0002	0.0002	-0.71	.475
	Public sports facilities	0.0001	0.0004	0.11	.914	-0.0001	0.0002	-0.77	.441
	Indoor swimming pools	-0.0007	0.0006	-1.22	.221	-0.0003	0.0002	-1.42	.155
	Golf driving ranges	-0.0009	0.0006	-1.57	.116	-0.0007	0.0004	-1.55	.121
	Fitness centers	0.0007	0.0006	1.09	.274	0.0003	0.0005	0.50	.615
	Subway stations	0.0001	0.0004	-0.05	.962	0.0001	0.0003	0.34	.736
Number of	Parks	0.4737	0.4441	1.07	.286	-0.3315	0.1531	-2.17	.030
	Public sports centers	3.3332	1.7011	1.96	.050	-0.4388	0.9340	-0.47	.639
	Golf driving ranges	0.0317	0.1246	0.25	.799	-0.0212	0.0640	-0.33	.741
	Fitness centers	0.0042	0.1110	0.04	.970	-0.0110	0.0393	-0.28	.781
	Subway stations	3.3332	1.7011	1.96	.050	-0.0787	0.4028	-0.20	.845
Density	Crossroads	0.1151	0.4770	0.24	.809	-0.0015	0.1368	-0.01	.991
Length	Roads	-0.0001	0.0001	-2.35	.019	-0.0001	0.0000	-2.31	.021

Note. * Neighborhood buffers were defined as 500-meter and 1,000-meter radii around each respondent's residence.

〈Table 3〉 Association between urban physical activity environment and BMI in women

Variables	Environmental factors	500 m*				1,000 m*			
		Estimate	SE	t	p	Estimate	SE	t	p
Distance to	Parks	-0.0001	0.0004	-0.30	.765	0.0003	0.0002	1.44	.151
	Public sports facilities	-0.0001	0.0004	-0.37	.710	0.0002	0.0002	0.97	.333
	Indoor swimming pools	0.0001	0.0006	0.04	.970	-0.0004	0.0002	-2.19	.028
	Golf driving ranges	0.0013	0.0006	2.19	.029	0.0004	0.0004	0.84	.404
	Fitness centers	0.0011	0.0006	1.93	.054	0.0004	0.0005	0.86	.391
	Subway stations	0.0001	0.0003	0.19	.851	0.0001	0.0003	0.23	.810
Number of	Parks	-0.4302	0.3795	-1.13	.257	-0.1693	0.1464	-1.16	.248
	Public sports centers	0.8259	1.3799	0.60	.550	-0.1849	0.9785	-0.19	.850
	Golf driving ranges	-0.0531	0.1198	-0.44	.658	-0.0077	0.0590	-0.13	.896
	Fitness centers	-0.0294	0.1019	-0.29	.773	0.0266	0.0368	0.72	.470
	Subway stations	-0.4302	0.3795	-1.13	.257	-0.0314	0.3854	-0.08	.935
Density	Crossroads	-0.1246	0.4172	-0.30	.765	-0.1809	0.1283	-1.41	.159
Length	Roads	0.0001	0.0001	0.04	.966	0.0001	0.0001	0.16	.872

Note. * Neighborhood buffers were defined as 500-meter and 1,000-meter radii around each respondent's residence.

number of subway stations within the 500-meter buffer was marginally associated with higher BMI (p=.050), but this relationship was not observed within the 1,000-meter radius (p=.845).

3. Associations between urban food environment and BMI

The influence of the food environment on BMI revealed gender-specific patterns. Among men, longer distance to convenience stores within the 500-meter buffer was associated with increased BMI (p=.090), while a higher number of convenience stores was marginally associated with lower BMI (p=.056). Additionally, higher density of snack bars within this buffer was associated with increased BMI in men (p=.094).

Among women, increased distance to pubs and Korean BBQ restaurants within the 1,000-meter buffer was marginally associated with lower BMI (p=.063), while a higher number of convenience stores within 500 meters was significantly associated with increased BMI (p=.010). These results suggest complex and gender-specific interactions between food environment exposures and BMI.

Ⅳ. Discussion

This study investigated how physical activity and food environments within an urban setting were associated with BMI, using Gangdong-gu, Seoul as a case study. Through spatial analyses using 500-meter

〈Table 4〉 Association between urban food environment and BMI in men

Variables	Environmental factors	500 m*				1,000 m*			
		Estimate	SE	t	p	Estimate	SE	t	p
Distance to	Fast food stores	0.0001	0.0004	0.19	.847	0.0000	0.0004	0.07	.948
	Pubs and Korean BBQ	-0.0002	0.0007	-0.25	.804	-0.0003	0.0007	-0.39	.694
	Convenience stores	0.0009	0.0005	1.69	.090	-0.0003	0.0004	-0.64	.519
	Street food stores	0.0006	0.0007	0.88	.381	-0.0006	0.0005	-1.08	.280
Number of	Fast food stores	0.2193	0.7632	0.29	.774	-0.0098	0.1453	-0.07	.947
	Pubs and Korean BBQ	-0.0076	0.0276	-0.27	.784	-0.0076	0.0086	-0.89	.372
	Conenience stores	-0.1426	0.0747	-1.91	.056	-0.0151	0.0292	-0.52	.606
	Street food stores	0.1107	0.0660	1.68	.094	-0.0006	0.0005	-1.08	.280

Note. * Neighborhood buffers were defined as 500-meter and 1,000-meter radii around each respondent's residence.

〈Table 5〉 Association between urban food environment and BMI in women

Variables	Environmental factors	500 m*				1,000 m*			
		Estimate	SE	t	p	Estimate	SE	t	p
Distance to	Fast food stores	0.0001	0.0004	0.38	.703	0.0001	0.0003	0.06	.952
	Pubs and Korean BBQ	-0.0011	0.0007	-1.62	.105	-0.0012	0.0006	-1.86	.063
	Convenience stores	-0.0004	0.0005	-0.82	.411	-0.0007	0.0004	-1.52	.128
	Street food stores	0.0005	0.0007	0.81	.420	-0.0001	0.0005	-0.11	.914
Number of	Fast food stores	-0.6010	0.7302	-0.82	.411	-0.0832	0.1364	-0.61	.542
	Pubs and Korean BBQ	0.0212	0.0258	0.82	.412	0.0129	0.0080	1.62	.106
	Convenience stores	0.1741	0.0679	2.57	.010	0.0302	0.0273	1.11	.269
	Street food stores	-0.0374	0.0601	-0.62	.534	-0.0001	0.0005	-0.11	.914

Note. * Neighborhood buffers were defined as 500-meter and 1,000-meter radii around each respondent's residence.

and 1,000-meter buffers around individuals' residences, our findings suggest that both proximity and density of built environment factors were significantly associated with BMI, although the relationships varied by gender and spatial scale.

Closer proximity to parks and more extensive road networks within 500 m and 1,000 m buffers were generally associated with lower BMI - particularly among men - while the food environment revealed gender-specific and more complex patterns. For men, shorter distances to convenience stores and higher densities of snack bars were associated with increased BMI, whereas for women, greater numbers of convenience stores, pubs, and BBQ restaurants within 1,000 m predicted higher BMI.

Consistent with prior literature, green and walkable spaces emerged as important determinants of lower BMI. Specifically, proximity to parks and longer road lengths were significantly associated with lower BMI, especially among men. These results support the notion that access to open spaces facilitates physical activity and contributes to healthier body weight outcomes (Sugiyama et al., 2008; Wolch et al., 2011). Studies conducted in Seoul and other dense urban settings have also emphasized the limited availability of open spaces as a key barrier to physical activity (Lee & Moudon, 2008). Moreover, highly connected streets encourage walking for public transit and daily physical activities, which have been known to reduce obesity risk (Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Saelens, & Handy, 2008). Road density and connectivity may thus serve as proxies for pedestrian-friendly environments that encourage walking and reduce sedentary behaviors.

The observed gender difference may reflect variations in leisure-time activities, perceived safety, or park usage patterns (Floyd, Spengler, Maddock, Gobster, & Suau, 2008). Furthermore, the stronger associations found in the 500-meter buffer suggest that immediate neighborhood environments may have a more direct impact on residents' physical activity and BMI. These physical activity-related built environment factors may also vary by age and socioeconomic status. For instance, younger adults might often use transit stops and adjacent commercial corridors, whereas older adults might rely on quieter residential streets for daily walks. Such variation implies that aggregate associations may limit stronger effects within subpopulations.

In contrast to the clear patterns observed for physical activity, food environments revealed more complex and gender-specific associations. Among men, shorter distances to convenience stores and higher densities of snack bars were associated with higher BMI, whereas among women, the number of convenience stores within 500 meters and the number of pubs and BBQ restaurants within 1,000 meters were positively associated with BMI. These findings are consistent with previous research indicating gender differences in food access and consumption behaviors potentially influenced by social roles, time use, and marketing exposure (Cannuscio et al., 2013; Lucan, Karpyn, & Sherman, 2010).

The limited significance of distance-based measures in some food environment variables may reflect the rapidly evolving urban food culture in Korea (Lee & Yoo, 2024). Seoul's foodscape is characterized by cheap and fast-served meals from corner-store snacks or delivered dishes, rather than typical fastfood outlets. Moreover, the socio-cultural phenomena such as *mukbang* ("eating broadcasts") and food-porn social-media trends have created new social norms with large portions and calorie-dense eating as entertainment (Wang et al., 2025). At the same time, a concurrent well-being movement has elevated interest in organic or plant-based foods among some demographic groups (Lee, Kim, & Jung, 2022). Our spatial variables could not fully capture these socio-cultural factors, suggesting the need for further studies. In particular, the expansion of online food delivery services and social media content—such as *mukbang* and food-related influencers—has created a virtual food environment that affects dietary behaviors independently of physical proximity.

Visible factors such as geographic accessibility and retail mix of food and recreational outlets remain important (Saelens & Handy, 2008). However, less visible factors have emerged through highly accessible delivery platforms and digital media. Individuals are now increasingly exposed to virtual foodscapes and activity cues beyond physical proximity (Yoon et al., 2018). These 'invisible' aspects of the foodscape can contribute to increased exposure to calorie-dense foods, promote frequent snacking or overeating, and potentially influence obesity. Future urban health research should integrate both on-site access and off-site virtual exposures to fully characterize obesogenic environments. Particularly in Seoul, the availability of convenience foods, rapid expansion of food delivery apps, and widespread food-related media content have reshaped the ways in which people access and consume food. This indicates that traditional concepts of "place" in food environment research should be expanded to include both visible and invisible dimensions—such as digital access, virtual exposure, and cultural trends (Yoon et al., 2018).

While, individual-level behavior change (e.g., diet and exercise) is commonly emphasized, our findings underscore the structural influences of the environment that cannot be easily changed by individuals. Therefore, population-level reductions in obesity will require institutional and systematic interventions. Urban design strategies should incorporate health equity considerations by ensuring equitable access to open green space with high walkability and better road connectivity, and healthy food options by regulating the spatial concentration of unhealthy food outlets to achieve meaningful population-level reductions in obesity.

This study contributes to the growing literature on spatial determinants of health by using objective geocoded data and a focused urban context. Urban health frameworks increasingly acknowledge the importance of not only individual behaviors but also the contextual factors that shape those behaviors (Giles-Corti et al., 2016; Rydin et al., 2012). By adopting a spatial analytic approach, this study enhances understanding of how micro-level environmental conditions—within walkable distances from home—impact weight-related outcomes. Moreover, our analysis of gender- and distance-specific associations highlights the need for more tailored public health strategies that address both environmental structures and behavioral pathways.

Several limitations must be noted in this study. First, the cross-sectional design limits the causal inference. Second, although proximity and density measures provide objective information about the built environment, they might not reflect individuals' perceived access or actual utilization of facilities. Future studies could incorporate subjective measures of accessibility and behavior-specific data to enhance interpretation. Third, the analysis did not include indicators such as access to fresh foods, including supermarkets or local produce markets due to data limitation, which may significantly influence dietary choices and nutritional quality. This omission might underrepresent the broader impact of the food environment, especially those promoting healthy eating. Fourth, the environmental data used in the study reflect conditions as of 2016, while health data cover 2012 to 2016. More importantly, given that the present year is 2025, the environmental conditions analyzed may no longer accurately reflect the current state of the urban environment. As a result, the policy relevance and applicability of the findings to today's urban health planning might be limited. Future studies using more recent datasets will be essential to develop timely and actionable insights. Lastly, the study did not apply sampling weights provided by the KCHS, which may limit the generalizability of the findings. The omission of weighting, although necessary due to spatial linking constraints, may introduce bias by underrepresenting or overrepresenting certain demographic groups. Future research should explore methods to integrate weighted estimates with geospatial analyses.

Despite these limitations, the study offers valuable insights into the spatial determinants of BMI. It underscores the importance of incorporating spatial equity into urban policy, such as prioritizing the allocation of green space in underserved neighborhoods or regulating unhealthy food outlet density in high-risk areas, to promote healthier urban living environments using micro-level urban data. Our findings highlight the need for targeted urban planning policies that enhance access to physical activity spaces and address gender differences in the food environment, while also considering how social and cultural influences may influence these patterns differently across populations.

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