

Spatial attributes and perceived safety: The mediating Role of path choice in high-density Campus

Rui Niu^{ID}, Syarmila Hany Haron^{*ID}, Na Xia^{ID}, Yue Huang,
DaHuai Zhao, JiaSheng Zhou



School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia

ARTICLE INFO	ABSTRACT
<i>Article history:</i> Received March 20, 2026 Received in revised form May 08, 2026 Accepted August 18, 2026 Available online September 01, 2026 <i>Keywords:</i> Circulation clarity CPTED Path choice Perceived safety Spatial visibility *Corresponding author: Syarmila Hany Haron School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia Email: syarmilahany@usm.my ORCID: https://orcid.org/0000-0002-9276-933X	<i>In high-density campuses built in the mid-20th century, compact layouts and limited visibility persistently challenge users' sense of safety. Although Crime Prevention Through Environmental Design (CPTED) offers a foundational framework, its spatial effectiveness in such contexts remains inadequately understood. This study investigates how spatial visibility, circulation clarity, and territoriality influence perceived safety, with a specific focus on the mediating role of path selection behavior. Survey data from 407 students on a high-density campus in Hohhot, Inner Mongolia, China were analyzed using partial least squares structural equation modeling (PLS-SEM). Results reveal a clear structural hierarchy: spatial visibility and circulation clarity exert significant direct and indirect (via path choice) effects on perceived safety, whereas territoriality demonstrates only a weak indirect influence. These findings suggest that in compact campuses, safety perception is shaped primarily by movement-based spatial experience rather than static territorial cues alone. Accordingly, campus renewal should prioritize enhancing visual transparency and circulation legibility while treating territoriality as a supplementary design strategy.</i>

Introduction

As high-density public building environments, university campuses are not only places for learning, living, and socializing, but their safety issues have also received increasing attention in recent years (Peng et al. 2024; Shariati 2022). Especially at night, mixed-use areas around campuses often have problems such as low spatial visibility and unclear traffic flow (D. Huang, Ceccato, and Kytä 2022). Research has shown that insufficient lighting, scattered layout, and weak natural monitoring in transition zones can significantly reduce people's sense of security and limit the effective use of space (Zhu et al. 2023; Navarrete-Hernandez and Afarin 2023; Ceccato et al. 2025). These issues are particularly prominent in old, high-density campuses, and

over time, the accumulation of spatial limitations has made the contradiction between usage intensity and environmental readability increasingly acute (Zencirkiran and Suta 2025; Feng, Duives, and Hoogendoorn 2022). In the post-pandemic era, the usage patterns of campus space have undergone significant changes, which directly affect the perception of campus safety by teachers and students (Amistadi, Bradecki, and Uherek-Bradecka 2023; Manifesty and Lee 2022). With the increasing and decreasing flow of people, frequent adjustments to functional spaces, and uneven distribution of usage, people's expectations for the closeness, openness, and interpersonal distance of the space are also changing unconsciously (Givon-Benjio et al. 2024). The impact of spatial clarity, continuity of flow, and environmental readability on safety perception is becoming increasingly prominent

(Basu et al. 2023; Zencirkiran and Suta 2025; te Braak and van Tienoven 2025). These new challenges indicate that campus safety is not only a matter of institutional management but also an inherent architectural issue in the design and layout of building environments and spaces (Peng et al. 2024).

Crime Prevention through Environmental Design (CPTED), as a design-oriented framework, derives its classic principles, such as natural monitoring, access control, and domain reinforcement, from low-density urban environments in the West (Cozens, Babb, and Stefani 2023). Although providing a foundation for safe design, these principles are largely based on the assumptions of open vision and simplified, streamlined systems (Senna, Iglesias, and Matsunaga 2025). Therefore, when directly applied to high-density Asian university campuses with compact layouts, vertically stacked functions, and complex flow lines, it faces significant contextual adaptation challenges (Yang and Koizumi 2025). This study defines "perceived safety" as a subjective spatial experience shaped by visual clarity, streamlined readability, and daily movement behavior, with the aim of expanding CPTED from a crime prevention-centered framework to a perception-oriented spatial design paradigm (Basu et al. 2023). Existing research on CPTED and campus environments reveals several limitations (Wen et al. 2025). First, although subjective safety perception has received increasing attention, it is often treated as a secondary outcome in CPTED-related studies and is not yet consistently integrated into quantitative models centered on spatial mechanisms and behavioral pathways. Second, analytical approaches tend to focus on static spatial attributes, while relatively little attention has been paid to the shaping role of dynamic movement patterns in safety perception (Zencirkiran and Suta 2025). Third, studies conducted in Asian contexts frequently adopt CPTED indicators developed in Western settings, which may not fully capture the spatial structural characteristics of high-density campuses (Yang and Koizumi 2025). Collectively, these limitations point to a core issue: the need to reexamine the applicability of CPTED-related spatial variables and their inherent hierarchical relationships in high-density campus environments.

Therefore, this study aims to critically examine the contextualized reinterpretation of the

CPTED principle required in high-density university campuses. Specifically, the study will explore how spatial visibility, circulation clarity, and territoriality affect students' path selection behavior and how this mobile-based behavior subsequently shapes perceived safety. This study attempts to reveal the intrinsic relationship between "spatial environment, mobile behavior, and security perception" behind campus security by empirically analyzing the mediating mechanism of path selection. Based on the analysis results of the structured questionnaire survey and structural equation modeling, we hope to provide empirical reference and practical guidance for the safety-oriented renewal and design of high-density university campuses (Manifesty and Lee 2022).

Methods

This study selected a public comprehensive university campus located in the suburbs of Hohhot, Inner Mongolia, China, as the research case. The campus was founded in the 1960s and has distinct characteristics of the planned economy era. The spatial layout is compact, and the functional divisions are relatively concentrated. With the continuous expansion of higher education to meet the growing number of students, the campus has undergone multi-stage expansion, and multiple high-rise buildings have been added one after another. Due to the tight supply of land, new buildings often have to "take advantage of every opportunity" and be embedded into the original spatial texture, which gradually leads to a denser built environment.

The long-term cumulative development has created a campus spatial pattern characterized by the interweaving of old and new buildings, narrow roads, insufficient open space, and limited visual transparency. The layout of teaching buildings and dormitory buildings is dense, resulting in widespread visual obstruction and scattered pedestrian spaces. The campus's building density is about 38%, with a plot ratio of 3.1, reflecting a high intensity of spatial development. Compared with the common low-density, clear functional zoning of newly built university campuses in China, this campus has formed a more complex, compact, and constrained spatial environment under the influence of historical development. Field observations have shown that there is a

relatively high flow of people during the day and night, especially in transitional areas and internal passages. These spatial features reflect long-term spatial intensification and represent typical characteristics of high-density university campuses in China, providing a suitable background for studying spatial mechanisms related to CPTED (D. Huang, Ceccato, and Kytta 2022). The research sample space covers the main pedestrian walkways, courtyard spaces, building entrance areas, and transition areas between

teaching and dormitory areas. The characteristics of this campus include a mixed-use spatial structure, interweaving old and new buildings, high building density, and fragmented pedestrian spaces, resulting in frequent visual obstructions and complex traffic flow patterns. These features are clearly visible at street and pedestrian levels and are further illustrated by on-site photographs and satellite imagery (see figures 1 and 2), which visually support the spatial conditions described above.



Figure 1. Study area layout of the selected high-density campus

Note: The yellow boundary indicates the study area. Areas outside the boundary are desaturated to emphasize the research scope. A north arrow and a 0–100 m scale bar is included for spatial reference

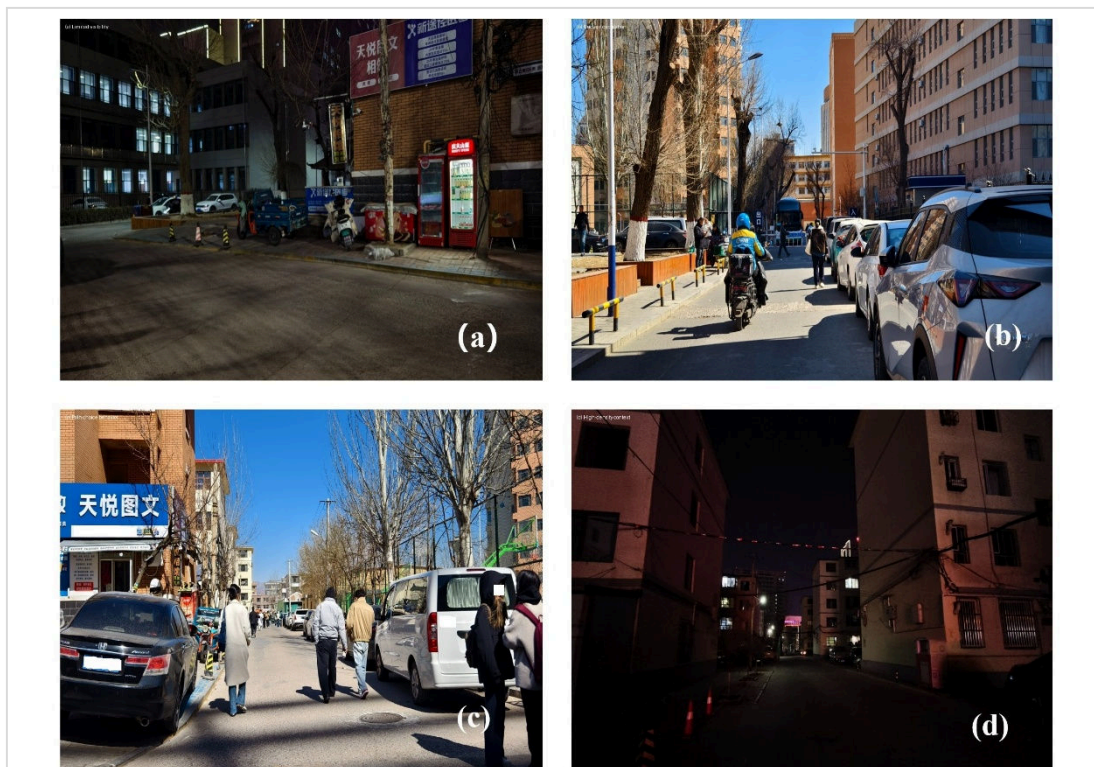


Figure 2. Field observations of spatial conditions and behavioral responses in a high-density campus
(a) Limited visibility caused by dense building arrangements and visual obstructions;
(b) Unclear circulation characterized by mixed pedestrian–vehicle movement;
(c) Path choice behavior reflecting navigation under constrained spatial conditions;
(d) Night-time environments are associated with reduced perceived safety

The data is mainly collected through structured questionnaire surveys. Participants are undergraduate and graduate students who have studied or resided on campus for at least one academic year. A total of 520 questionnaires were distributed, and 486 were collected. After excluding questionnaires with a large number of missing values, inconsistent answers, or items that did not pass the attention check, 407 valid questionnaires were ultimately retained for structural model analysis. Data collection takes place within a regular semester and lasts for two weeks. The sampling adopts a stratified sampling strategy, based on educational level and professional category, with classes as the sampling unit. The survey covers normal teaching days, including day and night. The data collection adopts a combination of on-site paper questionnaires and controlled online links.

Variable measurement combines subjective and objective indicators. Subjective variables were measured using a five-point Likert scale (1=strongly disagree; 5=strongly agree). Five

core concepts were evaluated: spatial visibility (perceived visual openness and continuity), circulation clarity (route recognizability and directional coherence), territoriality (perceived spatial boundary and area division), path selection tendency (Path Selection Tendency), and perceived safety as outcome variables (Senna, Iglesias, and Matsunaga 2025). This study tested the reliability and validity of the measurement model and reported the results in the results section. Objective spatial indicators are derived from campus planning analysis and field observations, including building density, boundary elements, and degree of visual obstruction. The degree of visual occlusion is divided into three levels: high, medium, and low, which are used for comparative analysis. This classification is only used for comparative purposes and not for precise spatial modeling.

Common method bias (CMB) was assessed due to the single-source, cross-sectional design. Harman's single-factor test showed that the first factor explained 32.05% of the variance < 40%;

(Podsakoff et al. 2003). Full collinearity VIF values were below 3.3 (Kock 2015), indicating that CMB is unlikely to bias the results.

Data analysis was conducted using SPSS (Version 26.0) and Smart PLS (Version 4.0) (Cheah, Magno, and Cassia 2024). Descriptive statistics and correlation analyses were performed first. Then, partial least squares structural equation modeling (PLS-SEM) was used to test the structural relationships between key constructs, including mediating effects. PLS-SEM was chosen because it is suitable for exploratory research, is robust to moderate sample sizes, and can test complex models (Hair and Alamer 2022). All latent variables were specified as reflective constructs, and control variables (gender, academic stage, and length of campus experience) were included in the analysis.

Results and discussion

Before evaluating the measurement and structural models, common method bias was examined. The first unrotated factor explained 32.05% of the total variance. All full collinearity VIF values were below 3.3. These results suggest that common method bias is unlikely to substantially affect the model estimates.

Preliminary analysis shows that there is a clear correlation between the layout of campus space and people's sense of security. A total of 407 valid questionnaires were retained for analysis. The demographic characteristics of the sample are shown in table 1.

Table 1. Sample Demographic Characteristics (N = 407)

Variable	Category	Frequency	Prop. (%)
Gender	Male	187	46.0
	Female	220	54.0
Academic Level	Undergraduate	250	61.4
	Graduate	157	38.6
Length of Campus Residency	1–2 years	119	29.2
	More than 2 years	288	70.8
Total		407	100.0

Note: All respondents had studied or lived on campus for at least one academic year

With a balanced gender ratio (54% female) and over 70% of students residing on campus for more than two years, the sample reflects substantial long-term spatial experience. The descriptive statistics indicate observable spatial

patterns in perceived safety. Visually open main roads tend to receive higher safety ratings, whereas narrow and densely vegetated paths are generally rated lower, particularly during nighttime. These descriptive patterns are consistent with prior findings highlighting the importance of spatial visibility and openness in shaping perceived safety (Park and Garcia 2020; G. Huang et al. 2024).

The measurement model demonstrates satisfactory reliability and validity (table 2). All indicator loadings exceed 0.70. Cronbach's α and composite reliability (CR) values range from 0.89 to 0.95, indicating strong internal consistency. Average variance extracted (AVE) values are above the recommended threshold of 0.50, confirming convergent validity. Discriminant validity is also established, as all HTMT values are below the conservative threshold of 0.85 (table 3).

Table 2. Measurement model reliability and validity results

Construct	Cronbach's α	CR	AVE
Spatial Visibility (SV)	0.898	0.929	0.766
Circulation Clarity (CC)	0.887	0.922	0.746
Territoriality (TR)	0.909	0.932	0.774
Path Selection Tendency (PST)	0.924	0.946	0.814
Perceived Safety (SA)	0.922	0.945	0.811

Note: CR = Composite Reliability; AVE = Average Variance Extracted. Recommended thresholds: Cronbach's $\alpha > 0.70$; CR > 0.70 ; AVE > 0.50

Table 3. Discriminant Validity (HTMT Matrix)

Constructs	SV	CC	TR	PST	SA
SV	—				
CC	0.595	—			
TR	0.025	0.048	—		
PST	0.753	0.753	0.107	—	
SA	0.642	0.625	0.091	0.788	—

Note: All HTMT values are below the conservative threshold of 0.85, confirming satisfactory discriminant validity

The structural model demonstrates a clear hierarchical mechanism among spatial attributes, movement behavior, and perceived safety (table 4). Spatial Visibility (SV), Circulation Clarity (CC), and Territoriality (TR) significantly predict Path Selection Tendency (PST), with SV and CC exhibiting comparatively stronger effects ($\beta = 0.45$, $p < 0.001$) than TR ($\beta = 0.12$, $p < 0.001$). Path Selection Tendency, in turn, serves as the

strongest predictor of Perceived Safety ($\beta = 0.54$, $p < 0.001$), underscoring its central mediating role within the model.

In addition to indirect pathways, SV ($\beta = 0.15$, $p = 0.001$) and CC ($\beta = 0.12$, $p = 0.017$) retain significant direct effects on Perceived Safety, indicating partial mediation. By contrast, the direct effect of TR on Perceived Safety is not

statistically significant ($\beta = 0.03$, $p = 0.397$), suggesting that its perceptual influence operates primarily through movement-based mechanisms. The model explains 62.3% of the variance in Path Selection Tendency and 54.8% of the variance in Perceived Safety (table 5), indicating substantial explanatory power.

Table 4. Structural Model Path Coefficients and Hypothesis Testing Results (N = 407)

Hyp.	Structural Path	β	t-value	p-value	Result
H1	SV $\rightarrow$ PST	0.45	12.753	<0.001	Supported
H2	CC $\rightarrow$ PST	0.45	13.212	<0.001	Supported
H3	TR $\rightarrow$ PST	0.12	3.527	<0.001	Supported
H4	PST $\rightarrow$ SA	0.54	10.474	<0.001	Supported
H5	SV $\rightarrow$ SA	0.15	3.432	0.001	Supported
H6	CC $\rightarrow$ SA	0.12	2.385	0.017	Supported
H7	TR $\rightarrow$ SA	0.03	0.848	0.397	Not Supported

Note: Indirect effects were tested using bootstrapping with 5,000 resamples; t-values are not reported for indirect paths. Model Fit: R^2 (PST) = 0.623; R^2 (SA) = 0.548

Table 5. Coefficient of Determination (R^2)

Endogenous Construct	R^2
PST	0.623
SA	0.548

Note: Interpretation of R^2 follows (Hair and Alamer 2022)

This finding supports the argument that safety perception is dynamically constructed through movement-based environmental interaction rather than solely through static territorial cues (Zeng et al. 2022).

Regarding mediation, Spatial Visibility also shows a significant direct effect on Perceived Safety ($\beta = 0.15$, $p < 0.01$), indicating a partial mediation pattern through Path Selection

Tendency. Circulation Clarity similarly exhibits a significant direct influence on Perceived Safety ($\beta = 0.12$, $p < 0.05$), suggesting a complementary direct-indirect relationship. In contrast, the direct effect of territoriality on Perceived Safety is not statistically significant ($\beta = 0.03$, $p > 0.05$), and its overall contribution appears comparatively limited. These findings resonate with recent reassessments of CPTED in dense urban contexts, which suggest that territoriality alone may have limited perceptual impact when spatial complexity and functional overlap are high (Al-Khazaleh et al. 2024). The overall structural model is illustrated in figure 3.

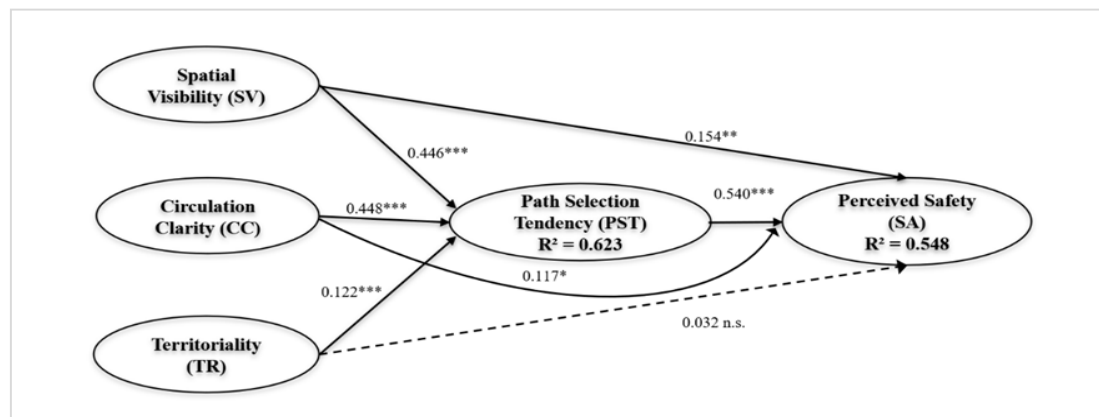


Figure 3. Structural equation model of path relationships

Note: Standardized path coefficients (β); *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, n.s. = not significant. R^2 indicates explained variance. Bootstrapping with 5,000 resamples (two-tailed)

These findings have important implications for theory and design. Firstly, the weakening of domain awareness raises situational questions about the view in classical CPTED theory that it is considered the primary deterrent (Crowe 2000; Newman 1972). In the high-density Asian campus of this study, due to vertical spatial overlap, blurred functional boundaries, and staggered usage periods, the definition of "domains" tends to flow, and the symbolic boundary's behavioral prompting effect is reduced. This reflects that in dense and complex environments, environmental legibility and flow coherence may outweigh rigid territorial demarcation in shaping perceived safety, a shift also identified in recent high-density urban safety research (Lis et al. 2022).

In contrast, the significant impact of visibility and streamlined clarity on path selection indicates that a sense of security is closely related to the movement-based experience. Safety is not just a static response to spatial forms but an experience gradually formed during the process of walking with clear vision and predictable paths. This interpretation aligns with recent environmental-behavior research emphasizing dynamic affordances and walkability as core determinants of perceived safety (Kwon et al. 2022).

From a practical perspective, this empirical hierarchical relationship provides a clear priority sequence for campus renewal. The primary measures should be to enhance the spatial visibility of key nodes (such as reducing enclosures, pruning vegetation reasonably, and maintaining lighting) and improve the clarity of flow lines (such as setting clear path guidance and identification systems). Territoriality can be used as a secondary strategy, achieved through lightweight methods such as material changes and activity prompts when conditions permit, rather than relying on rigid physical barriers, which have been shown to provide limited improvements in perceived safety in compact environments (Zhuang et al. 2025; Meng et al. 2023).

This study has certain limitations and also points out the direction for future research. Single-case design may limit the generalizability of conclusions, and cross-sectional questionnaire data is also difficult to make strict causal inferences from. In the future, the framework of "space-behavior-perception" can be further validated and improved through multi-campus comparison, longitudinal tracking, or by combining objective behavioral data such as GPS, an approach increasingly recommended in

contemporary urban analytics research (H. Huang et al. 2021).

Conclusions

This study reveals the hierarchical mechanism by which spatial attributes affect safety perception in high-density campus environments. The visibility of space and the clarity of movement lines do not directly affect the sense of security but mainly play a role by influencing people's movement behavior in space. Among them, path selection tendency serves as a key mediating mechanism, transforming spatial configuration into psychological safety outcomes, highlighting the dynamic interactive relationship between spatial structure and user behavior.

By combining the principles of crime prevention through environmental design (CPTED) with a behavioral mediation perspective, this study goes beyond traditional static interpretations of safe environments and emphasizes the importance of mobile experience-oriented spatial design in dense campuses. The research results indicate that a sense of security does not only come from domain boundaries or physical enclosures but is constructed by a clear flow system and transparent visual space, which support users to confidently walk and locate themselves in the environment.

From a practical perspective, the safety renovation of high-density campuses should adopt a layered design strategy: priority should be given to improving visual transparency and flow clarity as the main intervention measures, while domain reinforcement should be considered an auxiliary measure. This approach provides a theoretical and practical framework for optimizing campus space.

Of course, this study also has certain limitations. Although statistical tests show that the impact of common method bias is limited, cross-sectional data and a single campus sample still limit the causal inference and widespread generalization of conclusions, and further validation is needed in different contexts in the future.

References

- Amistadi, Lamberto, Tomasz Bradecki, and Barbara Uherek-Bradecka. 2023. "Resilient University Campus in the City in COVID and Post-COVID Era—Recommendations, Guidelines, and Evidence from Research in Italy and Poland." *URBAN DESIGN International* 28 (2): 141–51. <https://doi.org/10.1057/s41289-022-00211-y>.
- Basu, Nandita, Oscar Oviedo-Trespalacios, Mark King, Md. Kamruzzaman, and Md. Mazharul Haque. 2023. "What Do Pedestrians Consider When Choosing a Route? The Role of Safety, Security, and Attractiveness Perceptions and the Built Environment during Day and Night Walking." *Cities* 143 (December):104551. <https://doi.org/10.1016/j.cities.2023.104551>.
- Braak, Petrus te, and Theun Pieter van Tienoven. 2025. "Navigating the City: A Systematic Literature Review on Women's Perceived Safety in Urban Public Space." *Cities* 162 (July):105907. <https://doi.org/10.1016/j.cities.2025.105907>.
- Ceccato, Vania, Ute Besenecker, Barak Ariel, Hamid Eizadi, Martin Höglund, and Per Näsman. 2025. "Assessing Safety Perceptions and Lighting Conditions in a Metro Station." *Journal of Experimental Criminology*, August. <https://doi.org/10.1007/s11292-025-09683-8>.
- Cheah, Jun-Hwa, Francesca Magno, and Fabio Cassia. 2024. "Reviewing the SmartPLS 4 Software: The Latest Features and Enhancements." *Journal of Marketing Analytics* 12 (1): 97–107. <https://doi.org/10.1057/s41270-023-00266-y>.
- Cozens, Paul, Courtney Babb, and Danielle Stefani. 2023. "Exploring and Developing Crime Prevention through Environmental Design (CPTED) Audits: An Iterative Process." *Crime Prevention and Community Safety* 25 (1): 1–19. <https://doi.org/10.1057/s41300-022-00170-0>.
- Crowe, Timothy D. 2000. *Crime Prevention through Environmental Design: Applications of Architectural Design and Space Management Concepts*. 2nd ed. Butterworth-Heinemann.
- Feng, Yan, Dorine C. Duives, and Serge P. Hoogendoorn. 2022. "Wayfinding Behaviour in a Multi-Level Building: A Comparative Study of HMD VR and Desktop VR." *Advanced Engineering Informatics* 51 (January):101475. <https://doi.org/10.1016/j.aei.2021.101475>.
- Givon-Benjio, Nur, Hili Sokolover, Idan M. Aderka, Bat-Sheva Hadad, and Hadas Okon-Singer. 2024. "Perception of Interpersonal Distance and Social Distancing before and during COVID-19 Pandemic." *Scientific Reports* 14 (1): 4568. <https://doi.org/10.1038/s41598-024-55218-y>.
- Hair, Joseph, and Abdullah Alamer. 2022. "Partial Least Squares Structural Equation Modeling (PLS-SEM) in Second Language and Education Research: Guidelines Using an Applied Example." *Research Methods in Applied Linguistics* 1 (3): 100027. <https://doi.org/10.1016/j.rmal.2022.100027>.
- Huang, Dengkai, Vania Ceccato, and Marketta Kyttä. 2022. "Safety Perceptions in University Campuses: The Role of Environment." *Crime Prevention and Community Safety* 24 (3): 266–85. <https://doi.org/10.1057/s41300-022-00148-y>.
- Huang, Gonghu, Yiqing Yu, Mei Lyu, Dong Sun, Bart Dewancker, and Weijun Gao. 2024. "Impact of Physical Features on Visual Walkability Perception in Urban Commercial Streets by Using Street-View Images and Deep Learning." *Buildings* 15 (1): 113. <https://doi.org/10.3390/buildings15010113>.
- Huang, Haosheng, Xiaobai Angela Yao, Jukka M. Krisp, and Bin Jiang. 2021. "Analytics of Location-Based Big Data for Smart Cities: Opportunities, Challenges, and Future Directions." *Computers, Environment and Urban Systems* 90 (November):101712. <https://doi.org/10.1016/j.compenvurbsys.2021.101712>.
- Kock, Ned. 2015. "Common Method Bias in PLS-SEM." *International Journal of E-Collaboration* 11 (4): 1–10. <https://doi.org/10.4018/ijec.2015100101>.
- Kwon, Jae-Hong, Jeongseob Kim, Seungnam Kim, and Gi-Hyoung Cho. 2022. "Pedestrians Safety Perception and Crossing Behaviors in Narrow Urban Streets: An Experimental Study Using Immersive Virtual Reality Technology." *Accident Analysis & Prevention* 174 (September):106757. <https://doi.org/10.1016/j.aap.2022.106757>.
- Lis, Aleksandra, Karolina Zalewska, Łukasz Pardela, Ewa Adamczak, Alicja Cenarska, Klaudia Bławicka, Barbara Brzegowa, and Anastasiia Matiiuk. 2022. "How the Amount

- of Greenery in City Parks Impacts Visitor Preferences in the Context of Naturalness, Legibility and Perceived Danger.” *Landscape and Urban Planning* 228 (December):104556. <https://doi.org/10.1016/j.landurbplan.2022.104556>.
- Manifesty, Odilia Renaningtyas, and Junga Lee. 2022. “A Spatial Adaptation Strategy for Safe Campus Open Spaces during the COVID-19 Pandemic: The Case of Korea University.” *International Journal of Environmental Research and Public Health* 19 (15): 9390. <https://doi.org/10.3390/ijerph19159390>.
- Meng, Yumeng, Qingyu Li, Xiang Ji, Yiqing Yu, Dong Yue, Mingqi Gan, Siyu Wang, Jianing Niu, and Hiroatsu Fukuda. 2023. “Research on Campus Space Features and Visual Quality Based on Street View Images: A Case Study on the Chongshan Campus of Liaoning University.” *Buildings* 13 (5): 1332. <https://doi.org/10.3390/buildings13051332>.
- Navarrete-Hernandez, Pablo, and Kousha Afarin. 2023. “The Impact of Nature-Based Solutions on Perceptions of Safety in Public Space.” *Journal of Environmental Psychology* 91 (November):102132. <https://doi.org/10.1016/j.jenvp.2023.102132>.
- Newman, Oscar. 1972. *Defensible Space: Crime Prevention through Urban Design*. Collier Books.
- Park, Yunmi, and Max Garcia. 2020. “Pedestrian Safety Perception and Urban Street Settings.” *International Journal of Sustainable Transportation* 14 (11): 860–71. <https://doi.org/10.1080/15568318.2019.1641577>.
- Peng, Yu-Ling, Yuan Li, Wei-Ying Cheng, and Ke Wang. 2024. “Evaluation and Optimization of Sense of Security during the Day and Night in Campus Public Spaces Based on Physical Environment and Psychological Perception.” *Sustainability* 16 (3): 1256. <https://doi.org/10.3390/su16031256>.
- Podsakoff, Philip M., Scott B. MacKenzie, Jeong-Yeon Lee, and Nathan P. Podsakoff. 2003. “Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies.” *Journal of Applied Psychology* 88 (5): 879–903. <https://doi.org/10.1037/0021-9010.88.5.879>.
- Rahm, Johan, Catharina Sternudd, and Maria Johansson. 2021. “‘In the Evening, I Don’t Walk in the Park’: The Interplay between Street Lighting and Greenery in Perceived Safety.” *URBAN DESIGN International* 26 (1): 42–52. <https://doi.org/10.1057/s41289-020-00134-6>.
- Senna, Isangelo, Fabio Iglesias, and Lucas Heiki Matsunaga. 2025. “Measuring the Effects of Crime Prevention Through Environmental Design (CPTED) on Fear of Crime in Public Spaces.” *Crime Prevention and Community Safety* 27 (1–2): 1–17. <https://doi.org/10.1057/s41300-025-00223-0>.
- Shariati, Auzeen. 2022. “Crime Prevention through Environmental Design (CPTED) and Its Potential for Campus Safety: A Qualitative Study.” *Security Journal* 35 (4): 1198–1219. <https://doi.org/10.1057/s41284-021-00322-1>.
- Sohn, Dong-Wook. 2016. “Residential Crimes and Neighbourhood Built Environment: Assessing the Effectiveness of Crime Prevention through Environmental Design (CPTED).” *Cities* 52 (March): 86–93. <https://doi.org/10.1016/j.cities.2015.11.023>.
- Son, Dongpil, Boyeong Im, Jaeseok Her, and Seung-Nam Kim. 2024. “Effects of CPTED Principles on Intention to Burgle in High-Density Low-Rise Residential Areas of South Korea: A Virtual Reality Experiment.” *Sage Open* 14 (4): 21582440241296723. <https://doi.org/10.1177/21582440241296723>.
- Wang, Weiwei, Feng Zhen, Yang Cao, Yuyao Wang, and Yagen Ou. 2025. “How to Assess a University Campus Planning — a Case Study Based on Students’ Spatio-Temporal Behavior.” *Journal of Asian Architecture and Building Engineering* 24 (4): 2966–81. <https://doi.org/10.1080/13467581.2024.2358218>.
- Wen, Yu, Hong Qi, Tao Long, and Xinjia Zhang. 2025. “Designed for Safety: Characteristics and Trends in Crime Prevention through Environmental Design Research.” *Journal of Asian Architecture and Building Engineering* 24 (4): 3108–26. <https://doi.org/10.1080/13467581.2024.2366823>.
- Yang, Sihan, and Hideki Koizumi. 2025. “Space, Devices, Activities: A Crime Prevention Through Environmental Design (CPTED) Assessment in Kakogawa, Japan.” *International Journal of Law, Crime and Justice* 82 (September):100765. <https://doi.org/10.1016/j.ijlcj.2025.100765>.
- Zencirkiran, Asli, and Onur Suta. 2025. “Spatial Organization and User Experience in a

- University Campus: A Mixed-Method Space Syntax Analysis of Trakya University Balkan Campus.” *Sustainability* 17 (24): 11221. <https://doi.org/10.3390/su172411221>.
- Zeng, Erli, Yu Dong, Li Yan, and Alin Lin. 2022. “Perceived Safety in the Neighborhood: Exploring the Role of Built Environment, Social Factors, Physical Activity and Multiple Pathways of Influence.” *Buildings* 13 (1): 2. <https://doi.org/10.3390/buildings13010002>.
- Zhu, Meng, Rujie Teng, Canxiang Wang, Yu Wang, Jiaqi He, and Fan Yu. 2023. “Key Environmental Factors Affecting Perceptions of Security of Night-Time Walking in Neighbourhood Streets: A Discussion Based on Fear Heat Maps.” *Journal of Transport & Health* 32 (September):101636. <https://doi.org/10.1016/j.jth.2023.101636>.
- Zhuang, Xiaowen, Yi Cai, Zhenpeng Tang, Zheng Ding, and Christopher Gan. 2025. “Identification and Configuration Optimization of Key Campus Landscape Features Using Augmentation-Based Machine Learning and Configuration Analysis.” *Buildings* 15 (21): 3868. <https://doi.org/10.3390/buildings15213868>.
- Author(s) contribution**
- Rui Niu** contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.
- Syarmila Hany Haron** contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.
- Na Xia** contribute to methodology, supervision, and validation.
- Yue Huang** contribute to methodology, supervision, and validation.
- DaHuai Zhao** contribute to methodology, supervision, and validation.
- JiaSheng Zhou** contribute to methodology, supervision, and validation.