Exploring Pedestrian Comfort and Urban Mobility: A Multi-Modal Assessment of Walking Experiences at Popular Restaurant Destinations in Shanghai

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Abstract
This study examined pedestrian comfort and urban mobility in Shanghai's inner-core restaurant destinations by identifying three distinct access patterns: Public transportation + non-motorized/ long distance walk (PNLW), Public transportation + short distance walk (PSW), and Motorized vehicle + short distance walk (MSW). Using spatial audits, navigation data, and social media text analysis, it evaluates comfort through pedestrian characteristics and traffic conditions. Findings reveal that MSW destinations—despite being less sustainable—offer the highest pedestrian comfort due to better-designed access zones and reduced pedestrian-electric scooter conflict. PSW areas suffer from congestion and inadequate micro-scale planning, while PNLW zones are most impacted by infrastructural shortcomings. The study concludes that pedestrian comfort depends on the continuity and convenience of the space where different modes of transportation changed.

Keywords: pedestrian comfort; travel; destination;

1. Introduction

The travel behavior of citizens is closely related to urban space and urban transportation systems. In megacities such as Shanghai, the evolution of mixed-use developments, commercial hubs, and transit-oriented infrastructure has heightened the need for pedestrian-friendly environments. More comfortable walking can enhance travelers' willingness to travel actively (Knowles, et al, 2020) and is a core part of the sustainable travel transformation (Loo, 2021). Walking comfort is a measure of the quality and attributes provided by the walking environment through space and walking facilities, which makes the walking experience easier (Ma, et al, 2021). It includes material, physical and psychological comfort (Sarkar, 2003). However, walking during travel is not an isolated process: As a higher-level walking demand (Alfonzo, 2005), the comfort of walking is also dynamically influenced by factors such as the relationship between the person and the vehicle and travel characteristics.

Among various urban functions, dining play a unique role in shaping urban pedestrian flow. Popular restaurant destinations, often located in high-footfall commercial districts, naturally attract large volumes of pedestrian movement and serve as key nodes in urban pedestrian networks. While existing research primarily examines broad walkability metrics such as land use and infrastructure, fewer studies focus on how walkway conditions, traffic flow, and transportation infrastructure impact pedestrian experiences during the travel.

This study adopts the destination-oriented approach, aiming to fill this gap by evaluating the pedestrian comfort in Shanghai's inner-ring commercial areas, focusing on locations with high restaurant-driven foot traffic. By integrating navigation data, spatial audits, and text analysis from social media platforms, this research provides a comprehensive understanding of pedestrian experiences and offers multi-modal data-driven recommendations for urban planning and design. Specifically, it focuses on understanding how pedestrian comfort varies across different arrival modes and urban fabric at popular restaurants destinations.

The study has three primary objectives:
1) To analyze the access pattern of popular restaurant destinations in Shanghai's inner core area and the relationship with their urban fabric and transportation infrastructure.
2) Evaluate the pedestrian comfort in these areas based on walkway quality, pedestrian characteristics, and traffic conditions, and add other special criteria such as dedicated parking areas, station facilities, and attractiveness according to different arrival patterns. The relevant high-frequency words that appear on social media are also important supplementary evidence for the evaluation.
3) Seek the correlation between access patterns and pedestrian comfort.

2. Literature Review

Studies on pedestrian comfort in urban design focus on the influence of built environments on pedestrian behavior and perception, encompassing both objective and perceived characteristics of the built environment, as well as walking behavior and related factors. This research further examines pedestrian comfort during travel, investigating how travel characteristics—such as trip purpose, mode of transportation, and travel time—affect comfort levels.

Walking serves as a critical link between various travel segments and transportation modes, spanning multiple stages from origin to transfer points and final destinations. Pedestrian comfort directly influences individuals' willingness to adopt other modes of transportation. High-quality walking environments, convenient pedestrian facilities, and appropriate walking distances can significantly enhance residents' travel satisfaction (Van Lierop et al, 2018).

From a travel perspective, research on walking comfort treats walking as a distinct mode of transportation, views pedestrians as individual units within traffic flow, and integrates pedestrian systems as an essential component of urban transportation networks. This approach emphasizes the systemic role of walking in shaping overall mobility experiences and urban accessibility.

2.1 The influence of travel links on pedestrian comfort

Academic research has established that pedestrian comfort in transit station areas - encompassing bus stops, metro stations, and railway terminals - significantly influences travelers' modal choices and willingness to walk to transit nodes. Empirical studies utilizing citizen satisfaction evaluations demonstrate that perceived walkability (Gan et al, 2021) and sidewalk conditions, pedestrian facilities, and intersection design (Gupta et al, 2022) in station access zones, positively correlate with metro ridership. For Bus Rapid Transit (BRT) systems, research indicates that pedestrian comfort perceptions depend fundamentally on sidewalk quality and cleanliness, with tree-shaded routes particularly enhancing walking propensity (Jiang et al, 2012). Emerging scholarship employs quantitative measures like street tree density and bench availability to assess how Light Rail Transit (LRT) station-area built environments (within 5-minute walk radii) support active transportation adoption (Oluyomi et al, 2019).

Transfer stations present unique comfort considerations, where platform accessibility, vertical circulation systems, and crossing infrastructure substantially impact commuter experience, as evidenced by studies in Indian contexts (Sil et al, 2022). Alexander's seminal work establishes 180-200m (approximately 3-minute walk) as the maximum acceptable transfer distance for maintaining passenger comfort (Alexander, 2018).

The first-mile/last-mile (FMLM) challenge remains a critical barrier to transit adoption (Fehr & Peers et al, 2015). High-quality FMLM environments simultaneously enhance both utilitarian functionality and experiential quality of transit journeys (Tilahun et al, 2016). Ergonomics research reveals that travelers' overall comfort evaluations are disproportionately weighted toward terminal trip segments (Richards, 1978), with destination-area microclimate comfort particularly influencing satisfaction assessments (McKercher, 2015). Improved walkability in FMLM zones demonstrates pro-social impacts, enabling greater transit use among low-income commuters - with origin-area walkability proving more influential than destination conditions (Ha et al, 2023). For bus riders, FMLM comfort and transfer duration exert greater satisfaction impacts than in-vehicle conditions (Park et al, 2021).

Regarding metro access, "last-mile" qualitative aspects like sense of place outweigh basic facility availability in promoting walking mode share (Chidambara, 2019).

2.2 Pedestrian characteristics and pedestrian comfort

The fundamental significance of pedestrian comfort lies in optimizing travel experience, making micro-scale behavioral metrics essential for operationalizing comfort assessment. Under optimal conditions, empirical studies document an average walking speed of 1.24 m/s (Chen and Dong, 2005), with personal space requirements of 1.4-2.3 m^2/person (Fruin, 1971) and flow rates below 23 persons/m·minute maintaining perceived environmental freedom. The personal space construct, encompassing both pacing zones (physical movement requirements) and sensory zones (psychological buffer areas), has emerged as a robust proxy for design quality and level-of-service evaluation.

Contemporary research methodologies employ diverse approaches: sidewalk width-to-volume ratios for crowd density analysis, computer vision processing of transit vehicle dashcam footage for crossing behavior studies (Fan and Loo, 2021), and IoT-enabled environmental sensors (e.g., air quality monitors) capturing spatiotemporal usage patterns (Loo and Tang, 2019). Wi-Fi signal clustering techniques also effectively detect group movement patterns. Participatory sensing through opt-in smartphone applications further enriches data granularity by correlating mobility patterns with individual attributes.

While demographic (age/gender), socioeconomic, and cultural factors preclude universal comfort standards, consensus emerges around three core requirements: unimpeded walking pace, adequate personal space allocation, and controlled pedestrian densities. Comfort manifests behaviorally through unconstrained movement patterns-characterized by purposive gait unaffected by negative psychological states, minimal flow conflicts (<15° angular deviation in trajectory intersections), and limited friction with other modal users (vehicular/bicycle). These observable parameters collectively establish an evidence-based framework for comfort evaluation across varied urban contexts.

2.3 Auditing Frameworks and Criteria of pedestrian comfort measurement

Comfort has been explicitly incorporated into various walkability audit tools and guidelines, which can be categorized by scale and methodology. At the macro urban scale, quantitative tools provide comprehensive assessments of city-wide factors, while micro street-scale evaluations qualitatively characterize outdoor spaces through user perception. Current measurement instruments are inherently context-specific, can be classified into five methodological approaches:

1) Perceptual Tools
Neighborhood Environment Walkability Scale (NEWS) (Cerin et al, 2002)

2) Perceptual-Observational Hybrid Tools
Pedestrian Environment Data Scan (PEDS) (Clifton et al, 2007)
Systematic Pedestrian and Cycling Environment Scan (SPACES) (Pikora et al, 2002)
Systematic Social Observation of Public Spaces (SSO) (Sampson and Raudenbush, 1999)

3) Observational Tools
Chinese Urban Built Environment Scan Tool (CUBEST) (Su et al, 2014)
Analytic Audit Tool (AAT) (Brownson et al, 2004)
Active Neighborhood Checklist (ANC) (Hoehner et al, 2007)
Neighborhood Active Living Potential (NALP) (Gauvin et al, 2005)

4) Observational-Archival Hybrid Tools
Walkability Framework for Health (WFH) (Zuniga-Teran et al, 2016)
Pedestrian Level of Service - Quality (Q-PLOS) (Talavera-Garcia and Soria-Lara, 2015)

5)Archival Tools
Walkability Index (WAI) (Frank et al, 2010)
Walk Score (WS) (Arellana et al, 2020)
The Physical Activity and Redesigned Community Spaces (PARCS) study (Huang et al, 2016)

3. Methodology

3.1 Study Area and Site Selection

This study focuses on popular restaurant destinations within Shanghai's inner-ring commercial areas, selected based on Gaode Map navigation data. The inner ring represents the city's core zone, characterized by the highest density of transportation and pedestrian activity. To ensure that walking segments occur exclusively in outdoor built environments and urban streets, restaurants located within TOD (Transit-Oriented Development) buildings were excluded from the analysis.

The selection of restaurants was determined by Gaode Travel Score, a data-driven metric derived from real user navigation behavior, including travel popularity and experience quality. This score reflects a restaurant's relative

standing compared to others in the same category and urban context. The data is updated daily based on a 30-day dynamic rolling window, ensuring objectivity without manual intervention or manipulation.

To capture representative dining destinations, the study identified the top three most-visited restaurants in each administrative district within the inner ring, ensuring spatial diversity and high pedestrian accessibility (Fig.1). In addition, Yangpu District and Pudong District have no restaurants that meet the requirements. This approach allows for a systematic evaluation of walkability and pedestrian comfort in high-traffic urban dining areas.

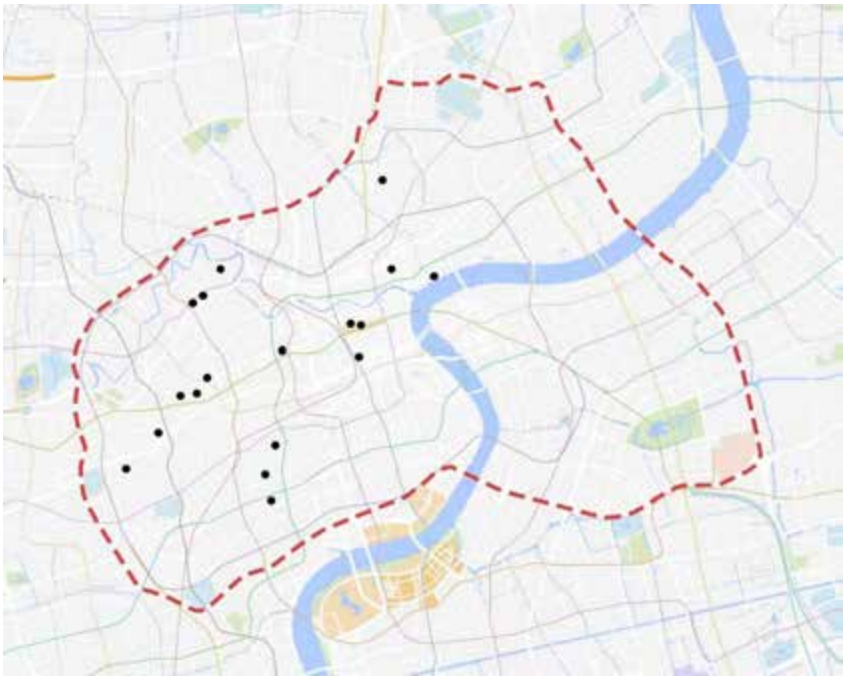

Figure 1 Selected restaurants

Source: Author's own illustration based on raw data from Gaode Map.

3.2 **Online Data Sources and Collection Methods**

This study employed a comprehensive multi-source data collection framework to systematically evaluate the pedestrian environment surrounding selected restaurants. The spatial analysis was conducted within an 800-meter radius buffer zone centered on each restaurant location, encompassing key pedestrian transportation infrastructure elements including sidewalks, parking facilities, and public transportation nodes including bus stops (within 300 meters) and subway stations (within 500 meters). These geospatial datasets were acquired through application programming interfaces (APIs) from Gaode, ensuring data accuracy and temporal relevance.

For dynamic pedestrian flow analysis, the study utilized Baidu Map's heatmap functionality, which provides real-time visualization of human mobility patterns through anonymized location data from mobile devices. Data collection was strategically scheduled during peak activity periods - specifically weekday evenings (17:30) and weekend noontime (11:30) - to capture maximum pedestrian volumes. These temporal samples enabled identification of high-traffic corridors for subsequent field observations while providing quantitative evidence of congestion patterns (Fig.2).

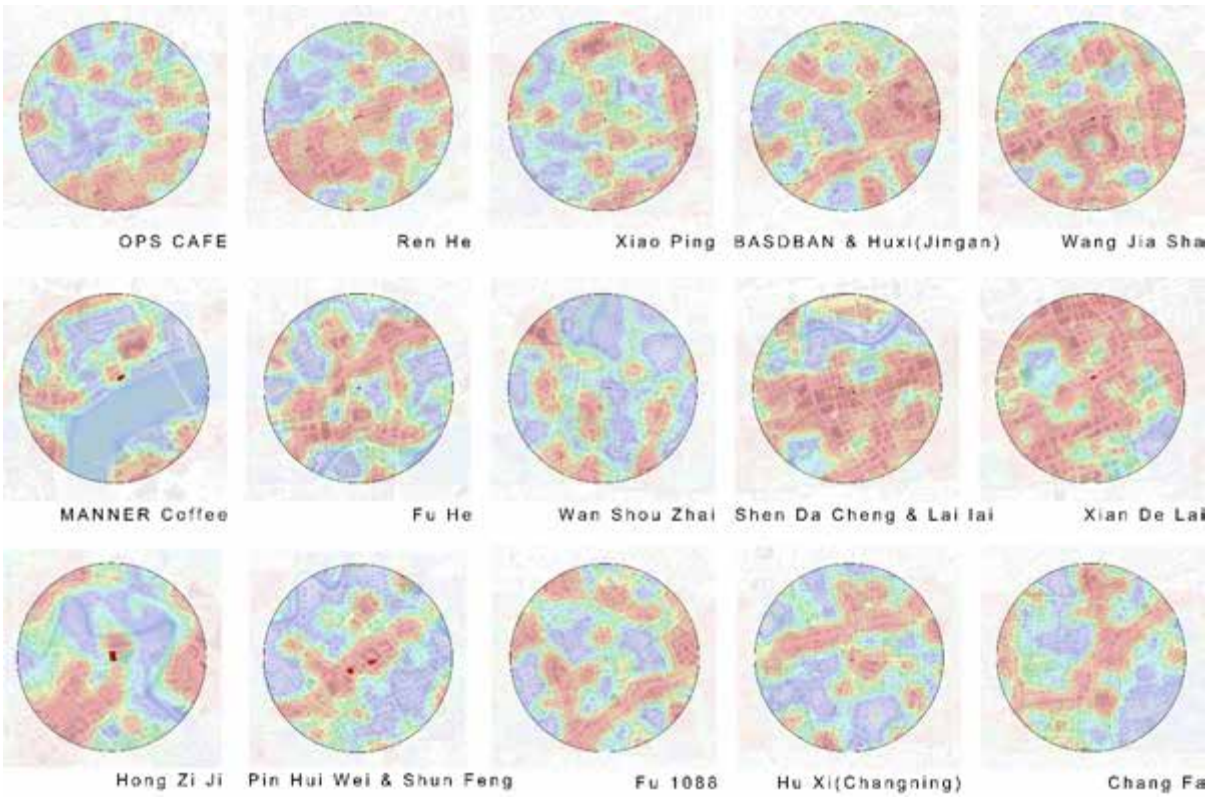

Figure 2 Heat map of the restaurants

Source: Author's own illustration based on raw data from Baidu Map.

Complementing the pedestrian flow data, shared bicycle availability data were extracted from the Meituan platform's real-time feed. This dataset, collected synchronously with the heatmap recordings, provided insights into micro-mobility patterns and last-mile connectivity around each study site. Spatial analysis of bicycle distribution patterns helped identify parking hotspots and potential conflicts with pedestrian flows.

To complement spatial and mobility data, social media text data was extracted from Xiaohongshu (Little Red Book), a platform where users share image-text posts. A structured keyword search protocol was implemented using terms such as "walking experience", "accessibility", and "pedestrian comfort" in combination with each restaurant's name.

This multi-method approach, combining spatial analysis, movement pattern visualization, and text analysis, provided a robust foundation for evaluating pedestrian comfort from both objective and subjective perspectives.

3.3 Quantitative pedestrian comfort evaluation method

Building on previous mobility-focused studies of pedestrian comfort, this research categorizes evaluation metrics into 4 common criteria (universally applicable criteria for all access pattern) and 9 specialized criteria (context-sensitive measures tailored to specific access patterns). To enable precise quantification, each restaurant is systematically scored across all relevant indicators using a standardized 0-2 point scale (where 0 = poor, 1 = moderate, 2 = optimal), with summation generating a composite Pedestrian Comfort Score (PCS) for individual restaurant (Tab. 1).

Table. 1 pedestrian comfort evaluation

Evaluation criteria			Pedestrian comfort score			Access pattern		
Category	criteria	Description	0	1	2	PNLW	PSW	MSW
Common criteria	Sidewalk Quality	Width	2m	2-3m	>3m	√	√	√
		maintenance	uneven and dirty surface	slightly uneven with minor stains	flat and clean surface			
	Pedestrian Characteristics	Pedestrian Flow Rate	>30 or <10 persons/min	20-30 persons/min	10-20 persons/min	√	√	√
		Queue Encroachment	queue obstructs sidewalk	minor queue	no queue			
	Traffic Conditions	traffic congestion	severe congestion (vehicles cannot move)	moderate congestion (vehicles slow down)	no congestion	√	√	√
		Pedestrian-Electric Scooter Mixing	frequent mixing (pedestrians avoid vehicles)	occasional mixing	no mixing			
Special criteria	Dedicated Parking Areas	Pavement Material Differentiation	no differentiation	marked differentiation	material differentiation	√	×	√
		Direct Access	no direct access	access via underground/ overground passage	direct entrance access			
		Dedicated Waiting Area	no dedicated waiting area	dedicated waiting area	no dedicated waiting area	×		
		Independent Parking Lot	no parking lot	available but insufficient	sufficient independent parking			
	Station Facilities	Escalators at Exits	no escalators	escalators available	escalators and accessible elevators	×	√	×
		Exit Time	underground passage and multi-level vertical transit	underground passage or multi-level vertical transit	no underground passage or multi-level vertical transit			
		Bus Stops	<10	10-20	>20			
		Walking Distance to Nearest Metro	>800m	500-800m	<500m	√		
	Attractiveness	-	ordinary street	historic/ commercial district	central business district	√	√	×

3.4 Pedestrian Comfort Audit

According to the evaluation framework (Tab. 1), the study employed a rigorous, multi-dimensional approach to assess pedestrian comfort through systematic field audits. Quantitative measurements followed standardized protocols: 1) sidewalk width was recorded using laser distance meters at 5-meter intervals along restaurant frontages, with three measurements taken at each point to ensure reliability (recording minimum, maximum and average widths). 2) Pedestrian flow rates were measured in units of 5 minutes through manual counting at 15-minute intervals during both weekday evening (17:30-19:30) and weekend midday (11:00-13:00) peak periods. 3) Queue encroachment was documented through scaled photographs and actual measurements of occupied sidewalk area, with particular attention to instances where more than 50% of walkway width was obstructed.

Qualitative assessments employed structured observation protocols. 1) Pathway maintenance was evaluated by features such as surface evenness, cleanliness, visual coherence, and drainage conditions. 2) Traffic conditions were analyzed through photograph recording during audit periods, with conflict points mapped. 3)Parking infrastructure was inventoried through field surveys documenting, including dedicated bicycle parking capacity, electro mobile parking encroachment, and vehicle parking lot capacity serving the restaurant. 4) Metro station accessibility was assessed through timed walk tests from nearest exits, documenting vertical circulation options and wayfinding signage to make sure how to smoothly reach the concourse level from the platform level and find the exit.

The audit incorporated specialized vertical mobility assessments, including inventory of skyway and step counts for underground passages. These vertical elements were found to disproportionately affect pedestrian comfort due to additional physical exertion required and the increased difficulty of finding the way.

All audit data was collected by trained teams using standardized digital forms with geotagged photographs and timestamped observations. The comprehensive methodology enabled both cross-site comparisons and context-specific analysis of pedestrian comfort determinants across Shanghai's varied urban environments. Particular attention was given to transitional spaces between different transport modes, where comfort compromises were most frequently observed. The audit framework successfully captured both measurable physical parameters and subjective user experience factors affecting pedestrian comfort.

3.5 Identifying Pedestrian Access Patterns Through Field Survey

To determine how pedestrians arrive at restaurants, the study employs a multi-method field audit protocol that combines behavioral observation, infrastructure mapping analysis and text analysis from Xiaohongshu.
Pedestrian access patterns during peak hours (weekday evenings (17:30-19:30) and weekend midday (11:00-13:00) by observing:1) Whether pedestrians used means of transportation such as vehicles, bicycles or electric bikes or wore helmets when they arrived. 2) Randomly track an array of pedestrians at the nearest subway exit, and calculate the proportion of these pedestrians who reach the destination restaurant among the total number of people who arrive at the restaurant during this period.

An analysis of the transportation infrastructure around the restaurant can also obtain supplementary evidence: 1) A distance of less than 500 meters from the restaurant to the nearest subway station is more likely to be dominated by public transportation. 2) The dense bicycle parking area near the restaurant will encourage pedestrians to ride bicycles at "the last mile". 3) Restaurants that are over 800 meters away from subway stations, have their own parking lots and are not popular check-in spots are more likely to be reached by private cars or ride-hailing services. 4) When the destination restaurant is highly attractive, such as having a good urban view or being located in a historical district, pedestrians are more likely to tend to reach it on foot.

In addition, by searching for Xiaohongshu posts with keywords such as "restaurant name", "travel", "subway", and "walking", and conducting word frequency analysis on the transportation methods within them, it can also help study and determine the arrival methods of most travelers.

Finally, the research will determine the access patterns of a certain restaurant based on the most dominant arrival means. This identifying method effectively reduces subjective bias through cross-validation of multi-dimensional data.

4. Results and Findings

4.1 Classification of Arrival Patterns

This study categorizes pedestrian access patterns into three typologies based on infrastructure constraints and behavioral preferences: PNLW (Public transportation combined with Non-motorized or Long-distance Walk), PSW (Public transportation combined with Short-distance Walk), and MSW (Motorized vehicle combined with Short-distance Walk). It should be noted that the usage frequency of buses has significantly decreased in both the field research and in text analysis of Xiaohongshu. The public transportation referred to in the research is more about the subway.

Each pattern reflects distinct urban fabric conditions—historic-district morphologies for PNLW, transit-oriented development for PSW, and motor-centric adaptations for MSW—collectively shaping pedestrian comfort and route choices. The classification underscores how spatial design and transport resource allocation either facilitate or hinder more comfortable last-mile connectivity.

4.1.1 Public transportation + Non-motorized/ long distance walk (PNLW)

The formation of the PNLW (Public Transportation + Non-motorized/Long-Distance Walk) access pattern is primarily attributed to restaurants being located beyond 500 meters or even 800 meters from metro stations,

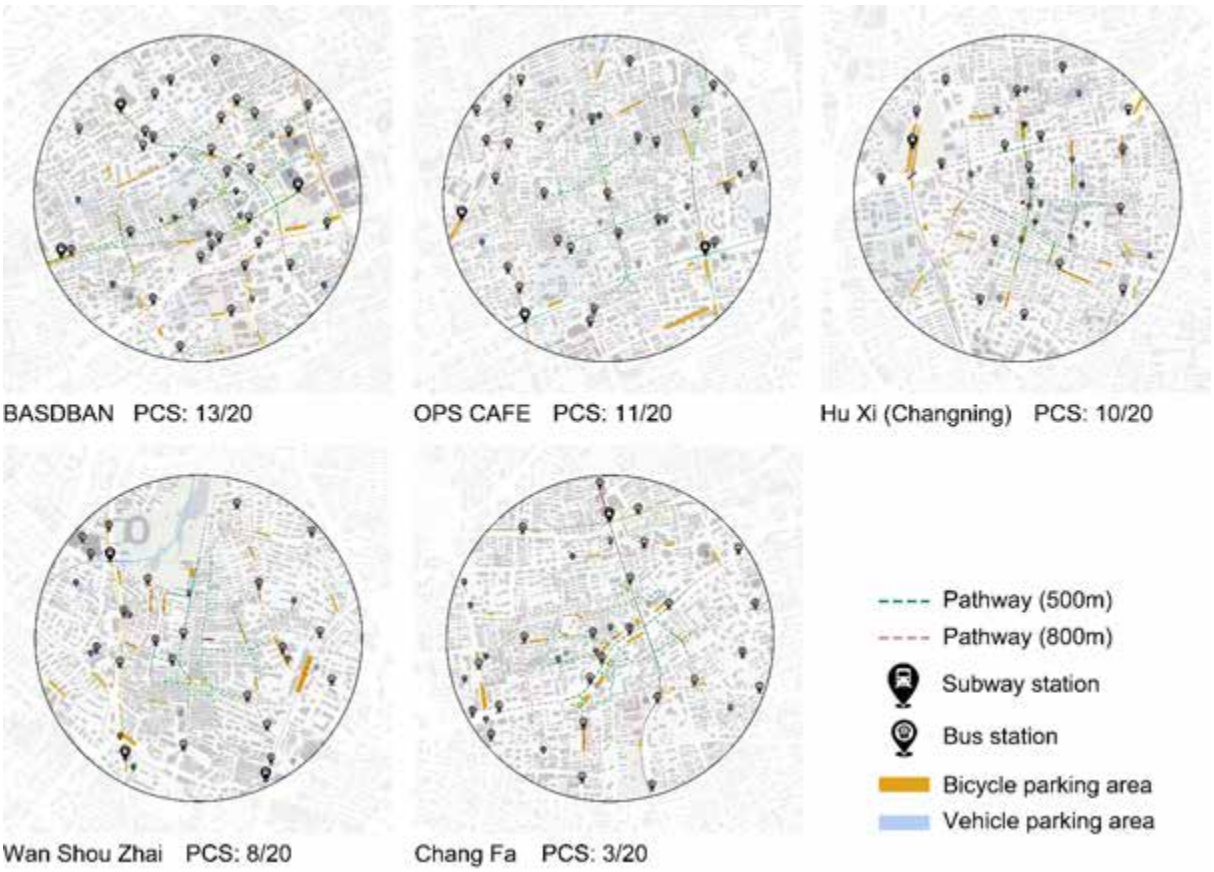

Figure 3 PNLW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

"Check-in" restaurants in historical district—such as BASDBAN, OPS CAFÉ, and Wan Shou Zhai—represent the first category of PNLW destinations due to: 1) Narrow roadways lacking dedicated bicycle lanes, forcing cyclists to share roads with motor vehicles, 2) Artificially enforced bicycle-restricted zones that create pedestrian-only segments along access routes.

Despite these constraints, such destination restaurants often benefit from being clustered with adjacent attractions, creating hybrid bicycle-and-walking routes that maintain strong pedestrian appeal.

The second category of PNLW destinations includes establishments like Hu Xi (Changning) and Chang Fa located near elevated roads. These sites present unique accessibility challenges: 1) Pedestrian flows are fragmented by overpass structures; 2)Certain road sections remain impassable for bicycles.

This spatial configuration effectively forces longer walking distances while limiting alternative micro-mobility options, reinforcing the PNLW pattern's dominance in these locations. The combination of physical barriers and policy restrictions creates a distinct pedestrian experience that differs markedly from transit-oriented or motor-centric access patterns.

4.1.2 Public transportation + short distance walk (PSW)

The PSW pattern emerges when restaurants are within 500 meters of the nearest subway exit (Fig. 4). These destinations—typically "check-in" spots—attract predominantly tourist visitors. Top-rated Huangpu District

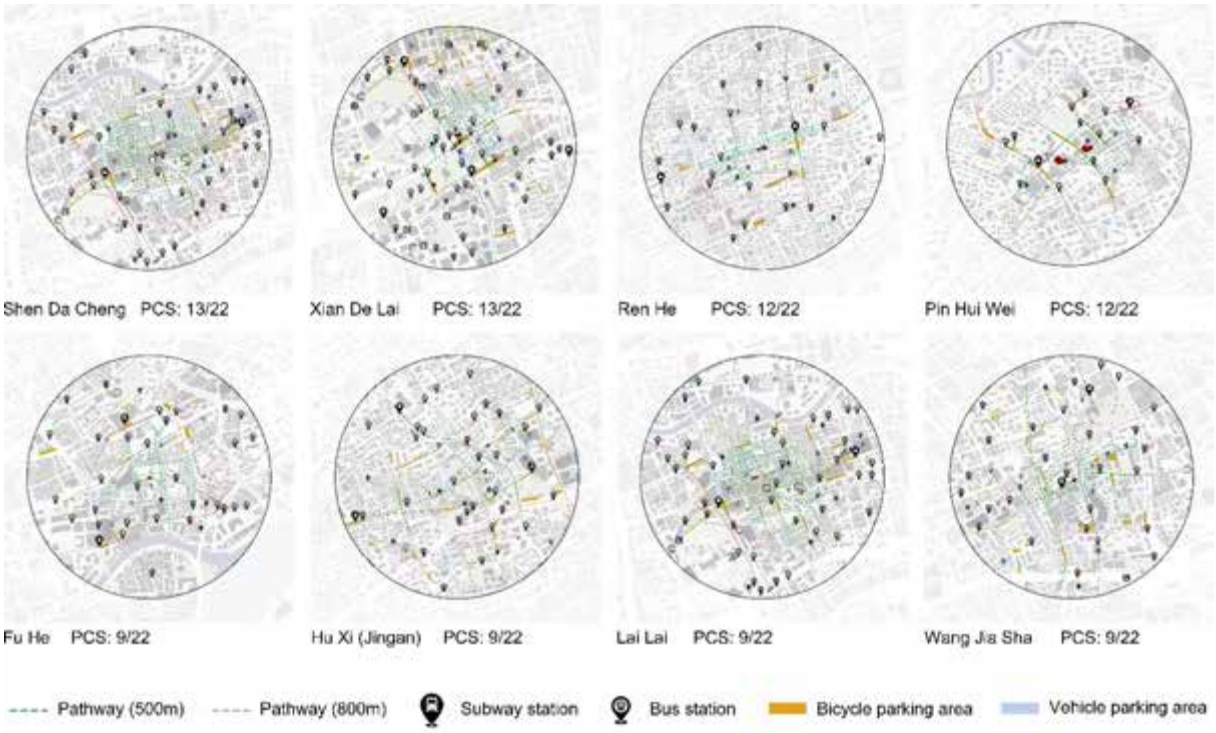

Figure 4 PSW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

Critical transit nodes that facilitate this pattern include major interchange stations, including Nanjing East Road (Lines 2/10), Jing An Temple (Lines 2/7/14), Nanjing West Road (Lines 2/12/13), Chang Shou Road (Lines 7/13), and Jia Shan Road (Lines 9/12). These hubs create concentrated restaurant clusters by capitalizing on two key advantages: their role as transportation interchanges and their embeddedness within vibrant commercial or historic districts. The resulting pedestrian networks enable dense, multimodal access to dining establishments. Moreover, PSW restaurants are supported by high bus-stop density (more than 10 stops within 300 meters, sometimes exceeding 20), reinforcing transit convenience.

This comprehensive transit ecosystem ensures consistent pedestrian flows while minimizing access friction, creating an environment particularly conducive to casual dining and tourism-oriented food establishments. The spatial efficiency of these areas demonstrates successful transit-oriented development principles in practice, where transportation infrastructure and commercial land uses achieve symbiotic integration.

4.1.3 Motorized vehicle + short distance walk (MSW)

The MSW pattern represents a distinct category where travelers predominantly utilize private vehicles or ride-hailing services to access restaurants, followed by brief pedestrian segments. This access mode emerges under two primary circumstances: 1) when restaurants are situated beyond convenient walking distance from metro stations (>800 meters) but provide dedicated parking lots; and 2) when the dining occasion involves group gatherings where motorized transport is preferred for social or logistical reasons (Fig. 5).

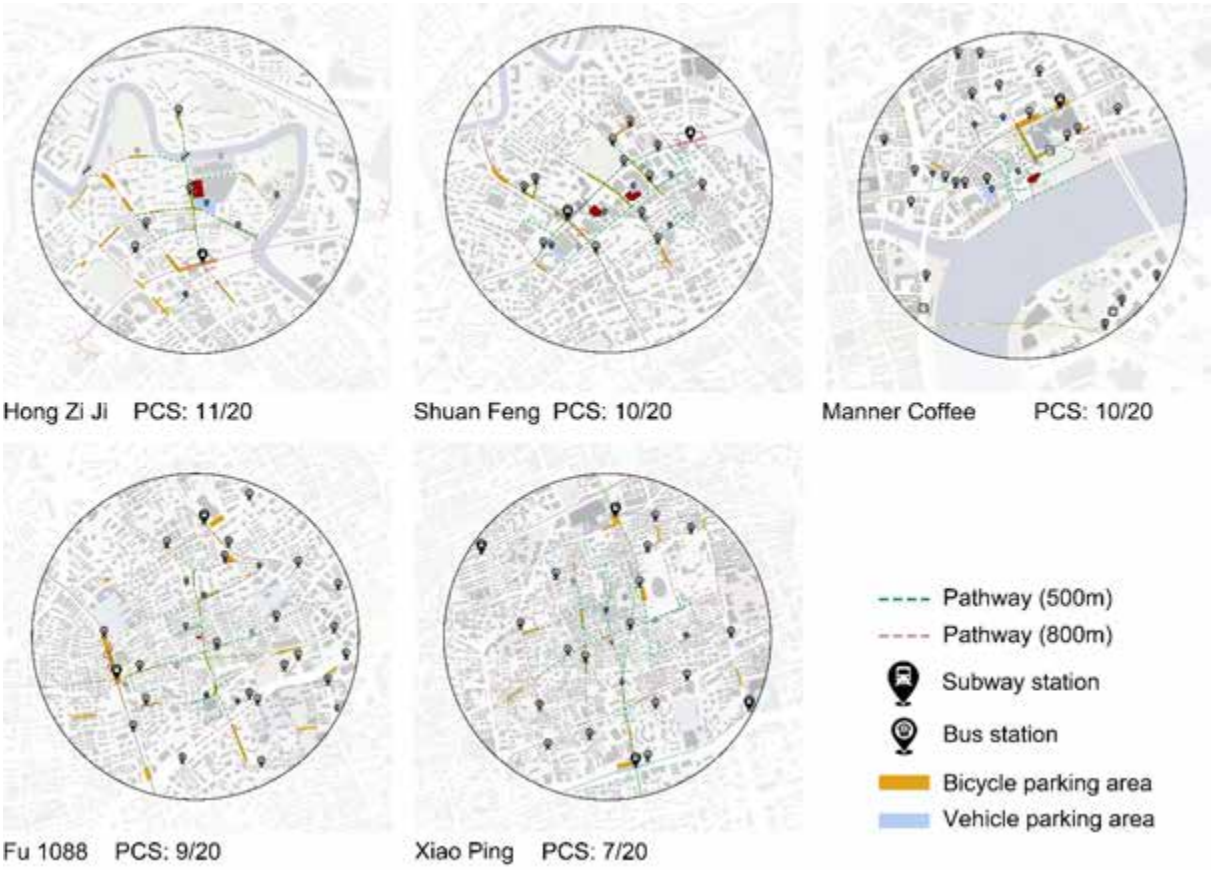

Figure 5 MSW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

Notably, restaurants located in historical districts - such as Fu 1088 - present unique challenges for MSW accessibility. These establishments are typically surrounded by low-rise commercial buildings with limited parking capacity, as most available spaces are allocated to private lots serving adjacent properties. This parking scarcity inadvertently increases reliance on short-distance walking, as patrons are often compelled to park at more distant locations and complete their journey on foot.

The spatial analysis reveals that MSW pattern restaurants cluster in two distinct urban contexts: 1) commercial centers with sufficient surface parking lots (e.g., Hong Zi Ji, Shun Feng), and 2) where public transport coverage is sparse but road infrastructure supports convenient vehicle access such as urban waterfront spaces (e.g., Manner Coffee and Hong Zi Ji) and lower-grade urban roads (e.g., Fu 1088, Xiao Ping). In both settings, the walking segments, though short, often present disproportionate comfort challenges due to inadequate sidewalk provisioning and lack of weather protection along parking-to-restaurant routes.

4.2 Pedestrian Comfort Assessment

The pedestrian comfort scores (PCS) varied notably across the three access patterns. On average, restaurants accessed via the MSW pattern achieved the highest comfort score (11.6/20), followed by PSW pattern with 10.5/22, and PNLW pattern with the lowest score of 9.0/20. These differences primarily stem from distinct infrastructure

challenges: MSW's transitional zone deficiencies, PSW's crowd management issues during peak hours, and PNLW's inherent distance penalties compounded by narrow sidewalks. The superior performance of MSW destinations can be attributed to clearer spatial organization, dedicated parking access, and better-maintained pedestrian zones. In contrast, PSW areas, while benefiting from proximity to transit infrastructure, often suffered from high pedestrian density and queue encroachment near exits. PNLW destinations showed the greatest variability, with comfort scores largely dependent on sidewalk quality and traffic mixing conditions.

These results highlight how pedestrian comfort is shaped by both macro-level accessibility and micro-scale design solutions specific to each access pattern. Sidewalk infrastructure, traffic separation, and spatial crowd management are critical determinants of perceived pedestrian comfort, often outweighing the presumed advantages of public transit-oriented accessibility.

4.2.1 PNLW: Structural and Psychological Barriers in Long-distance Walk

The PNLW access pattern exhibits several challenges that significantly compromise pedestrian comfort (Tab.2). Primary issues include inadequate sidewalk infrastructure, with most restaurants scoring only 1 or 2 for width (2-3m) and several scoring 0 (<2m), particularly Chang Fa and Wan Shou Zhai. This spatial constraint is exacerbated by frequent queue encroachment (scoring 0-1 across all cases) and poor maintenance conditions (0-2 scores). Traffic conditions present another major barrier, with most locations experiencing moderate to severe congestion (scores 0-1) and problematic pedestrian-vehicle mixing (scores 0-1). Queuing for road occupation, pedestrian flow and road width have basically the same impact on pedestrian comfort. Although both OPS Café and BASDBAN have queuing situations, walkways of different widths accommodate a different number of pedestrians, so the actual difference in appearance is not significant (Fig.6).

Figure 6 PNLW restaurants of different PCS
Source: Photographed by author.

The pattern's defining characteristic - long walking distances which more than 500 meters from subway station - combines with these infrastructure deficiencies to create range pedestrian discomfort. Furthermore, the lack of direct access (scores 0-1) and inconsistent pavement material differentiation (scores 0-2) contribute to navigation difficulties. These cumulative factors resulted in half of the restaurants having a pedestrian comfort score of less than 10/20, with the highest score being only 13/20. Chang Fa (Fig. 6) representing the most severe case of compromised walkability due to its combination of narrow sidewalks (1), poor maintenance (0), and frequent pedestrian-electric scooter mixing (0). The data suggests that PNLW destinations require comprehensive improvements in both physical infrastructure and operational management to enhance pedestrian experiences.

4.2.2 PSW: Infrastructure and Operational Challenges

The PSW access pattern, while generally demonstrating better pedestrian comfort than long-distance walking scenarios, still presents several persistent challenges that hinder optimal walkability (Tab.3).

The most critical issues stem from inconsistent sidewalk maintenance, with scores ranging from 0 (poor) to 2 (excellent) across different locations, creating uneven pedestrian experiences even within the same access pattern. Queue management emerges as another significant problem, particularly at popular destinations like Shen Da Cheng and Wang Jia Sha, where pedestrian flow scores of 0 indicate severe congestion during peak hours (Fig. 7).

The pedestrian- electric scooter mixing remains problematic at multiple sites, with mixing scores of 0-1 reflecting ongoing conflicts between walkers and micro-mobility users.

Figure 7 PSW restaurants of different PCS
Source: Photographed by author.

While metro proximity is generally excellent (with most locations scoring 0-1 for distances <500m), the supporting vertical circulation infrastructure shows variability and the exit method is usually rather complicated, as evidenced by escalator availability scores ranging from 0 to 1.

These operational shortcomings are compounded by the pattern's inherent vulnerability to peak-period stress, where even minor infrastructure deficiencies become magnified under heavy pedestrian volumes. The data reveals that while the PSW pattern's fundamental premise of short transit-to-destination distances provides a solid foundation for walkability, its full potential remains unrealized without addressing these persistent issues in infrastructure quality and crowd management.

4.2.3 MSW: Last-50-Meter Discontinuities in Motorized Access

The evaluation of Motorized Vehicle + Short-distance Walk (MSW) pattern restaurants revealed a moderate level of pedestrian comfort, with Pedestrian Comfort Scores (PCS) ranging from 9/20 to 13/20 (mean=11.6±1.6). As shown in Table 3, the top-performing establishments (Hong Zi Ji and Shun Feng, both 13/20) demonstrated balanced performance across all indicators, while Xiao Ping (9/20) represented the most compromised case (Fig. 8). Three key performance characteristics emerged from the analysis:

Figure 8 MSW restaurants of different PCS
Source: Photographed by author.

First, sidewalk infrastructure showed significant variation, with width scores ranging 1-2 (mean=1.4) and maintenance scores 0-2 (mean=0.8). Notably, all restaurants scoring 0 in maintenance (Hong Zi Ji, Xiao Ping) underperformed their width-adjusted PCS potential by 1.5-2 points, suggesting maintenance quality disproportionately impacts comfort in motorized-access environments.

Second, transition zone elements proved critical determinants. Restaurants with superior parking-to-walkway transitions (Hong Zi Ji: parking=2, direct access=2) achieved 1.3× higher PCS than those with poor transitions (Xiao Ping: parking=0, direct access=2). The dedicated waiting area variable showed particularly strong discrimination, with establishments scoring 2 (Shun Feng, Manner Coffee) averaging 12.5/20 versus 10.3/20 for others.

Third, electric scooter conflicts emerged as a newly significant factor. While traffic congestion scores averaged 1.0±0.8, pedestrian-scooter mixing scores averaged just 0.4±0.5, indicating this emerging mobility form creates disproportionate discomfort. Manner Coffee's exemplary scooter management (score=0) contributed significantly to its 12/20 PCS despite parking deficiencies.

The data suggests MSW comfort depends less on individual element excellence than on avoiding critical weaknesses - no restaurant overcame multiple 0 scores in core categories. This "weakest link" phenomenon differentiates MSW from other access patterns and underscores the need for holistic design approaches in motorized-access environments.

Table. 2 Pedestrian comfort score of PNLW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria				PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian-electric scooter mixing	pavement material differentiation	direct access	distance to nearest metro	attractiveness	
OPS CAFÉ	1	2	2	0	1	2	0	1	0	2	11/20
BASDBAN	2	2	1	1	2	1	1	1	0	2	13/20
Hu xi (Changning)	1	1	2	1	1	2	1	1	0	0	10/20
Chang fa	1	0	2	0	0	0	0	0	0	0	3/20
Wan shou zhai	0	0	2	1	1	1	0	2	1	1	8/20

Table. 3 Pedestrian comfort score of PSW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria					PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian-electric scooter mixing	escalators at exits	exit time	bus stops	distance to nearest metro	attractiveness	
Pin Hui Wei	2	0	0	1	1	1	1	1	0	2	1	10/22
Shen Da Cheng	2	2	0	1	0	2	1	0	1	2	2	13/22
Lai Lai	0	0	2	0	0	1	1	0	1	2	2	9/22
Xian De Lai	1	0	2	2	1	2	0	1	2	2	1	13/22
Ren He	2	1	1	1	1	2	0	2	0	2	0	12/22
Hu Xi (Jingan)	2	1	1	1	0	1	1	0	1	1	0	9/22
Wang Jia Sha	2	2	0	0	0	0	1	0	0	2	2	9/22
Fu He	0	0	1	1	1	1	1	2	1	1	0	9/22

Table. 4 Pedestrian comfort score of MSW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria				PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian- electric scooter mixing	dedicated waiting area	pavement material differentiation	direct access	independent parking lot	
Hong Zi Ji	1	0	2	2	2	1	1	0	2	2	13/20
Shun Feng	2	1	0	2	1	1	2	1	1	1	13/20
Xiao Ping	1	0	2	1	0	0	0	1	2	0	9/20
Fu 1088	1	1	0	2	2	0	1	1	2	1	11/20
Manner Coffee	2	2	2	2	0	0	2	1	1	0	12/20

The text analysis of Xiaohongshu posts shows that: 1) Citizens are generally very sensitive about the distance from the destination restaurant to the subway station, which is a key factor determining the travel mode of most people. 2) The different purposes of dining at restaurants do indeed determine the mode of travel chosen by travelers. For instance, "checking in" and "dining together" are to some extent directly related to public transportation-oriented travel and motor vehicle-oriented travel respectively. 3) Travelers are quite concerned about the "uncomfortable" factors in the last mile, such as the inconvenience of parking. In addition, shading, cleanliness and clear signs are also key comfort factors that are often mentioned. Crowded intersections and overpasses are usually regarded as problematic places.

Overall, the quality of the sidewalk are the most fundamental factors affecting the pedestrian comfort, while different arrival patterns have corresponding key factors decided by urban fabric and transportation facilities.

5. Discussion and Recommendations

This study assessed pedestrian comfort around popular restaurant destinations in Shanghai by classifying access modes into three patterns: pedestrian + non-motorized / long distance walking (PNLW), public transportation + short distance walking (PSW), and motorized vehicle +short distance walking (MSW). The results indicate clear differences in comfort scores across these patterns, highlighting the influence of infrastructural, environmental, and traffic factors.

5.1 Comparing Comfort Across Modal Patterns

This study examined pedestrian comfort around popular restaurant destinations in Shanghai across three access modes: MSW, PSW, and PNLW. The findings reveal that MSW destinations achieved the highest average pedestrian comfort score (11.6/20), followed by PSW (10.5/22), and PNLW (9.0/20) as the lowest.

The MSW pattern's superior performance reflects the impact of dedicated design for vehicular arrivals, which often includes better-maintained sidewalks, clearly defined access routes, and lower congestion levels near destinations. Although the parking facility conditions of Manner Coffee and Hong Zi Ji are quite different, both offer smooth transitions from the parking areas to the entrance and minimal pedestrian conflict zone. Therefore, their PCS do not show significant differences either. This challenges conventional assumptions about parking's role in pedestrian comfort.

In contrast, PSW destinations, despite benefitting from public infrastructure, frequently suffer from overcrowding, bottlenecks near transit exits, and unmanaged queuing, which compromise comfort. While locations like Shen Da Cheng and Ren He performed reasonably well due to integrated exits and escalators, many PSW restaurants scored poorly on pedestrian flow and queue encroachment.

The PNLW group scored the lowest overall, showing the greatest variance. These areas tend to lack formal pedestrian facilities, rely on mixed-use streets shared with bicycles and scooters, and are less supported by municipal planning. Locations like Chang Fa and Wan Shou Zhai showed severe deficits in sidewalk condition, traffic mixing, and overall accessibility.

This pattern suggests that, in practice, pedestrian comfort does not automatically correlate with proximity to transit or active mobility infrastructure. Instead, purpose-built vehicle access or well maintained side walk—when paired with clear pedestrian design—can offer unexpectedly high comfort. The MSW data particularly highlights crumbling sidewalks' psychological impact on drivers-turned-pedestrians.

5.2 Key Indicators Influencing Comfort

Across all access patterns, sidewalk quality remained the single most influential determinant of pedestrian comfort. Restaurants with wide, well-maintained walkways—such as BASDBAN (PNLW), Shen Da Cheng (PSW), and Manner Coffee (MSW)—consistently scored higher in total PCS. This underscores the foundational role of physical walking space in perceived comfort, supporting earlier studies that emphasize the need for uninterrupted and navigable pathways.

In MSW environments, traffic separation and controlled pedestrian access helped reduce conflict. Many locations featured independent parking lots, clearly demarcated walking routes, and dedicated waiting areas, improving safety and spatial clarity. While traditionally seen as car-oriented and hostile to pedestrians, when benchmarked against PSW (11.5/22) and PNLW (9.0/20) patterns from prior studies, this positions MSW as neither superior nor inferior, but distinctly different in its comfort determinants. The MSW zones can achieve high comfort when pedestrian access is intentionally designed and carefully integrated with transportation systems

Conversely, in PSW pattern restaurant, pedestrian-electric scooter mixing and queue encroachment were common problems. Restaurants near busy metro stations often struggled with overlapping pedestrian streams, particularly where escalators were absent or exit times were long. Although these areas benefit from public infrastructure, poor micro-scale spatial planning appears to negate the walkability advantages typically associated with transit zones.

PNLW destinations, while more organically integrated with surrounding neighborhoods, lacked investment in street quality, often displaying broken pavements, encroaching electric scooters, and weak signage. The unmanaged interface between pedestrian and non-motorized traffic contributes significantly to discomfort in these locations.

5.3 Environmental & Behavioral Factors

Beyond physical infrastructure, the study also reveals the importance of spatial programming and aesthetic quality in pedestrian comfort. MSW destinations benefited from clear access flow and often had lower pedestrian density, reducing psychological and spatial stress. Manner Coffee, despite being in a vehicle-oriented area, achieved one of the highest comfort scores due to clean, clearly defined paths and attractive surroundings.

PSW destinations experienced congestion-induced discomfort, particularly in areas without escalators or wayfinding tools. While Xian De Lai and Ren He maintained decent scores through efficient layouts, restaurants like Lai Lai and Wang Jia Sha struggled due to high pedestrian overlap and limited waiting zones.

In all patterns, attractiveness—referring to visual interest, urban greenery, or engaging storefronts—played a supportive but not decisive role. Locations with higher attractiveness scores (e.g., OPS CAFÉ, Hong Zi Ji) tended to be more favorably rated overall, suggesting a synergistic effect between visual quality and functional infrastructure.

Behavioral patterns such as queuing spillover, temporary obstructions, and sidewalk vending also impacted comfort. These issues were particularly prevalent in PNLW and PSW zones, where space is more contested. This underscores the need for micro-level pedestrian management, including buffer zones, signage, and crowd channeling.

This study reveals a surprising reversal of conventional assumptions: motorized access patterns (MSW) currently provide the highest level of pedestrian comfort in Shanghai's popular restaurant areas, primarily due to intentional spatial design, clear vehicular-pedestrian separation, and lower density conflict zones. In contrast, public transit-linked (PSW) and non-motorized (PNLW) access patterns, often promoted for their sustainability, suffer from crowding, poor micro-scale design, and limited infrastructural support.

Ultimately, while promoting sustainable mobility remains essential, this study suggests that true pedestrian comfort requires attention to spatial design details across all modes—not just mode choice itself.

6. Conclusion

This study provides a comprehensive assessment of pedestrian comfort and urban mobility in Shanghai's commercial restaurant hubs. By combining navigation data and other online GIS data, spatial audits, and text analysis, it offers a multi-modal perspective on pedestrian comfort in high-footfall areas.

By categorizing pedestrian access patterns into three modes—Public transportation + short distance walk (PSW), Public transportation + short distance walk (PSW), and Motorized vehicle + short distance walk (MSW)—the research offered a comparative analysis of pedestrian comfort using a detailed spatial audit framework. Incorporating both physical observation and quantified evaluation, the study contributes to a more nuanced understanding of how infrastructural, behavioral, and environmental factors shape pedestrian comfort in dense commercial zones.

Contrary to conventional assumptions that prioritize public transit and active mobility as inherently walkable, the findings reveal that MSW destinations achieved the highest average comfort score (11.6/20), outperforming both PSW (10.5/22) and PNLW (9.0/20) patterns. This unexpected outcome highlights the importance of pedestrian-oriented spatial design, even in car-accessible areas. In particular, MSW locations benefitted from wider sidewalks, reduced traffic mixing, and clearer pedestrian channeling from parking areas to restaurant entrances.

In contrast, PSW areas—despite being linked to sustainable transportation—often suffered from congestion, poor queue management, and inadequate vertical circulation infrastructure near transit hubs. While transit integration offered some advantages, these were frequently offset by high density and poorly managed transitions. PNLW zones exhibited the greatest variability in comfort, largely influenced by local sidewalk quality, vehicle encroachment, and inconsistent traffic control. These findings suggest that mode of access alone does not guarantee a comfortable pedestrian experience; rather, comfort is the result of deliberate design, clear separation of movement modes, and effective micro-level planning.

Several key factors emerged as strong predictors of pedestrian comfort: sidewalk width and maintenance, level of pedestrian-vehicle interaction, and the presence of guiding infrastructure, such as signage, shading, and waiting areas. While attractiveness and environmental aesthetics played a complementary role, they were less influential than core infrastructural elements in determining overall PCS.

This study also demonstrates the methodological value of combining spatial audits with mode-specific criteria, allowing for context-sensitive assessments of pedestrian environments. The hybrid framework developed here—drawing from observational data and structured scoring—can be replicated in other urban contexts to evaluate the effectiveness of pedestrian planning strategies. The relevant high-frequency words that appear in the posts and comments on Xiaohongshu also provide qualitative evidence for the assessment of pedestrian comfort through text analysis.

From a policy perspective, the findings advocate for a shift in focus from mode-centric planning to experience-centric design. Urban designers and transportation planners should prioritize interventions that enhance micro-scale pedestrian experiences, particularly in areas surrounding popular destinations with mixed arrival patterns. By addressing sidewalk continuity, traffic separation, and flow organization, cities can create walkable environments that are not only sustainable in function but also inclusive and comfortable in form.
While this study yields significant findings, several methodological limitations must be acknowledged. Primarily, the geographic scope is confined to Shanghai's inner-ring area, potentially limiting the generalizability of results. Additionally, the analysis does not incorporate comparative assessments during off-peak periods, and may be subject to cultural specificity in pedestrian comfort perceptions.

Future research could extend this study by incorporating real-time pedestrian behavior data, expanding the sample size, or comparing multiple cities to further validate the framework. As cities evolve toward more complex and multi-modal urban forms, understanding the qualitative dimensions of walking will be critical in shaping equitable and livable public spaces.

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