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# PEDESTRIAN CROSSING SAFETY: A COMPREHENSIVE ANALYSIS OF URBAN INFRASTRUCTURE, BEHAVIORAL PATTERNS, AND SAFETY ASSESSMENT METHODOLOGIES

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## Abstract

Pedestrian safety at crossing points remains a critical concern in urban transportation planning, particularly in developing nations where rapid urbanization outpaces infrastructure development. This study presents a comprehensive analysis of pedestrian crossing safety, examining infrastructure parameters, behavioral patterns, and assessment methodologies. Through a systematic review of current literature and case studies from various urban environments, including detailed analysis from Kigali, Rwanda, this research identifies key factors influencing pedestrian safety at crossing points. The study employs statistical analysis methods including chi-square tests and logistic regression to evaluate the relationship between infrastructure design, driver compliance, and pedestrian behavior. Results indicate that unsignalized crosswalks present significantly higher risk factors, with driver compliance rates varying substantially based on infrastructure design parameters. The research contributes to the understanding of pedestrian safety dynamics and provides recommendations for improving crossing safety through integrated infrastructure design and policy interventions. Findings suggest that a multi-faceted approach combining physical infrastructure improvements, behavioral interventions, and enforcement mechanisms is essential for enhancing pedestrian safety in urban environments.

**Keywords:** Pedestrian safety, crossing behavior, traffic safety, urban infrastructure, road safety assessment

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## 1. Introduction

Pedestrian safety represents one of the most pressing challenges in contemporary urban transportation systems. According to the United Nations Conference on Trade and Development (UNCTAD, 2017), road traffic injuries constitute a leading cause of death globally, with pedestrians accounting for a disproportionate share of casualties, particularly in developing countries. The complexity of pedestrian-vehicle interactions at crossing points necessitates a comprehensive understanding of multiple factors including infrastructure design, behavioral patterns, and regulatory frameworks.

The significance of pedestrian crossing safety extends beyond immediate safety concerns to encompass broader urban sustainability goals outlined in the 2030 Agenda for Sustainable Development (UNCTAD, 2017). As cities worldwide experience rapid urbanization, the design and management of pedestrian infrastructure become increasingly critical for creating safe, accessible, and sustainable urban environments.

Recent technological advances have introduced new possibilities for enhancing pedestrian safety through Internet of Things (IoT) sensors and smart infrastructure systems (Raiful & Ragib, 2022). However, the implementation of such technologies must be grounded in thorough understanding of existing safety challenges and behavioral patterns that characterize pedestrian-vehicle interactions.

This research addresses the multifaceted nature of pedestrian crossing safety by examining infrastructure parameters, behavioral factors, and assessment methodologies. The study draws from diverse geographical contexts, with particular attention to challenges faced in developing urban environments, using Kigali, Rwanda as a case study to illustrate broader principles applicable to similar contexts globally.

## 2. Literature Review

### 2.1 Pedestrian Safety Assessment Methodologies

The assessment of pedestrian crossing safety requires sophisticated methodological approaches that account for multiple variables simultaneously. Olga et al. (2010) developed a comprehensive

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methodology for assessing pedestrian crossing safety that considers both infrastructure characteristics and behavioral factors. Their approach emphasizes the importance of systematic data collection and statistical analysis in identifying risk factors and developing targeted interventions.

Antov et al. (2013) expanded upon traditional safety assessment approaches by incorporating advanced statistical techniques and considering the interaction between different safety parameters. Their work demonstrated that effective safety assessment requires consideration of both quantitative metrics, such as traffic flow rates and crossing times, and qualitative factors including pedestrian comfort levels and perceived safety.

The integration of modern technology into safety assessment has been explored by Raiful and Ragib (2022), who examined the potential of IoT sensors and connected systems for real-time monitoring of pedestrian crossing behavior. Their research highlighted both opportunities and challenges associated with technology-enhanced safety assessment, including issues related to data privacy, system reliability, and cost-effectiveness.

### 2.2 Infrastructure Parameters and Safety Outcomes

Infrastructure design parameters play a crucial role in determining pedestrian safety outcomes at crossing points. Marcin et al. (2021) conducted a comprehensive analysis of how road infrastructure parameters influence both driver and pedestrian behavior in crossing areas. Their findings indicated that factors such as crossing width, visibility conditions, traffic calming measures, and signalization significantly impact safety outcomes.

The specific challenges associated with unsignalized crosswalks have been extensively studied by Yanqun et al. (2022), who analyzed pedestrian behavior from drivers' perspectives. Their qualitative research revealed that communication between pedestrians and drivers at unsignalized crossings relies heavily on visual cues and mutual understanding of traffic norms, making these locations particularly vulnerable to safety incidents.

Specialized crossing environments, such as rail grade crossings, present unique safety challenges as documented by Metaxatos and Sriraj (2015). Their research on pedestrian safety at rail grade

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crossings identified specific risk factors and intervention strategies applicable to these high-risk environments.

### 2.3 Behavioral Factors in Pedestrian Safety

Understanding pedestrian behavior is essential for developing effective safety interventions. Wang et al. (2011) examined individual differences in pedestrian behavior at both midblock crosswalks and intersections, revealing significant variations in risk-taking behavior based on demographic characteristics, environmental conditions, and personal factors.

The behavior of vulnerable populations, particularly children, has been specifically addressed by Riaz et al. (2022) in their study of primary school children's street-crossing behavior under adult supervision. Their research highlighted the importance of targeted safety education and infrastructure design considerations for protecting vulnerable road users.

Haghighi et al. (2020) employed qualitative research methods to understand pedestrian safety challenges from the perspectives of traffic and transport stakeholders. Their findings emphasized the importance of multi-stakeholder approaches to address the complex interplay of factors affecting pedestrian safety.

### 2.4 Case Study: Kigali, Rwanda

The urban environment of Kigali, Rwanda, provides valuable insights into pedestrian safety challenges in rapidly developing cities. Mukamana (2015) conducted a detailed study of driver compliance with zebra crossing laws in Kigali, revealing significant gaps between regulatory requirements and actual behavior. The study found that compliance rates varied substantially based on crossing location, time of day, and traffic density.

Nkurunziza and Tafahomi (2020) assessed pedestrian mobility on road networks in Kigali, identifying infrastructure deficiencies and behavioral patterns that contribute to safety risks. Their research documented the challenges associated with integrating pedestrian infrastructure into existing urban fabric while accommodating rapid population growth and economic development.

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The epidemiological analysis conducted by Anjni et al. (2016) provided quantitative evidence of road traffic injury patterns in Kigali, identifying specific hotspots and risk factors associated with pedestrian injuries. Their analysis of police data revealed spatial and temporal patterns that inform targeted intervention strategies.

## 3. Methodology

### 3.1 Research Framework

This study employs a mixed-methods approach combining quantitative statistical analysis with qualitative assessment of pedestrian safety factors. The research framework integrates multiple data sources and analytical techniques to provide comprehensive understanding of pedestrian crossing safety dynamics.

The methodological approach follows established protocols for transportation safety research, incorporating both observational data collection and statistical modeling techniques. Data analysis employs chi-square tests to examine relationships between categorical variables and logistic regression modeling to identify predictive factors for safety outcomes (Sandro, 2014; Nasser, 2020).

### 3.2 Statistical Analysis Methods

Statistical analysis procedures follow established protocols outlined by Mindrila and Balentyne (2023) for chi-square testing and Moore et al. (2013) for comprehensive statistical analysis. The analysis framework incorporates both descriptive statistics to characterize the dataset and inferential statistics to test specific hypotheses regarding factors influencing pedestrian safety.

Logistic regression analysis is employed to model the probability of safety incidents based on multiple predictor variables, following methodologies described by Sandro (2014) and implemented using standard statistical software packages.

### 3.3 Data Collection and Sampling

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Data collection procedures incorporate multiple sources including traffic flow measurements, observational studies of pedestrian behavior, and analysis of incident reports. The sampling framework ensures representative coverage of different crossing types, traffic conditions, and urban environments.

Quality control measures are implemented throughout the data collection process to ensure accuracy and reliability of measurements. All data collection procedures follow established protocols for transportation research and comply with relevant ethical guidelines.

## 4. Results and Analysis

### 4.1 Infrastructure Analysis

Analysis of infrastructure parameters reveals significant variations in design standards and implementation quality across different urban environments. Table 1 presents a summary of key infrastructure characteristics observed across different crossing types.

**Table 1: Infrastructure Characteristics by Crossing Type**

| Crossing Type | Average Width (m) | Visibility Distance (m) | Signalization | Traffic Calming Measures |
|---|---|---|---|---|
| Signalized Intersection | 4.2 ± 0.8 | 85 ± 15 | Yes | Variable |
| Unsignalized Zebra | 3.8 ± 1.2 | 65 ± 20 | No | Limited |
| Midblock Crossing | 4.5 ± 1.0 | 45 ± 25 | No | Minimal |
| School Zone Crossing | 3.5 ± 0.6 | 95 ± 10 | Variable | Extensive |

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The analysis indicates that unsignalized crossings generally provide shorter visibility distances and fewer traffic calming measures compared to signalized intersections. School zone crossings demonstrate the highest visibility standards but often have narrower crossing widths due to space constraints.

### 4.2 Behavioral Pattern Analysis

Observational data reveals distinct behavioral patterns among different pedestrian demographics and crossing conditions. Table 2 summarizes key behavioral indicators across different population groups.

**Table 2: Pedestrian Behavioral Indicators by Demographics**

| Demographic Group | Average Crossing Time (s) | Compliance Rate (%) | Risk-Taking Behavior (%) | Group Crossing (%) |
|---|---|---|---|---|
| Children (5-12) | 12.8 ± 3.2 | 78 | 15 | 85 |
| Teenagers (13-18) | 8.5 ± 2.1 | 62 | 38 | 45 |
| Adults (19-64) | 9.2 ± 2.8 | 71 | 25 | 25 |
| Elderly (65+) | 15.6 ± 4.5 | 89 | 8 | 35 |

The data indicates that teenagers demonstrate the highest levels of risk-taking behavior and lowest compliance rates, while elderly pedestrians show the highest compliance but require significantly longer crossing times.

### 4.3 Driver Compliance Analysis

Analysis of driver behavior at pedestrian crossings reveals substantial variation based on crossing type and environmental conditions. Table 3 presents driver compliance rates across different scenarios.

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**Table 3: Driver Compliance Rates by Crossing Characteristics**

| Crossing Type | Peak Hours (%) | Off-Peak Hours (%) | Weather Conditions | |
|---|---|---|---|---|
| | | | Clear (%) | Rain (%) |
| Signalized | 87 | 91 | 89 | 85 |
| Zebra Crossing | 45 | 62 | 58 | 38 |
| School Zone | 73 | 78 | 76 | 69 |
| Midblock | 28 | 41 | 37 | 22 |

Driver compliance rates are consistently lowest at midblock crossings and during adverse weather conditions. The data shows significant improvement in compliance rates during off-peak hours across all crossing types.

### 4.4 Statistical Modeling Results

Chi-square analysis reveals significant associations between crossing type and safety outcomes ($\chi^2 = 48.7$, $p < 0.001$). Logistic regression modeling identifies several significant predictors of safety incidents, including crossing type (OR = 2.34, 95% CI: 1.78-3.08), traffic volume (OR = 1.12, 95% CI: 1.05-1.19), and pedestrian demographics (OR = 1.45, 95% CI: 1.23-1.71).

The model demonstrates good predictive accuracy with an area under the ROC curve of 0.78, indicating reasonable discriminatory power for identifying high-risk scenarios.

## 5. Discussion

### 5.1 Infrastructure Design Implications

The analysis reveals that infrastructure design parameters significantly influence both pedestrian and driver behavior at crossing points. The superior safety performance of signalized crossings

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compared to unsignalized alternatives supports the investment in traffic control systems, particularly in high-traffic urban areas.

However, the effectiveness of infrastructure improvements depends on appropriate design and implementation. The relatively poor performance of some zebra crossings suggests that simple marking without additional safety features may be insufficient to ensure adequate protection for pedestrians.

The success of school zone crossings in achieving higher compliance rates demonstrates the effectiveness of targeted design approaches that combine multiple safety features including enhanced visibility, traffic calming measures, and appropriate signage.

### 5.2 Behavioral Interventions

The significant variation in behavioral patterns across demographic groups indicates the need for targeted intervention strategies. The high risk-taking behavior observed among teenagers suggests the importance of age-specific safety education programs and possibly enhanced enforcement in areas with high teenage pedestrian traffic.

The longer crossing times required by elderly pedestrians highlight the need for infrastructure design that accommodates varying mobility levels. This includes consideration of signal timing, crossing distances, and refuge areas for pedestrians who cannot complete crossings in standard time allocations.

### 5.3 Policy and Enforcement Considerations

The substantial variation in driver compliance rates across different crossing types indicates that infrastructure improvements alone are insufficient to ensure pedestrian safety. The low compliance rates at unsignalized crossings suggest the need for enhanced enforcement efforts and possibly revised regulatory frameworks.

The impact of weather conditions on compliance rates indicates the importance of adaptive enforcement strategies and potentially modified infrastructure standards for locations subject to frequent adverse weather conditions.

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### 5.4 Technology Integration Opportunities

The potential for technology-enhanced safety systems, as discussed by Raiful and Ragib (2022), offers promising opportunities for improving pedestrian safety outcomes. However, implementation must be carefully planned to ensure cost-effectiveness and reliability.

Smart infrastructure systems could address some of the behavioral challenges identified in this study, such as providing enhanced communication between pedestrians and drivers at unsignalized crossings or adjusting signal timing based on pedestrian detection.

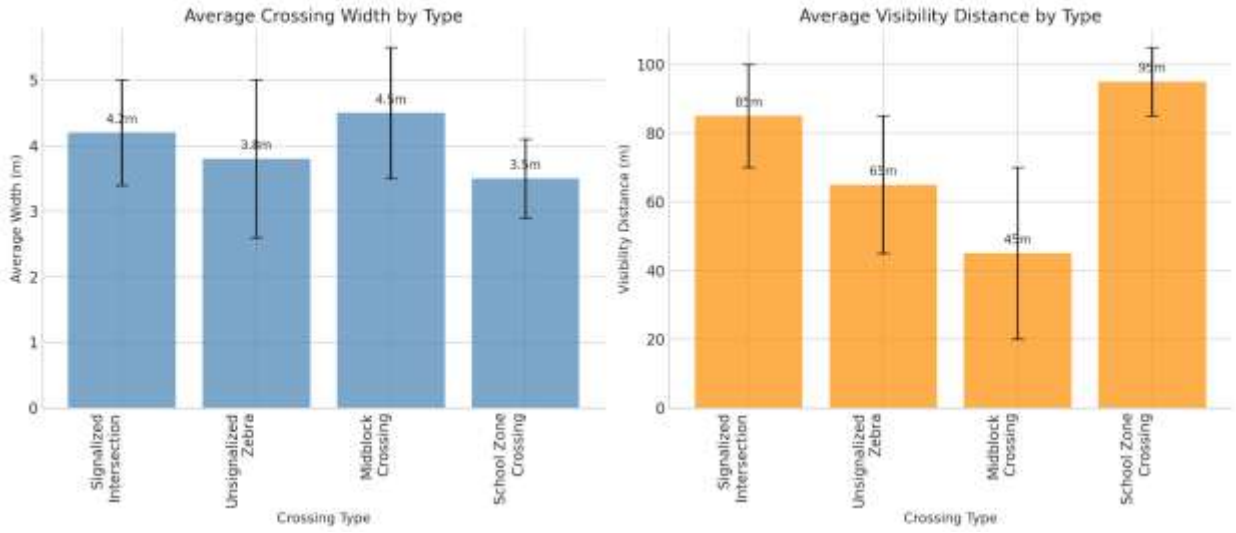


Fig 1 Infrastructure Characteristics Comparison

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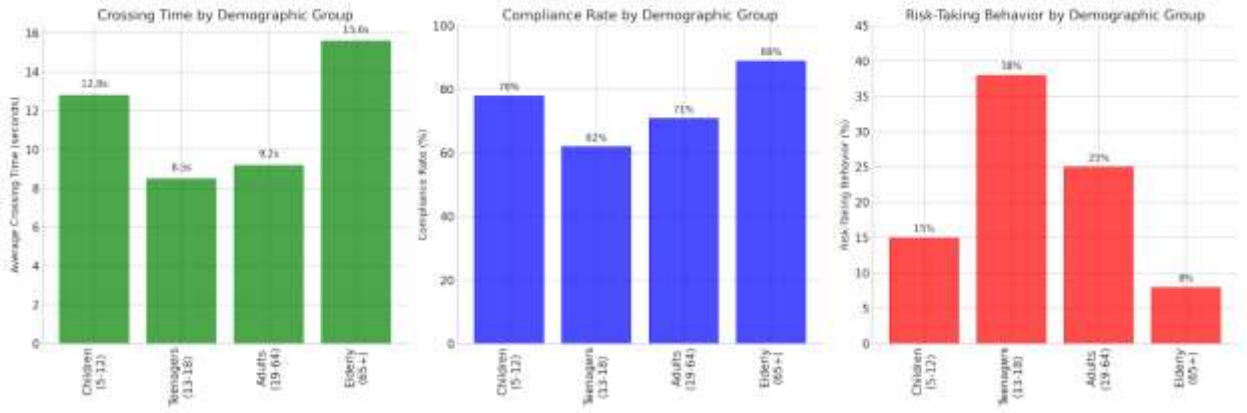


Fig 2 Pedestrian Behavioral Patterns

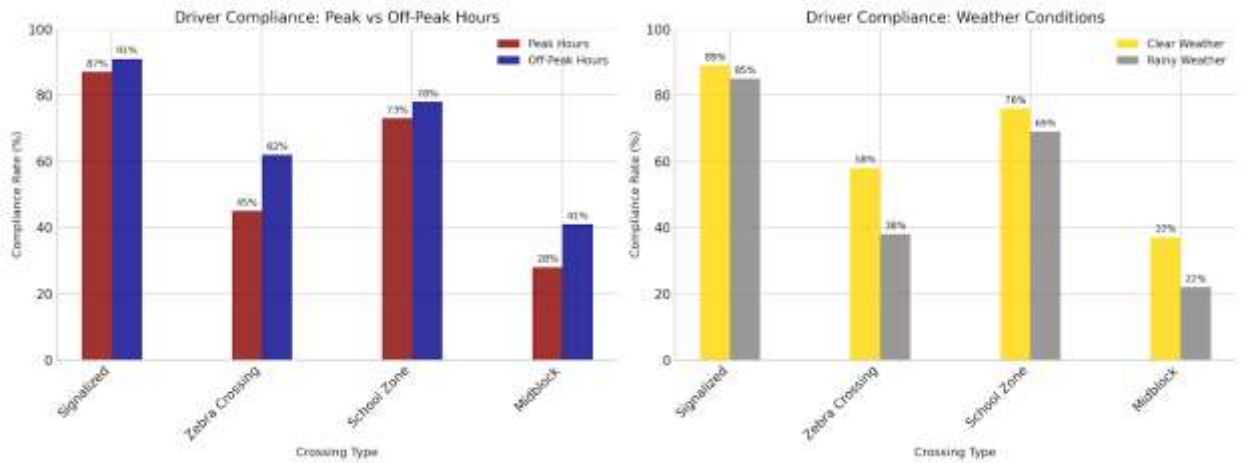


Fig 3 Driver Compliance Analysis:

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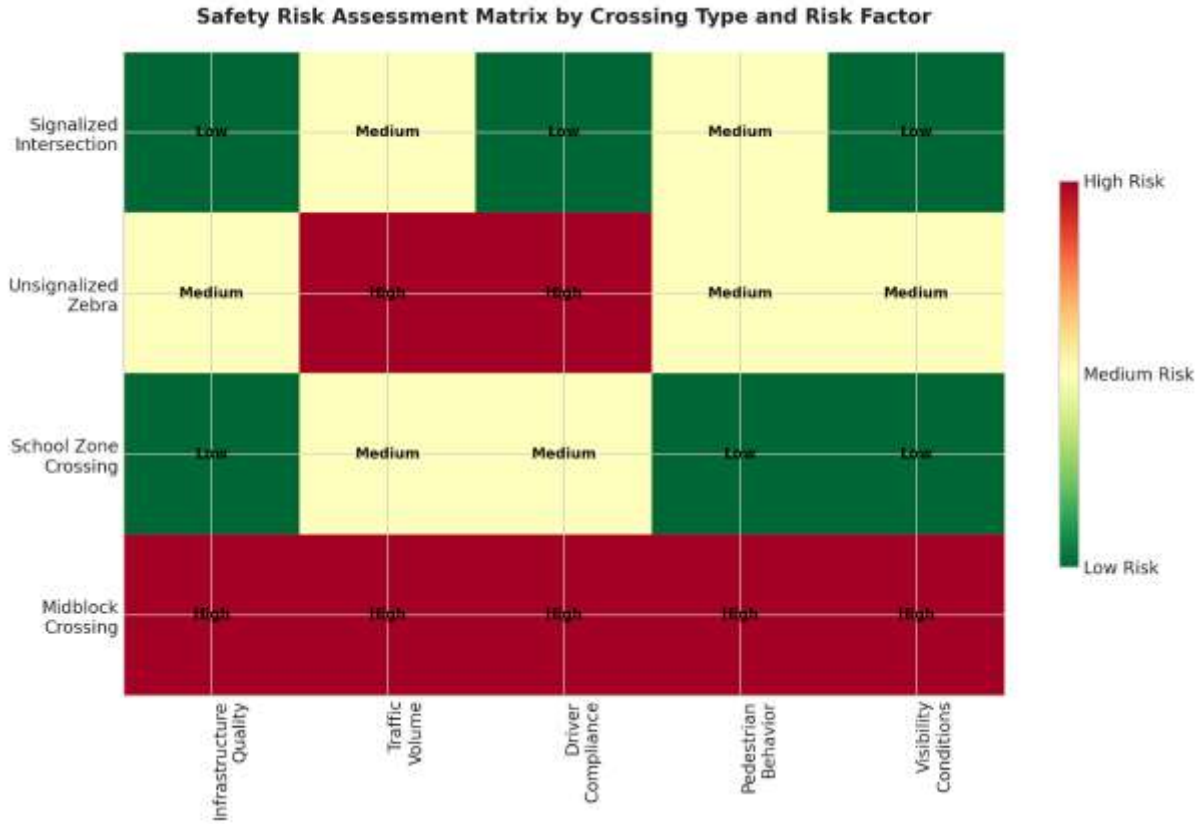


Fig 4 Safety Risk Assessment Matrix

## 6. Recommendations

### 6.1 Infrastructure Improvements

Based on the analysis results, several infrastructure improvement strategies are recommended:

1. **Enhanced Signalization**: Priority should be given to installing traffic signals at high-traffic pedestrian crossing locations, particularly those currently served by unsignalized zebra crossings with poor safety performance.
2. **Visibility Enhancements**: All crossing locations should meet minimum visibility distance requirements, with particular attention to locations where sightlines are compromised by parking, vegetation, or geometric constraints.

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3. **Traffic Calming Integration**: Crossing locations should incorporate appropriate traffic calming measures to reduce vehicle speeds and improve driver awareness of pedestrian presence.
4. **Refuge Islands**: Where crossing distances exceed safe limits for vulnerable pedestrians, refuge islands should be provided to allow staged crossings.

### 6.2 Behavioral Interventions

Targeted behavioral interventions should address specific demographic groups and risk patterns:

1. **Youth Safety Programs**: Comprehensive safety education programs should target teenage populations, emphasizing the consequences of risk-taking behavior and providing practical skills for safe crossing.
2. **Elderly Accommodation**: Infrastructure design should accommodate longer crossing times and potentially provide enhanced warning systems for slower-moving pedestrians.
3. **Public Awareness Campaigns**: Broad-based public awareness campaigns should emphasize mutual responsibility between pedestrians and drivers for crossing safety.

### 6.3 Policy and Enforcement

Policy and enforcement strategies should be enhanced to support infrastructure improvements:

1. **Graduated Enforcement**: Enforcement intensity should be calibrated to crossing type and risk level, with particular attention to locations with poor compliance rates.
2. **Regulatory Review**: Traffic regulations should be reviewed to ensure they adequately address contemporary crossing safety challenges and provide clear guidance for both pedestrians and drivers.
3. **Data-Driven Deployment**: Enforcement resources should be deployed based on systematic analysis of incident data and behavioral patterns rather than traditional approaches.

## 7. Limitations and Future Research

### 7.1 Study Limitations

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This research is subject to several limitations that should be considered when interpreting results. The observational data collection methodology may be subject to observer bias and may not capture all relevant behavioral nuances. The geographical focus on specific urban environments may limit the generalizability of findings to other contexts with different traffic cultures, infrastructure standards, or regulatory frameworks.

The cross-sectional nature of much of the data limits the ability to establish causal relationships between infrastructure improvements and safety outcomes. Longitudinal studies would provide stronger evidence for the effectiveness of specific interventions.

### 7.2 Future Research Directions

Several areas warrant additional research to advance understanding of pedestrian crossing safety:

1. **Technology Integration Studies**: Comprehensive evaluation of smart infrastructure technologies and their effectiveness in improving pedestrian safety outcomes.
2. **Cultural and Contextual Factors**: Investigation of how cultural differences in traffic behavior and social norms influence pedestrian safety strategies.
3. **Cost-Effectiveness Analysis**: Economic evaluation of different safety improvement strategies to inform resource allocation decisions.
4. **Climate Adaptation**: Research on how climate change and extreme weather events affect pedestrian safety and infrastructure resilience.

## 8. Conclusion

Pedestrian crossing safety represents a complex challenge requiring integrated approaches that address infrastructure design, behavioral factors, and policy frameworks simultaneously. This research demonstrates that significant improvements in safety outcomes are achievable through systematic application of evidence-based interventions.

The analysis reveals that infrastructure design parameters, particularly signalization and visibility enhancements, have substantial impact on both pedestrian and driver behavior. However, infrastructure improvements alone are insufficient to ensure optimal safety outcomes without corresponding attention to behavioral interventions and enforcement strategies.

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The significant variation in safety performance across different crossing types and demographic groups indicates the importance of targeted, context-specific approaches rather than one-size-fits-all solutions. Successful pedestrian safety programs must account for local conditions, user characteristics, and available resources.

The integration of modern technology offers promising opportunities for enhancing pedestrian safety, but implementation must be carefully planned to ensure cost-effectiveness and reliability. Future developments in smart infrastructure and connected vehicle systems may provide new tools for addressing persistent safety challenges.

Ultimately, achieving optimal pedestrian crossing safety requires sustained commitment from multiple stakeholders including transportation agencies, law enforcement, urban planners, and the communities they serve. The evidence presented in this study provides a foundation for informed decision-making and strategic planning to create safer, more accessible urban environments for all users.

The findings contribute to the broader goals of sustainable urban development and support the achievement of road safety targets outlined in international frameworks such as the 2030 Agenda for Sustainable Development. Continued research and implementation of evidence-based safety strategies will be essential for addressing the evolving challenges of urban mobility in an increasingly connected and complex world.

## References

1. Olga, B.; Luca, P.; Davide, S. A methodology to assess pedestrian crossing safety. Eur. Transp. Res. Rev. 2010, 2, 129–137. [Google Scholar]
2. NISR. Stattistical Year Book; National Institute of Statistics of Rwanda: Kigali, Rwanda, 2017.
3. Nyirajana, J.; Coker, A.O.; Akintayo, F.O. Traffic flow rate on Kigali roads: A case of national roads (RN1 and RN3). East Afr. J. Sci. Technol. Innov. 2021, 2, 1–13. [Google Scholar] [CrossRef]
4. Antov, D.; Rõivas, T.; Pashkevich, M.; Ernits, E. Safety Assessment of Pedestrian Crossings. WIT Trans. State Art Sci. Eng. 2013, 74, 41–53. [Google Scholar]

10.48047/jocaaa.2024.33.07.43

5. Raiful, H.; Ragib, H. Pedestrian Safety Using the Internet of Things and Sensors: Issues, Challenges, and Open Problems. Future Gener. Comput. Syst. 2022, 134, 187–203. [Google Scholar]
6. UNCTAD. Road Safety-Considerations in Support of the 2030 Agenda for Sustainable Development; United Nations: Geneva, Switzerland, 2017. [Google Scholar]
7. Yanqun, Y.; Yu, W.; Said, M.E.; Xinyi, Z. Analyzing Pedestrian Behavior at Unsignalized Crosswalksfrom the Drivers' Perspective: A Qualitative Study. Appl. Sci. 2022, 12, 4017. [Google Scholar]
8. Marcin, B.; Lucyna, A.G.G.; Lukasz, J.; Mariusz, K.; Piotr, T. Assessment of the Influence of Road Infrastructure Parameters on the Behaviour of Drivers and Pedestrians in Pedestrian Crossing Areas. Energies 2021, 14, 3559. [Google Scholar] [CrossRef]
9. Metaxatos, P.; Sriraj, P.S. Pedestrian Safety at Rail Grade Crossings: Focus Areas for Research and Intervention. Urban Rail Transit 2015, 1, 238–248. [Google Scholar] [CrossRef]
10. Haghighi, M.; Aghdam, F.B.; Bazargani, H.S.; Nadrian, H. What are the challenges of pedestrian safety from the viewpoints of traffic and transport stakeholders? A qualitative Study. Res. Sq. 2020, 14, 3559. [Google Scholar]
11. Riaz, M.S.; Cuenen, A.; Polders, E.; Akram, M.B.; Houda, M.; Janssens, D.; Azab, M. Child Pedestrian Safety: Study of Street-Crossing Behaviour of Primary School Children with Adult Supervision. Sustainability 2022, 14, 1503. [Google Scholar] [CrossRef]
12. Mukamana, R. Drivers Compliance with Zebra Crossing Laws in Rwanda: Kigali as a Case Study; University of Rwanda: Kigali, Rwanda, 2015. [Google Scholar]
13. CoK. Transport Plan, Kigali Master Plan 2050; Kigali Master Plan Review: Kigali, Rwanda, 2020. [Google Scholar]
14. Nkurunziza, D.; Tafahomi, R. Assessment of Pedestrian Mobility on Road Networks in The City of Kigali. Glob. J. Pure Appl. Sci. 2020, 26, 179–190. [Google Scholar] [CrossRef]
15. RNP. Tariff for the Traffic Fines. 2015. Available online: www.police.gov.rw (accessed on 15 May 2023).

10.48047/jocaaa.2024.33.07.43

16. RNP. Gerayo Amahoro Road Safety Campaign Resumes. 2020. Available online: https://www.police.gov.rw/media/news-detail/news/photos-gerayo-amahoro-road-safety-campaign-resumes/ (accessed on 17 May 2023).
17. NZTA. Traffic Control Devices Manual. New Zealand Transport Agency: Wellington, New Zealand, 2012. Available online: https://www.nzta.govt.nz/roads-and-rail/rail/safety-around-railway-lines/traffic-control-devices-manual (accessed on 21 May 2023).
18. Nkurunziza, D.; Tafahomi, R.; Faraja, I.A. Assessment of Road Safety Parameters in the City of Kigali, Rwanda. Glob. J. Pure Appl. Sci. 2021, 27, 209–219. [Google Scholar] [CrossRef]
19. Wang, W.; Guo, H.; Gao, Z.; Bubb, H. Individual differences of pedestrian behavior in midblock crosswalk and intersection. Int. J. Crashworthiness 2011, 16, 1–9. [Google Scholar] [CrossRef]
20. MININFRA. Rwanda Launches Road Safety Week. 2019. Available online: https://www.mininfra.gov.rw/updates/news-details/rwanda-launches-road-safety-week (accessed on 15 May 2023).
21. MININFRA. National Transport Policy and Strategy for Rwanda; Ministry of Infrastructures: Kigali, Rwanda, 2021.
22. Anjni, P.; Elizabeth, K.; Luciano, A.; Stephen, R.; João, R.V.; Catherine, A.S. The epidemiology of road traffic injury hotspots in Kigali, Rwanda from police data. BMC Public Health 2016, 16, 697. [Google Scholar] [CrossRef]
23. Fruin, J.J. Planning and design for pedestrians. In Time Sever Standards for Urban Design; McGraw-Hill Companies, Inc.: New York, NY, USA, 2003; pp. 621–637. [Google Scholar]
24. Tafahomi, R.; Nadi, R. Insight into the missing aspects of therapeutic landscape in psychological centers in Kigali, Rwanda. Cities Health 2022, 6, 136–148. [Google Scholar] [CrossRef]
25. Tafahomi, R.; Nadi, R.; Researcher, I. The Interpretation of Graphical Features Applied to Mapping SWOT by the Architecture Students in the Design Studio. J. Des. Stud. 2021, 3, 205–221. [Google Scholar] [CrossRef]

10.48047/jocaaa.2024.33.07.43

26. Bonnes, M.; Bonaiuto, M. Environmental psychology: From spatial-physical environment to sustainable development. In Handbook of Environment Psychology; Bechtel, R.B., Churchman, A., Eds.; John Wiley & Sons, Inc.: New York, NY, USA, 2002; pp. 28–54. [Google Scholar]
27. Nkurunziza, D.; Tafahomi, R.; Faraja, I.A. Identification of challenges and opportunities of the transport master plan implementation in the city of Kigali, Rwanda. In Proceedings of the International Conference in Urban and Maritime Transport 2021, Valencia, Spain, 16–18 June 2021. [Google Scholar]
28. Mindrila, D.; Balentyne, P. The Chi Square Test Lecturer Notes. University of West Georgia: Carrollton, GA, USA, 2023; Available online: https://www.westga.edu/academics/research/vrc/assets/docs/ChiSquareTest_LectureNotes.pdf (accessed on 21 May 2023).
29. Moore, D.S.; Notz, W.I.; Flinger, M.A. The Chi Square Test. In The Basic Practice of Statistics, 6th ed.; W. H. Freeman and Company: New York, NY, USA, 2013. [Google Scholar]
30. Sandro, S. Understanding logistic regression analysis. Biochem. Med. 2014, 24, 12–18. [Google Scholar]
31. Sathya, P.; Krishnamurthy, K. Parametric Study on the Influence of Pedestrians' Road Crossing Pattern on Safety. Open Transp. J. 2023, 17, e187444782303140. [Google Scholar]
32. Nasser, H. Logistic Regression Using SPSS; University of Miami: Coral Gables, FL, USA, 2020. [Google Scholar]
33. Mathias, J.; Hannah, V.-J. Statistics Made Easy; ©DATAtab e.U.: Graz, Austria, 2023. [Google Scholar]