

Pedestrian Refuge Islands in Mixed Traffic Cities an Integrated Evaluation of Design Performance and Safety Perception in Ho Chi Minh City

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Abstract: Pedestrian safety remains a major challenge in rapidly motorizing cities, particularly in low- and middle-income countries where mixed traffic conditions complicate pedestrian–vehicle interactions. Pedestrian refuge islands are widely implemented to facilitate staged crossings on multi-lane roads, yet empirical evidence on their effectiveness in such environments remains limited. This study evaluates pedestrian refuge islands in Ho Chi Minh City using an integrated assessment framework that combines technical design compliance, expert road-safety audits, and pedestrian perception surveys. Twenty pedestrian refuge island locations constructed between 2018 and 2024 were examined across different roadway contexts, including twelve urban and eight suburban sites. The integrated assessment results show effectiveness scores ranging from 63 to 76 points, with an average of approximately 70 points on a 100-point scale. Survey findings indicate that 65% of respondents recognized improvements in crossing conditions, while 35% reported no clear change or remained uncertain about the treatment's impact. The results suggest that pedestrian refuge islands can improve pedestrian crossing conditions, but their effectiveness depends strongly on design quality, visibility, maintenance, and interactions with surrounding traffic.

Keywords: Pedestrian safety, pedestrian refuge islands, mixed traffic, safety perception, road safety audit.

1. Introduction

Active transportation, particularly walking, is increasingly promoted as a key strategy for addressing multiple urban challenges, including environmental sustainability, traffic congestion, and public health [1, 2]. Encouraging walking not only reduces dependence on motorized transport but also contributes to healthier lifestyles and more livable urban environments.

Despite these benefits, pedestrian safety remains a significant global concern. In the United States, the

proportion of pedestrian fatalities increased from 14.2% of all traffic deaths in 2012 to 17.7% in 2022, while the total number of pedestrian fatalities rose by more than 55% during the same period [3, 4]. Globally, pedestrian deaths reached approximately 274,000 in 2021, accounting for nearly one-quarter of all road traffic fatalities [5]. While several high-income regions have achieved gradual reductions in pedestrian fatalities through infrastructure investment and safety policies, Southeast Asia has experienced a notable increase in

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pedestrian risk over the past decade [6].

The Safe System approach has increasingly been adopted as a framework for improving road safety by emphasizing infrastructure design, speed management, vehicle safety, and institutional coordination [7]. Cities such as Portland and Philadelphia have implemented integrated safety programs to reduce pedestrian fatalities through coordinated policy and infrastructure interventions. Similar strategies have been adopted across European countries, where long-term investments in street design and traffic calming have contributed to sustained safety improvements [8].

However, infrastructure interventions often perform differently in low- and middle-income countries (LMICs). Rapid motorization, heterogeneous vehicle flows, and informal driving behaviors create mixed traffic environments that present unique challenges for pedestrian safety. In such contexts, pedestrians frequently interact with motorcycles, cars, buses, and informal road users within constrained road space.

Pedestrian refuge islands have been implemented as practical infrastructure measures to facilitate safer road crossings. By providing a protected waiting space between opposing traffic streams, pedestrian refuge islands allow pedestrians to cross wide roads in stages, thereby reducing exposure time and simplifying crossing decisions (Fig. 1).

In rapidly motorizing cities such as Ho Chi Minh City, pedestrian refuge islands have increasingly been implemented as a pragmatic staged-crossing solution within limited right-of-way conditions. They are one of the significant measures to improve traffic safety in the city (Fig. 2; Fig. 3).

Nevertheless, empirical evidence regarding the performance of pedestrian refuge islands in mixed traffic environments remains limited. Traditional engineering evaluations often focus on geometric design compliance or crash statistics, while paying less attention to how pedestrians perceive and interact with these facilities. Pedestrian safety perception plays a critical role in shaping crossing behavior and willingness to use designated crossing infrastructure.

This study addresses this gap by evaluating pedestrian refuge islands implemented in Ho Chi Minh City through an integrated assessment framework that combines technical design evaluation, expert road safety audits, and pedestrian perception surveys. The study aims to answer three research questions:

How effective are implemented pedestrian refuge islands based on integrated technical, expert, and user-based assessments?

How do pedestrians perceive safety improvements at pedestrian refuge island locations?

Which design and contextual factors most constrain performance and perceived safety?



Fig. 1 Phan Dang Luu- No Trang Long intersection, Binh Thanh, Ho Chi Minh City.

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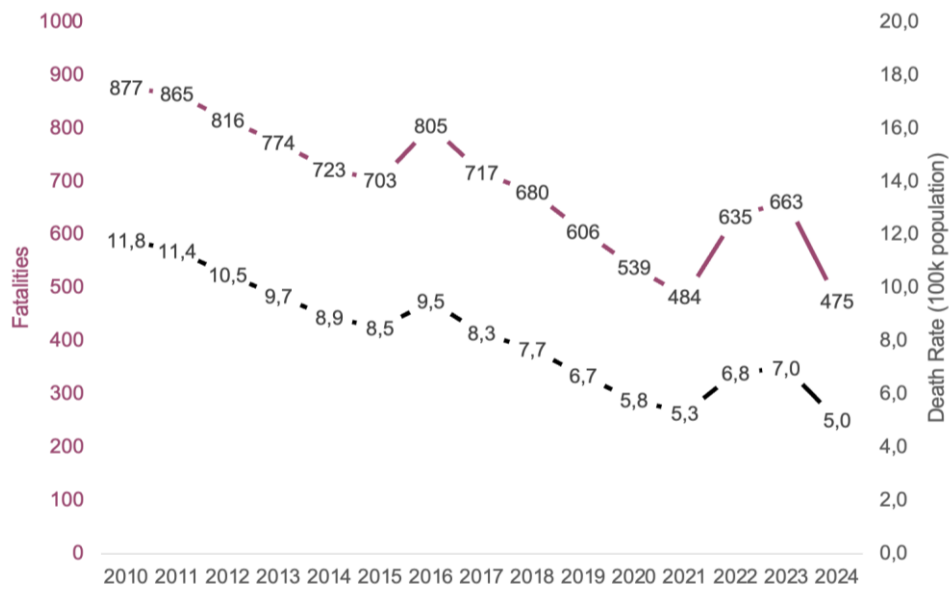


Fig. 2 Fatalities and death rate (2010-2024).

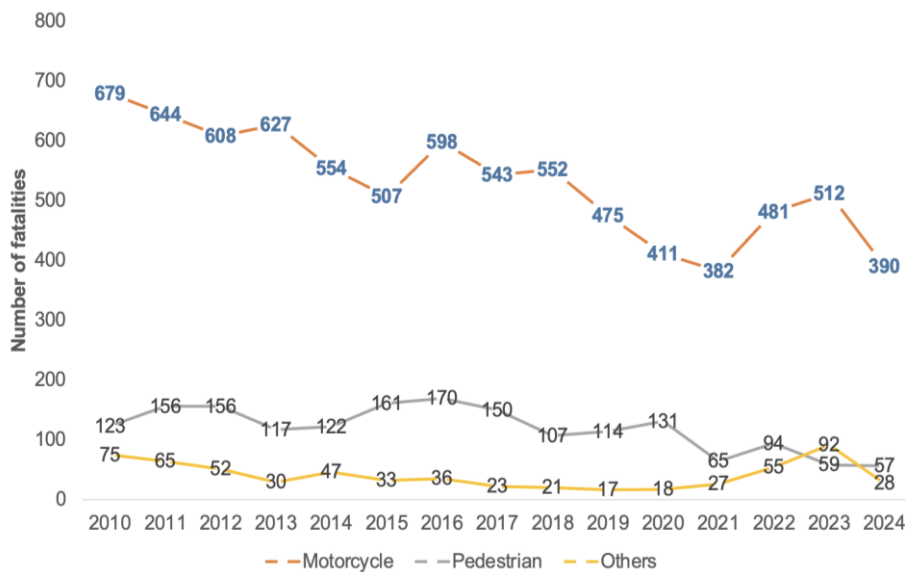


Fig. 3 Death by road user type (2010-2024).

2. Literature Context

Pedestrian refuge islands are widely recognized as an effective countermeasure for improving pedestrian safety on multi-lane roads. By dividing crossings into two stages, pedestrian refuge islands reduce pedestrian exposure time and simplify crossing decisions. In high-income countries, pedestrian refuge islands are typically implemented alongside complementary measures such as traffic calming, lane narrowing, and signal coordination.

However, empirical evidence from LMIC contexts remains limited. Mixed traffic environments introduce additional complexities, including motorcycle encroachment, inconsistent yielding behavior, and wide variations in operating speeds. These conditions may influence both the operational performance of pedestrian refuge islands and pedestrian perceptions of safety.

Recent road safety research has emphasized the distinction between objective safety performance and

subjective safety perception. While infrastructure may meet technical design standards, pedestrians may still perceive crossings as unsafe due to traffic behavior, speed conditions, or poor visibility. Integrating user perception into infrastructure evaluation can therefore provide a more comprehensive understanding of pedestrian safety outcomes.

3. Methodology

3.1 Study Context and Scope

Building on the research gap identified in the previous section, this study evaluates the real-world performance of pedestrian refuge islands implemented in Ho Chi Minh City. The city provides a relevant case for examining pedestrian infrastructure in a mixed traffic environment characterized by high motorcycle volumes, heterogeneous vehicle flows, and frequent pedestrian exposure on wide arterial roads.

The study focuses on pedestrian refuge islands installed in Ho Chi Minh City between 2018 and 2024 as part of local road-safety improvement initiatives. Twenty pedestrian refuge island locations were selected for evaluation, including twelve sites located in urban districts and eight sites located in suburban corridors. These sites provide an opportunity to examine how pedestrian refuge islands function under different traffic intensities, roadway geometries, and surrounding land-use contexts. Rather than examining a single performance indicator, the study adopts a multidimensional evaluation approach to better capture the interactions among infrastructure design, operational conditions, and user experience.

3.2 Integrated Assessment Framework

To address the gap between engineering evaluation and pedestrian perception identified in the literature, the study employs an integrated assessment framework that combines three complementary components: technical design compliance, an expert road safety audit, and a user perception survey. Together, these

components provide a more comprehensive understanding of pedestrian refuge island performance in a mixed traffic context.

The first component evaluates the technical design quality of each pedestrian refuge island. This assessment focuses on whether the infrastructure design aligns with established safety principles and functional requirements for pedestrian crossings. Key aspects examined include the suitability of the location within the roadway context, the physical dimensions and protection of the refuge space, the visibility and conspicuity of the island, interactions with vehicle speeds, pedestrian accessibility conditions, and the degree of design standardization across sites. Technical compliance accounts for 45% of the overall effectiveness score, reflecting the foundational role of design quality in pedestrian infrastructure performance.

The second component consists of expert road safety audits conducted by certified road safety engineers. These structured field inspections focus on identifying potential safety risks and operational conflicts that may not be captured through design compliance alone. Particular attention is given to roadway geometry and alignment, potential conflict points between pedestrians and vehicles, the adequacy of pavement markings and signage, lighting conditions, and the presence of roadside hazards that could affect pedestrian safety. The expert audit accounts for 20% of the final evaluation score.

The third component incorporates pedestrian user perception, recognizing that infrastructure effectiveness also depends on how safe and usable it is perceived to be by road users. Pedestrians and other road users were surveyed at each site to gather feedback on perceived safety improvements, remaining barriers or obstacles during crossing, and overall satisfaction with the crossing environment. This perception-based assessment accounts for 35% of the total effectiveness score, reflecting the importance of user experience in determining whether infrastructure interventions achieve their intended safety outcomes.

3.3 Limitations

Several limitations should be acknowledged when interpreting the results. First, the evaluation is cross-sectional and conducted after the implementation of the pedestrian refuge islands. As baseline crash or speed data were not consistently available across sites, it was not possible to perform a causal before-and-after safety analysis. Second, variations in traffic conditions over time, including seasonal changes and enforcement intensity, were not explicitly controlled.

Consequently, the findings should be interpreted as reflecting relative performance and user experience across sites rather than quantified reductions in crashes. Despite these limitations, the integrated assessment framework provides useful insights into how pedestrian refuge island design, operational conditions, and pedestrian perception interact in shaping the effectiveness of pedestrian crossing infrastructure in mixed traffic environments.

3.4 Data Collection and Scoring Method

Data collection was conducted through a combination of field observations, structured safety audits, and on-site pedestrian surveys at each pedestrian refuge island location. The evaluation process was designed to capture both infrastructure characteristics and user experience under real operating conditions.

For the technical compliance assessment, field teams conducted systematic observations using a standardized checklist developed from pedestrian safety design principles and urban road safety guidelines. Each pedestrian refuge island was evaluated across multiple design dimensions, including location suitability, refuge width and protection, visibility and conspicuity, interaction with vehicle speeds, pedestrian accessibility, and consistency of design implementation. Individual criteria were scored on a standardized scale and aggregated into an overall technical compliance score for each site.

The expert road safety audit was conducted by

certified road safety engineers through structured site inspections. The audits focused on identifying operational safety issues that could influence pedestrian crossing risk, including roadway geometry, traffic alignment, potential conflict points between pedestrians and vehicles, adequacy of pavement markings and signage, nighttime visibility, and the presence of roadside hazards. Audit findings were converted into a structured scoring format to ensure comparability across locations.

For the user perception component, short intercept surveys were conducted with pedestrians and road users at each site. Respondents were asked to evaluate perceived safety conditions at the crossing location, including whether the pedestrian refuge island improved crossing safety, whether any obstacles remained during the crossing process, and their overall level of satisfaction with the crossing environment. Surveys were conducted during typical daytime traffic periods to capture regular user experience rather than atypical traffic conditions.

To allow comparison across sites, scores from the three evaluation components were normalized and aggregated into a composite effectiveness index. The final score for each pedestrian refuge island was calculated using a weighted combination of the three assessment components: technical compliance (45%), expert road safety audit (20%), and user perception survey (35%). This weighting structure reflects the complementary roles of engineering design, professional safety assessment, and pedestrian experience in determining the overall effectiveness of pedestrian crossing infrastructure.

The survey collected 200 responses, with the demographic profile indicating a male-dominated sample. Male respondents accounted for 124 participants (62%), while female respondents represented 76 participants (38%). In terms of age distribution, the sample was strongly concentrated among young adults. The 18-25 age group accounted for the largest share of respondents, with 129 participants, suggesting that this demographic is particularly engaged with the pedestrian

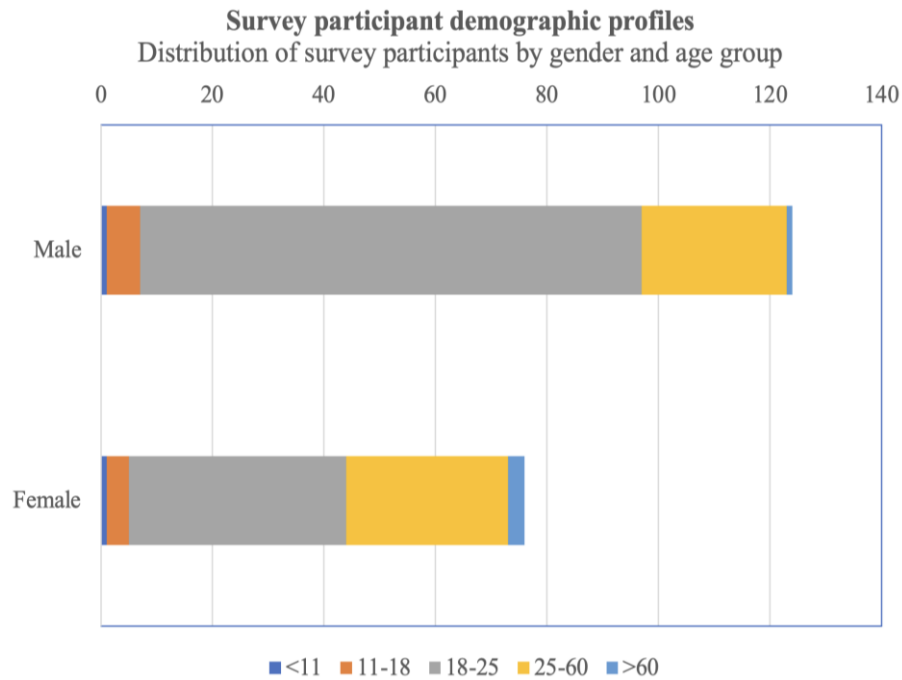


Fig. 4 Survey participants' demographic profiles distribution by gender and age group.

crossing environments examined in this study. Working-age adults aged 25-60 accounted for 27.5% of the sample, while younger participants aged 11-18 represented approximately 5% of respondents (Fig. 4).

The survey sample is dominated by respondents aged 18-25, primarily students, with additional representation from the 25-60 age group, mainly office workers. Reported usage patterns indicate that many respondents use pedestrian refuge island crossings occasionally, suggesting that these facilities serve both regular commuters and occasional pedestrians. A smaller proportion reported never using the facilities, which may reflect limited awareness or a preference for alternative crossing behaviors. Consistent with Ho Chi Minh City's travel patterns, motorcycle use is the predominant travel mode among respondents, although walking, buses, and private cars are also represented, indicating that pedestrian refuge islands serve users with diverse mobility needs.

4. Results

4.1 Technical Design Compliance

The technical design compliance assessment evaluates

the extent to which the implemented pedestrian refuge islands satisfy key design requirements for pedestrian crossings. The evaluation considered several criteria, including refuge width and protection, visibility and conspicuity, accessibility conditions, interaction with vehicle speeds, and contextual suitability within the roadway environment.

Across the 20 evaluated locations, technical design compliance scores ranged from 65 to 77 points, with an average of approximately 71. In general, the pedestrian refuge islands provide clearly defined waiting spaces that allow pedestrians to cross multi-lane roads in two stages. Several locations demonstrate relatively strong design performance, particularly those with adequate refuge width, clearly visible pavement markings, and alignment with pedestrian desire lines.

However, variations in design implementation were observed across sites. At several locations, the effective refuge width was partially reduced due to motorcycle encroachment or roadside activities. In addition, faded pavement markings and insufficient nighttime illumination were observed at some locations,

potentially reducing the visibility of the crossing facilities to approaching drivers.

Overall, the technical assessment suggests that while most pedestrian refuge islands meet the basic geometric requirements for staged pedestrian crossings, improvements in visibility, design standardization, and maintenance could further enhance their operational performance.

4.2 Expert Road Safety Audit

The expert road safety audits provide an independent evaluation of operational safety conditions at each pedestrian refuge island site. These audits were conducted through structured field inspections performed by certified road safety engineers, focusing on roadway geometry, conflict points, pavement markings, lighting conditions, and roadside hazards.

Audit scores ranged from 62 to 72 points, with an average score of approximately 67 points across the evaluated locations. Sites receiving higher audit scores generally exhibited clear pedestrian markings, adequate visibility, and fewer roadside conflicts affecting pedestrian crossings.

Nevertheless, several operational issues were identified during the inspections. In some locations, faded pavement markings reduced the visual prominence of pedestrian crossings. Limited nighttime illumination was also observed in several suburban corridors. Additionally, motorcycle encroachment into refuge spaces was observed at several sites, reducing the pedestrian protection provided by the median.

These observations indicate that operational safety conditions are influenced not only by infrastructure design but also by surrounding traffic activities and driver behavior.

4.3 Pedestrian Safety Perception

The pedestrian perception survey provides insight into how users experience pedestrian refuge island crossings in practice. Survey responses indicate that

pedestrian refuge islands are generally perceived as an improvement compared with untreated crossing conditions.

Approximately 65% of respondents reported recognizing some level of improvement following the installation of pedestrian refuge islands, while 35% indicated no clear change or remained uncertain about the impact of the treatment.

Perception scores across the evaluated sites ranged from 64 to 74, with an average of approximately 69. Locations with clearly visible pavement markings, adequate refuge width, and sufficient nighttime lighting tended to receive higher perception scores. In contrast, sites affected by motorcycle encroachment and limited visibility showed lower perception scores and a greater proportion of neutral responses.

These findings suggest that pedestrian perception is strongly influenced by the quality of design implementation and maintenance rather than by the presence of the pedestrian refuge island alone.

4.4 Integrated Effectiveness Assessment

Table 1 presents the integrated effectiveness scores for the twenty evaluated pedestrian refuge island locations constructed between 2018 and 2024. The sample includes twelve urban sites located in Quận 1, 3, 5, 6, Tân Bình, Bình Thạnh and eight suburban sites situated in Tân Phú, Hóc Môn, Quận 12, and Thủ Đức district. The integrated effectiveness scores range from 63 to 76 points, with an average score of approximately 70 points on a 100-point scale. Fig. 5 illustrates the distribution of effectiveness scores across all evaluated locations, showing that most sites cluster around the overall mean.

Urban sites generally achieved slightly higher effectiveness scores due to clearer pavement markings, better lighting conditions, and stronger pedestrian activity. Suburban locations showed greater variability in performance, particularly in interactions between vehicle speed and visibility conditions.

Table 1 Integrated effectiveness scores for the evaluated pedestrian refuge island locations.

Location	Street/Intersection/Ward	Area type	Technical Design	Safety Audit	User Perception	Final Score
1	Lê Duẩn Blvd – Bến Nghé Ward, District 1	Urban	72	70	68	70
2	Nguyễn Bình Khiêm St – Bến Nghé Ward, District 1	Urban	75	72	70	72
3	Bà Huyện Thanh Quan St – Ward 6, District 3	Urban	68	66	65	66
4	Trần Quốc Toản St – Ward 7, District 3	Urban	70	68	67	69
5	Hồng Bàng St – Ward 2, District 5	Urban	73	69	70	71
6	Đặng Nguyên Cẩn St – Ward 13, District 6	Urban	66	64	63	64
7	Chợ Lớn St – Ward 11, District 6	Urban	74	70	72	72
8	Cách Mạng Tháng Tám St – Ward 4, Tân Bình	Urban	71	69	68	70
9	Lý Thường Kiệt St – Ward 7, Tân Bình	Urban	69	65	66	67
10	Quách Thị Trang Square intersection – Bến Thành Ward, District 1	Urban	76	72	73	74
11	Phan Đăng Lưu – Nơ Trang Long intersection – Ward 7, Bình Thạnh	Urban	70	67	68	69
12	Trường Chinh St – Ward 13, Tân Bình	Urban	67	64	65	66
13	Lê Trọng Tấn St – Sơn Kỳ Ward, Tân Phú	Suburban	65	62	63	63
14	Gò Dầu St – Tân Quý Ward, Tân Phú	Suburban	68	65	66	66
15	Nguyễn Ảnh Thủ St – Trung Chánh, Hóc Môn	Suburban	70	66	68	68
16	Quốc lộ 22 – Bà Điểm, Hóc Môn	Suburban	72	68	70	70
17	Hà Huy Giáp St – Thạnh Lộc Ward, District 12	Suburban	74	70	71	72
18	Nguyễn Văn Quá St – Đông Hưng Thuận Ward, District 12	Suburban	69	66	67	68
19	Nguyễn Xiển St – Long Bình Ward, Thủ Đức City	Suburban	73	69	70	71
20	Xa lộ Hà Nội – Hiệp Phú Ward, Thủ Đức City	Suburban	77	72	74	76

Distribution Of Effectiveness Scores Across 20 Refuge Island Locations

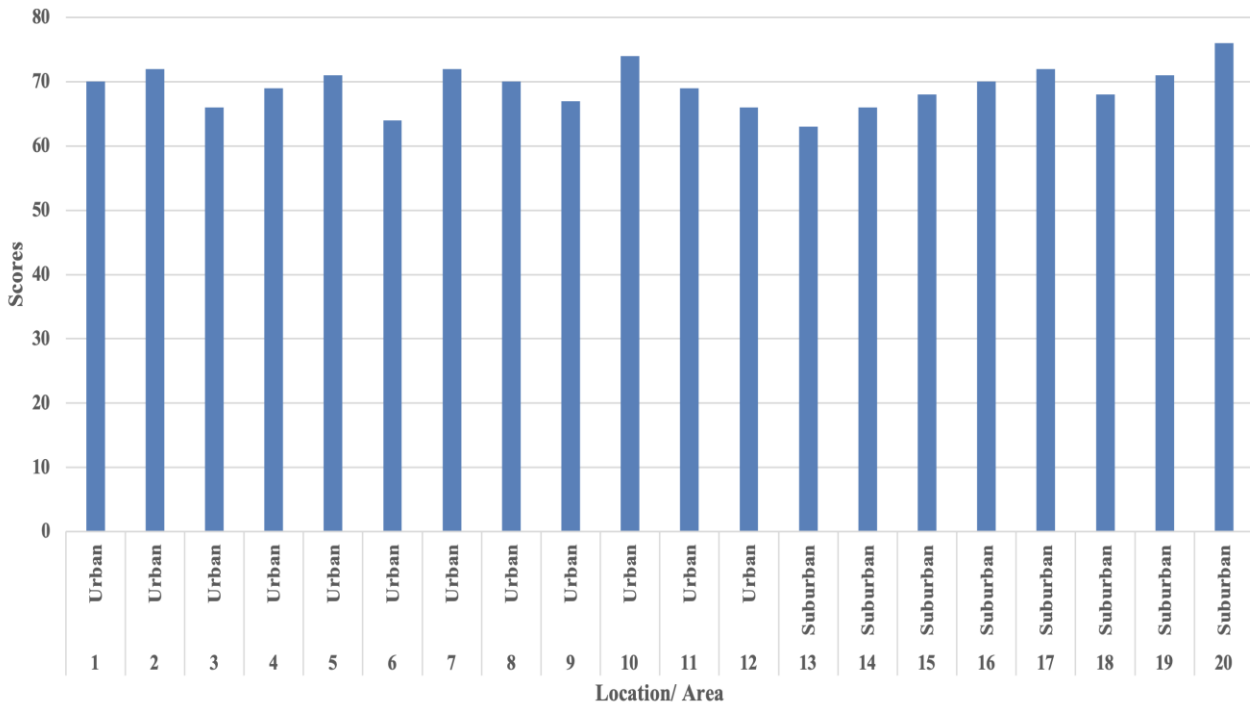


Fig. 5 Distribution of integrated effectiveness scores across the evaluated refuge island locations.

5. Discussion

The results indicate that pedestrian refuge islands improve pedestrian crossing conditions but do not fully resolve safety concerns in mixed traffic environments. While the infrastructure introduces structure into the crossing process, pedestrians continue to evaluate safety based on vehicle speed, visibility, and driver behavior.

Vehicle speed appears to be the most influential factor shaping pedestrian perception. Even when staged crossings are available, high approach speeds reduce the perceived protective function of pedestrian refuge islands.

Design quality and maintenance also play important roles. Narrow refuge spaces, faded markings, and poor lighting reduce the functional performance of these facilities. Motorcycle encroachment further limits the usable refuge space for pedestrians.

These findings highlight the importance of integrating infrastructure design with broader traffic management strategies in mixed-traffic cities.

6. Conclusion

This study evaluated pedestrian refuge islands in Ho Chi Minh City using an integrated assessment framework that combined technical design evaluation, expert road safety audits, and pedestrian perception surveys.

The results show that pedestrian refuge islands provide measurable improvements in pedestrian crossing conditions, but that perceived safety benefits remain moderate. Vehicle speed, visibility conditions, and infrastructure maintenance were identified as key factors influencing both operational performance and pedestrian perception.

The findings suggest that pedestrian refuge islands should not be treated as standalone interventions. Their

effectiveness depends on integration with speed management strategies, clear visual design, and consistent maintenance practices.

By linking technical infrastructure assessment to pedestrian perception, this study contributes to a more comprehensive understanding of pedestrian crossing infrastructure in mixed-traffic cities.

Future research should incorporate crash data, speed measurements, and behavioral observations to further examine long-term safety impacts.

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