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Evaluating Pedestrian Safety Perception in Ho Chi Minh City under Mixed Traffic Conditions

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Abstract: This study investigates pedestrian safety perception in Ho Chi Minh City under mixed traffic conditions by evaluating comfort, crash risk, and injury risk perceptions in two scenarios: walking along and crossing multilane roads. Using visual experiments with 510 participants, the study identifies how sidewalk quality, obstructions, crossing infrastructure, and traffic conditions shape pedestrian experiences. Statistical modeling reveals that protected sidewalks and comprehensive crossing features significantly enhance perceived safety and comfort. Findings emphasize the need for improved pedestrian infrastructure and traffic calming in dense urban settings to support safer, more inclusive mobility under mixed traffic conditions like Vietnam.

Key words: Pedestrian safety, pedestrian perception, mixed traffic conditions.

1. Introduction

Road traffic crashes remain a major global challenge, leading to millions of deaths and injuries each year. According to the WHO (World Health Organization), more than 1.2 million people lose their lives in road crashes annually, with around 50 million more suffering non-fatal injuries. These incidents also cause widespread damage to property and place a heavy burden on national economies, especially in low- and middle-income countries, where over 90% of all road traffic deaths occur. Globally, the economic cost of traffic crashes is estimated to range between 1% and 3% of the world's GNP (gross national product) each year.

In Vietnam, which the WHO classifies as a low-income country with a GDP (gross domestic product) per capita of $790, the impact of road traffic crashes is particularly severe. The country records a mortality rate of 24.5 road traffic deaths per 100,000 people, and the economic loss from these crashes is equivalent to 2.9% of its annual GDP.

Active transportation, such as walking, is increasingly seen as a solution to various urban challenges from reducing environmental harm and easing congestion to encouraging healthier lifestyles [1, 2]. However, pedestrian safety remains a pressing concern around the world. In the United States, for instance, pedestrian deaths rose from 14.2% of all traffic fatalities in 2012 to 17.7% in 2022, with the total number of pedestrian fatalities increasing by more than 55% [3, 4]. Globally, pedestrian deaths rose by 3% between 2010 and 2021, reaching 274,000 and accounting for nearly a quarter of

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all road traffic fatalities [5]. While many regions have seen reductions in pedestrian fatalities, Southeast Asia experienced a sharp 42% increase during the same period [6].

To tackle this issue, the Safe Systems approach has been adopted in several cities like Portland and Philadelphia. This model emphasizes holistic safety strategies aimed at reducing pedestrian deaths [7]. European countries have also embraced this approach with noticeable success, seeing fewer pedestrian fatalities over time [8]. Unfortunately, low-income countries continue to struggle due to poor infrastructure and insufficient planning [6].

In Vietnam, the road safety crisis is multifaceted (Fig. 1, Fig. 2). A significant portion of traffic fatalities involve vulnerable road users: pedestrians account for 23%, cyclists for 3%, and motorcyclists for 28%.

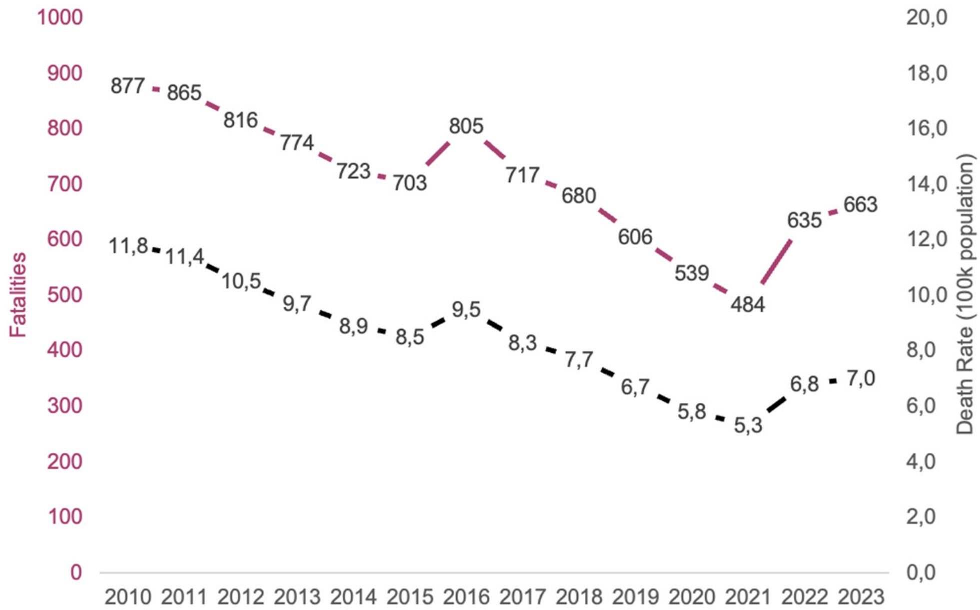

Fig. 1 Fatalities and death rate (2010-2023).

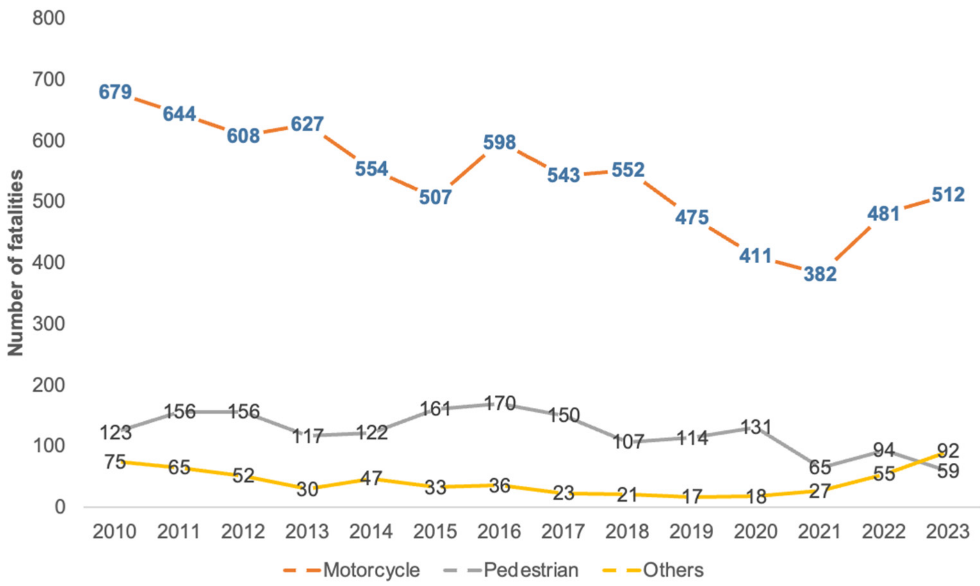

Fig. 2 Death by road user type (2010-2023).

This study aims to explore how pedestrians in Ho Chi Minh City perceive risk in mixed-traffic conditions. Specifically, it assesses their feelings of comfort, perceived likelihood of crashes, and perceived fatality risks. Interviewers are selected around two school zones, Le Quy Don (Fig. 3) and Tran Quang Khai (Fig. 4) in District 11.

2. Methods of Data Collection & Analysis

To clearly distinguish between the related concepts of perceived comfort, crash exposure risk, and severe injury risk, the author used a stepwise questionnaire method. This structured approach was designed to help respondents think through each concept separately. First, participants answered a simple yes/no question about their comfort walking or crossing in a given setting. This initial question served to anchor their attention to the visual context. Next, they rated the perceived likelihood of a crash occurring using a 5-point Likert scale. This shifted the focus from general comfort to more specific concerns about exposure to crashes. Finally, we asked about the risk of severe injury such as death or serious harm in the event of a crash, using another binary question. This gradual shift from broad perceptions to specific risks was intended to support clearer, more focused evaluations.

The survey consisted of five main sections: an introduction, screening questions, travel behavior, visual experiments, and socio-demographics. The introduction explained the study's purpose, procedures, and participation requirements, and served as a means to obtain informed consent. Individuals under 18 years old were excluded during the screening process. In the travel behavior section, we asked about respondents' typical modes of transport, use of mobility aids, walking patterns, and frequency of walking trips.

The core of the survey involved visual experiments, where each participant was shown five randomized scenarios. In each, they assessed their comfort, perceived crash risk, and perceived injury risk in various pedestrian settings. The final section gathered demographic details, including gender, age, education, household size, and income level.

Designing the visual experiments, we identified several variables that could be modified based on actual situations and they were grouped into three domains: the built environment, traffic conditions, and pedestrian infrastructure. Each experimental scenario or "Setting" was created using specific combinations of these variables (Table 1).

Within the built environment domain, we included general walking or crossing contexts. In Setting 1, the traffic conditions included three variables: Traffic Volume (congested or uncongested), Vehicle Size (large or small), and Walking Direction (the same or opposite traffic). In the crossing walking focused Setting 2, we included Traffic Volume and Vehicle Size and added the Pedestrian Group variable to explore how people perceive safety when crossing alone versus with others.

We deliberately excluded vehicle speed from all scenarios. In Ho Chi Minh City, where the study took place, traffic is generally dense and slow-moving, making speed a less useful differentiator. Additionally, representing speed visually posed practical challenges.

Fig. 3 Le Quy Don Secondary School in District 11, Ho Chi Minh City.

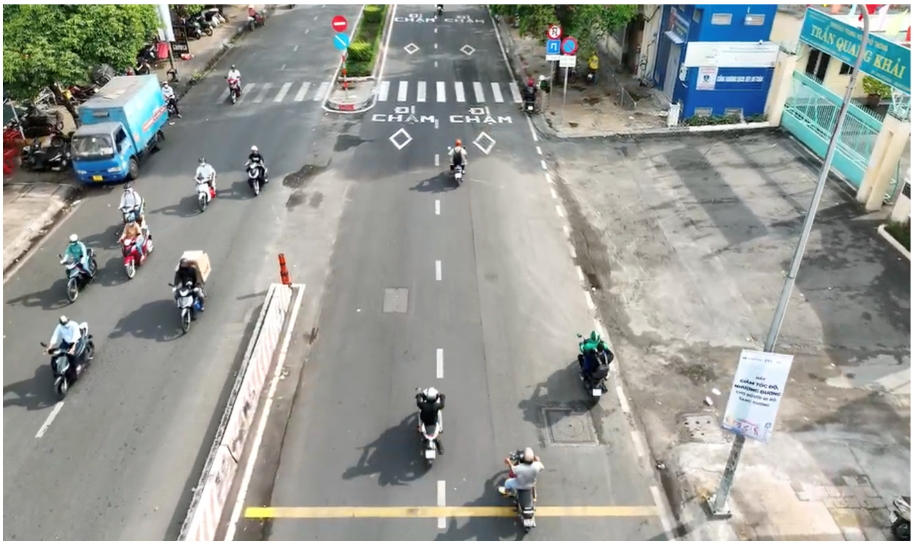

Fig. 4 Tran Quang Khai Secondary School in District 11, Ho Chi Minh City.

Table 1 Experiment framework for two pedestrian settings.

Experiment settings	Setting 1	Setting 2
Built environment	Walking along a multilane road	Crossing a multilane road
Traffic conditions	• Traffic Volume (V): Congested (1), Uncongested (2) • Vehicle Size (Sz): Large (1), Small (2) • Walking Direction (D): Same as traffic (1), Opposite (2)	• Traffic Volume (V): Congested (1), Uncongested (2) • Vehicle Size (Sz): Large (1), Small (2) • Pedestrian Group (G): Present (1), Absent (2)
Pedestrian infrastructure	• Footpath/Sidewalk (S): Protected (1), Unprotected (2), • Obstruction on Sidewalk (O): None (1), Business street (2), Motorcycle parking (3), Motorcycle riding (4)	• Crossing Types (C): Zebra crossing_ZC (1) ZC + Traffic signal_TS (2) ZC + Refugee islands_RI (3) ZC + TS + RI (4) ZC + TS + RI+Pedestrian Signal (5)

Table 2 15 scenarios for Setting 1 (Set 1).

#	Question 1	Question 2	Question 3
1.	V1-Sz2-D1-S1-O1	V1-Sz2-D2-S2-O4	V2-Sz2-D1-S2-O1
2.	V1-Sz1-D2-S1-O2	V1-Sz2-D1-S2-O4	V2-Sz2-D1-S2-O2
3.	V1-Sz2-D1-S2-O1	V2-Sz1-D1-S1-O1	V2-Sz1-D2-S1-O1
4.	V1-Sz2-D2-S2-O2	V2-Sz1-D1-S1-O2	V2-Sz1-D2-S1-O2
5.	V1-Sz2-D2-S2-O3	V2-Sz1-D1-S1-O3	V2-Sz1-D2-S2-O1

Table 3 10 scenarios for Setting 2 (Set 2).

#	Question 4	Question 5
1.	V1-Sz2-G1-C5	V2-Sz1-G1-C2
2.	V1-Sz1-G2-C3	V2-Sz1-G2-C5
3.	V2-Sz1-G2-C1	V1-Sz2-G2-C5
4.	V2-Sz2-G2-C4	V1-Sz2-G1-C1
5.	V1-Sz2-G2-C2	V1-Sz1-G1-C4

Pedestrian infrastructure variables in Settings 1 included Footpath/Sidewalk presence and obstructions, and we distinguished between protected sidewalks and unprotected sidewalks. We also category obstruction into four cases such as none, business street, motorcycle parking, and motorcycle riding. For Setting 2, we varied the Crossing Type to include zebra crossings and zebra crossings combined with controls like traffic signals, pedestrian signals, or refuge islands. Based on the specific context in the city, we generated 15 scenarios for Setting 1 (Table 2) and 10 scenarios for Setting 2 (Table 3).

We identified three dependent variables of interest for modeling: the perception of comfort (*C*), the perception of crash exposure risk (*E*), and the perception of severe injury risk (*I*). A fractional factorial design was used to derive a set of experiment-specific variables, denoted as vector *X*, which include factors such as traffic conditions, pedestrian infrastructure, and the built environment in various hypothetical pedestrian scenarios.

In addition to the experimental conditions, we also accounted for participants' travel behavior (*T*) and socio-demographic characteristics (*S*) as independent variables. Given the presence of multiple dependent variables, a multivariate modeling framework was adopted. The residual error terms for the respective models are denoted ϵ_C, ϵ_E, and ϵ_I.

We estimated three separate models to assess the perceived levels of comfort (*C*), crash exposure risk (*E*), and severe injury risk (*I*). The dependent variables *C* and *I* are binary, whereas *E* is ordinal with ordered response levels. All models incorporate sets of independent variables: experiment-specific scenario variables (*X*), participants' travel behavior (*T*), and socio-demographic characteristics (*S*). The residual error terms for each equation are denoted by ϵ_C, ϵ_E, and ϵ_I.

The model equations are as follows:

(1) Binary logit model for perception of comfort (*C*): estimates the probability that a participant perceives the walking environment as comfortable.

$$\text{logit}(P(C=1)) = \alpha_C + \boldsymbol{\beta}_C^X \mathbf{X} + \boldsymbol{\beta}_C^T \mathbf{T} + \boldsymbol{\beta}_C^S \mathbf{S} + \epsilon_C \quad (1)$$

(2) Cumulative logit model for ordinal crash exposure risk (*E*): $P(E \leq k)$ represents the probability that the perceived crash exposure risk is at or below level *k*, for ordered levels $k = 1, 2, ..., K$. The thresholds α_{Ek} are estimated separately for each ordinal category.

$$\text{logit}(P(E \leq k)) = \alpha_{E_k} - \left(\boldsymbol{\beta}_E^X \mathbf{X} + \boldsymbol{\beta}_E^T \mathbf{T} + \boldsymbol{\beta}_E^S \mathbf{S} + \epsilon_E\right), \quad \text{for } k = 1, 2, ..., K \quad (2)$$

(3) Binary logit model for perception of severe injury risk (*I*): estimates the probability that a participant perceives a high risk of severe injury in the scenario.

$$\text{logit}(P(I=1)) = \alpha_I + \boldsymbol{\beta}_I^X \mathbf{X} + \boldsymbol{\beta}_I^T \mathbf{T} + \boldsymbol{\beta}_I^S \mathbf{S} + \epsilon_I \quad (3)$$

where, for Eqs. (1)-(3):

- X: Vector of experiment-specific variables (e.g., traffic conditions, pedestrian infrastructure)
- T: Vector of travel behavior attributes
- S: Vector of sociodemographic variables
- α_C, α_I: Intercepts for the binary models
- α_{Ek}: Thresholds for the cumulative logit model of E
- β^X, β^T, β^S: Coefficient vectors for the predictors X, T, and S, respectively
- ϵ_C, ϵ_E, ϵ_I: residual error terms.

3. Results

This section presents a comparative analysis of pedestrian-specific factors from survey methods, including socio-demographic attributes and travel behavior patterns. It also summarizes the modeling outcomes of pedestrian environments across the survey.

Fig. 5 highlights demographics, including gender, age, and education. Behavioral patterns, household, and mobility characteristics are presented in Fig. 6.

Due to differences in contextual and behavioral variables, each setting was modeled separately. There are 510 participants and 1,530 observations for Setting 1 and 1,020 for Setting 2.

3.1 Walking along a Multilane Road

This setting explores pedestrian perceptions while walking along multilane roads. Modeling results show that sidewalk conditions significantly affect perceived comfort and safety. Obstructions such as motorcycle parking (-2.561; $p < 0.001$), motorcycle riding (-1.978; $p < 0.001$), and business street (-1.352; $p < 0.001$) substantially decreased comfort. Conversely, unprotected sidewalks (1.732; $p < 0.001$) and protected sidewalks (2.123; $p < 0.001$) significantly improved comfort.

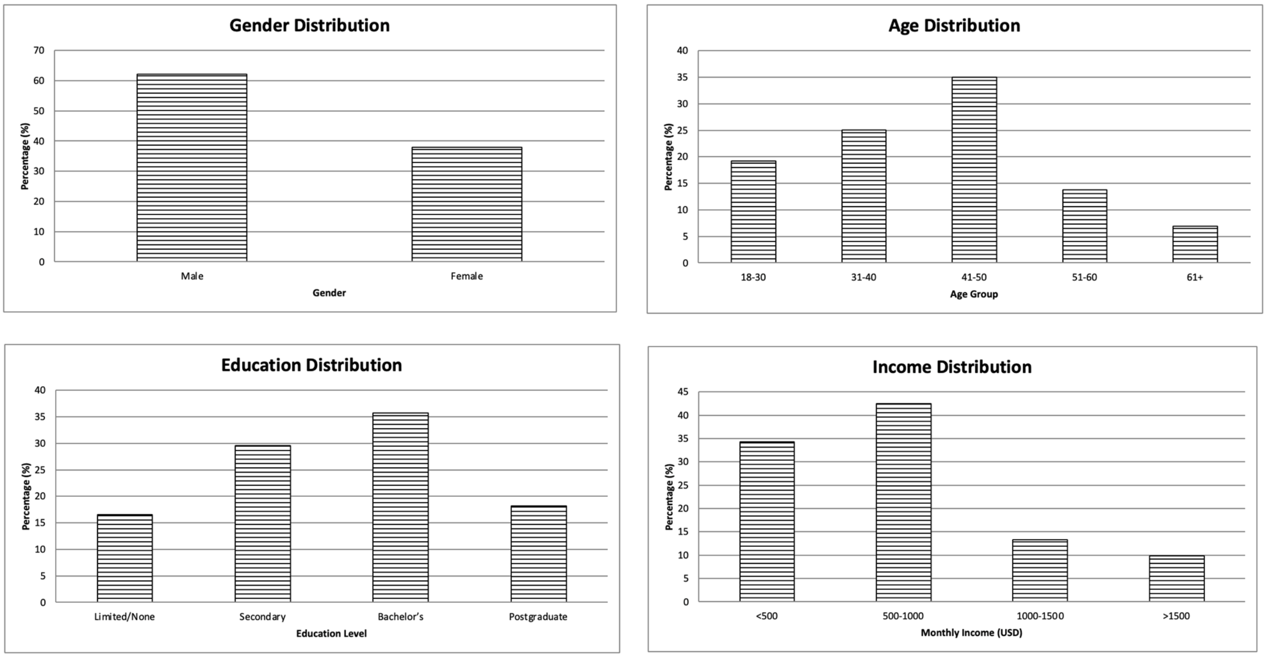

Fig. 5 Demographics of interviewers, including gender, age, education and income.

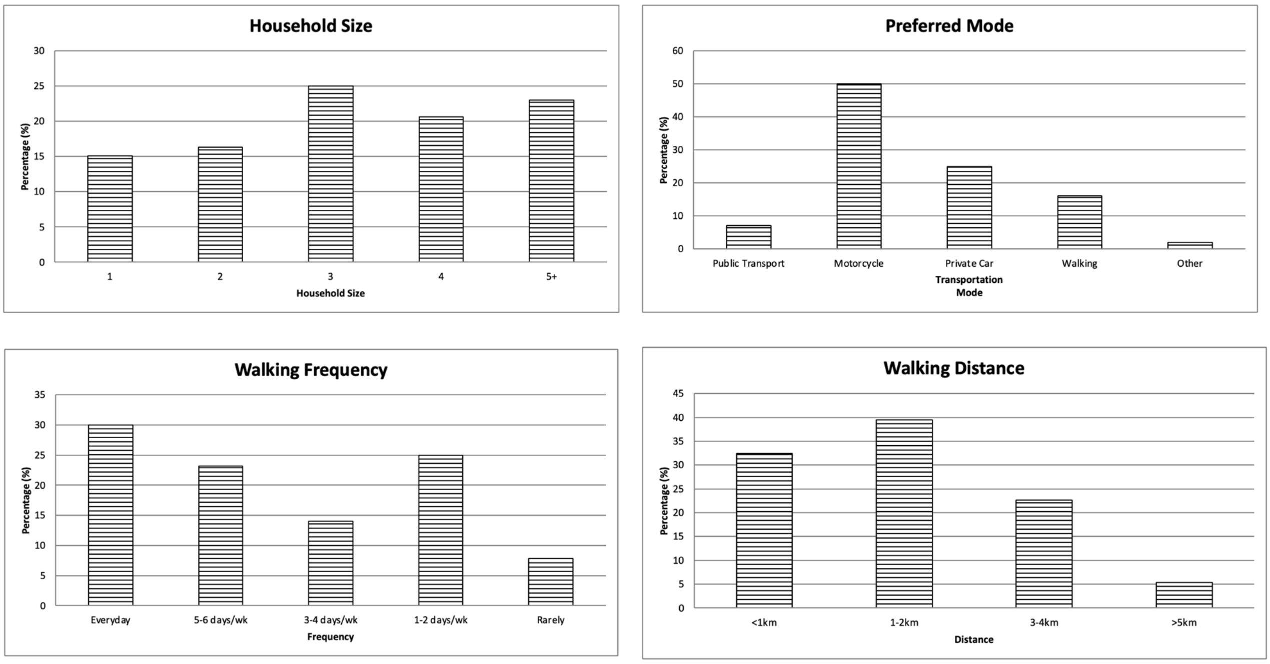

Fig. 6 Behavioral patterns, household, and mobility characteristics of interviewers.

Similar patterns were observed for crash exposure and severe injury risks. Respondents perceived the lowest risks when sidewalks were protected (Exposure: -3.721; Injury: -2.961; $p < 0.001$), followed by unprotected sidewalks (Exposure: -2.673; Injury: -2.384; $p < 0.001$). Obstructions such as motorcycle riding, business streets, and motorcycle parking significantly increased perceived risks.

Traffic congestion was associated with higher exposure and injury risks (Exposure: 0.497, $p < 0.05$; Injury: 0.552; $p < 0.001$). Traffic flow direction had no significant effect on comfort or safety perceptions.

3.2 Crossing a Multilane Road

This setting examines pedestrian perceptions while crossing multilane roads, a high-risk activity in Ho Chi Minh City. Modeling results indicate that crossing type strongly influences perceived comfort and safety. Pedestrian crossings significantly improved comfort levels, with zebra crossing combination with traffic signal and refugee island rated highest (6.058; $p < 0.001$), followed by zebra crossing combination with refugee island (4.204; $p < 0.001$).

In terms of perceived crash exposure and severe injury risks, zebra crossing combination with traffic signal and refugee island were considered safest (Exposure: -3.837; Injury: -3.245; $p < 0.001$), followed by refuge islands and pedestrian signals.

Traffic conditions also influenced perceptions. Respondents felt safer during congested periods (Exposure: -0.562; Injury: -0.363; $p < 0.001$).

4. Discussions

This study advances the understanding of pedestrian perceptions in urbanizing environments by empirically analyzing how infrastructural and traffic-related features shape perceived safety and comfort under mixed traffic conditions in Ho Chi Minh City by distinguishing between two common urban pedestrian scenarios such as walking along and crossing multilane roads.

4.1 Walking along Multilane Roads

The findings indicate that sidewalk quality plays a significant role in shaping pedestrian experiences. Both protected and unprotected sidewalks were positively associated with comfort and perceived safety, with protected sidewalks exerting a significantly stronger effect. Conversely, sidewalk obstructions such as motorcycle riding, informal business activity, and parked motorbikes were linked to marked declines in perceived comfort and increases in perceived crash and injury risk. These results underscore the importance of dedicated, unobstructed pedestrian space, which is positively associated with comfort and perceived safety.

Traffic congestion was also found to elevate perceived crash exposure and injury risk. Notably, walking direction relative to traffic flow did not significantly influence perceived safety or comfort. This suggests that the static characteristics of pedestrian infrastructure exert a more substantial influence on perception than dynamic traffic variables in dense, slow-moving traffic environments.

4.2 Crossing Multilane Roads

The results from crossing scenarios reveal the critical role of comprehensive crossing infrastructure in enhancing pedestrian safety perception. Facilities that combine zebra crossings, traffic signals, and refuge islands were consistently associated with the highest levels of comfort and lowest perceived risks. These findings support a systems-based design approach, where multiple safety features operate synergistically to improve pedestrian experiences.

Interestingly, participants reported feeling safer during periods of traffic congestion. This counterintuitive outcome may be attributed to the reduced speed and increased predictability of vehicular movement during high-density traffic conditions.

4.3 Implications for Urban Design and Policy

The evidence presented highlights key priorities for urban planners and policymakers aiming to promote safer and more inclusive pedestrian environments. First, investments in sidewalk infrastructure should focus not only on physical presence but also on quality to ensure protection from traffic and removal of encroachments. Second, crossing infrastructure should incorporate multiple design features, including pedestrian signals and refuge islands, to effectively mitigate perceived and actual risks. Lastly, traffic management strategies that emulate the speed-reducing benefits of congestion, such as physical traffic-calming measures, may help improve pedestrian comfort without inducing vehicular delays.

These findings underscore the necessity of adopting pedestrian conditions in urban transport planning, particularly in low- and middle-income contexts where mixed traffic conditions are prevalent. By aligning infrastructure development with user perceptions, cities like Ho Chi Minh City can foster safer, more walkable urban spaces that support public health, sustainability, and equitable access to mobility.

5. Conclusions

In conclusion, this study highlights how infrastructure shapes pedestrian perceptions in Ho Chi Minh City. Quality sidewalks and well-designed crossings greatly enhance comfort and safety, while obstructions and poor infrastructure increase perceived risk. Surprisingly, congestion can improve crossing safety due to slower traffic. These insights stress the need for pedestrian-focused planning to create safer, more inclusive urban environments.

References

[1] Che, W., Zhang, Y., Wang, D., and Zhang, Y. 2024. “Active Transport and Urban Mobility: A Comprehensive Review.” *Journal of Transport and Health* 29: 101495.

[2] Fitch, D. T., McLeod, K., and Marshall, W. E. 2022. “Improving Pedestrian Safety through Urban Design.” *Transportation Research Part D: Transport and Environment* 105: 103223.

[3] IIHS (Insurance Institute for Highway Safety). 2024. “Fatality Facts 2022: Pedestrians.” https://www.iihs.org/topics/fatality-statistics/detail/pedestrians.

[4] NHTSA (National Highway Traffic Safety Administration). 2024. *Traffic Safety Facts 2022: A Compilation of Motor Vehicle Crash Data*. New York: U.S. Department of Transportation. https://www.nhtsa.gov.

[5] WHO (World Health Organization). 2023. *Global Status*

Report on Road Safety 2023. Geneva: World Health Organization.

[6] WHO (World Health Organization). 2023. *Global Road Safety: Regional Trends and Policy Challenges*. Geneva: World Health Organization.

[7] USDOT (United States Department of Transportation). 2022. "Safe System Approach for Pedestrian Safety." https://www.transportation.gov/policy-initiatives/safety/safe-system.

[8] European Commission. 2024. "EU Road Safety Policy Framework 2021-2030: Next steps towards 'Vision Zero'." https://transport.ec.europa.eu.