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Sustainable road mobility and safety in urban areas: risk assessment of urban bicycle-car transport systems

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Abstract

This paper addresses the problem of sustainable road mobility and transport safety in four Polish cities of different sizes and characteristics: Krapkowice, Opole, Wrocław and Warsaw. The aim of the study was to assess the level of risk in selected urban transport systems and to identify the main hazards affecting the development of safe and sustainable mobility. The research applied a mixed-method approach combining official road incident data with an online survey conducted among urban transport users. The analysis covered drivers, cyclists, pedestrians and passengers, and included hazards related to infrastructure quality, traffic organisation, user behaviour, visibility and weather conditions. Risk was assessed using a Preliminary Hazard Analysis (PHA) framework based on probability and severity values. The results showed that the most significant risks were associated with poor road signage, excessive speed, traffic congestion, non-compliance with traffic regulations and aggressive road-user behaviour. In the cycling dimension, the lack of dedicated cycle infrastructure emerged as the most critical hazard. The study concludes that improving sustainable urban mobility requires integrated actions in infrastructure, speed management, cycling safety and intelligent traffic management.

Keywords: urban mobility; road transport safety; risk assessment; sustainable cities; traffic hazard

1 Introduction

Urban mobility is a key component of sustainable city development because it affects accessibility, environmental performance, quality of life and public safety. Although cities increasingly promote public transport, walking and cycling, road mobility still plays a dominant role in everyday urban travel and remains essential for commuting, logistics and access to services. For this reason, the safety of urban road systems continues to be one of the core challenges of sustainable transport policy.

At the same time, urban road transport is exposed to multiple interacting risk factors, including growing traffic volumes, infrastructural deficiencies, weather-related disturbances and unsafe behaviour of road users. These problems affect drivers, cyclists, pedestrians and passengers, and their intensity may differ between smaller and larger cities. As a result, the assessment of urban mobility should include not only transport efficiency and environmental goals, but also structured identification of safety-related hazards. Recent studies confirm that sustainable urban mobility should be understood as a coordinated system of infrastructure, behaviour, governance and digital management rather than as a simple modal shift strategy (Anastasiadou & Kehagia, 2025; Iannacci et al., 2025; Gulc & Budna, 2023). Despite the growing literature on smart and sustainable mobility, fewer studies directly combine this perspective with a comparative risk assessment of urban road transport systems in Polish cities of different sizes [Tang et al., 2020; Sudhakaran et al., 2025; Wawer et al., 2022].

Therefore, the aim of this paper is to assess the level of risk in selected urban transport systems and to identify the main hazards affecting safe and sustainable road mobility in four Polish cities: Krapkowice, Opole, Wrocław and Warsaw. In this way, the paper links road safety analysis with the broader perspective of sustainable urban mobility and provides a basis for practical recommendations for urban transport policy. The scientific contribution of the study lies in combining official incident data with user-perceived hazard severity within a single probability-severity framework applied to urban bicycle-car mobility. This makes it possible to identify not only highly severe hazards, but also those that occur frequently enough to become systemically critical for sustainable urban transport planning.

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2 Literature background

Sustainable urban mobility is increasingly understood as a multidimensional concept that combines environmental, social, economic and safety-related objectives. In this perspective, urban transport systems should not only reduce emissions and improve accessibility, but also minimise exposure to accidents, congestion and other operational disruptions. Recent studies emphasise that safe mobility is an integral part of sustainable urban development and should be considered together with infrastructure quality, transport organisation and user behaviour.

Current literature also highlights the growing importance of smart mobility and data-based transport management. This perspective is also supported by studies showing that smart mobility solutions, including ICT-based traffic management and Intelligent Transport Systems, can improve both transport efficiency and urban safety when integrated with broader sustainability goals (Wawer et al., 2022; Wolniak, 2023; Hawlena-Gądek & Wróbel, 2020). In this sense, sustainable mobility should be treated as a system-level challenge involving infrastructure, technology, governance and risk mitigation (Anastasiadou and Kehagia 2025; Iannacci et al. 2025; Wawer et al. 2022; Wolniak 2023).

Another important strand of research concerns resilience and structured transport risk assessment (Pokorny, P. & Pitera, K. 2019; Vanparijs, J.; Panis, L.I.; Meeusen, R. et.al. 2015; Reynolds, C.C., Harris, M.A., et al. 2009; Prati, G., Marín Puchades, V., et.al. 2018; Cantisani, G., Moretti, L., & De Andrade Barbosa, Y. 2019; Pearson, L., Berkovic, D., et.al. 2023; Alonso-Almeida, M. d. M. 2022; Sawhney, N. 2023. Recent studies indicate that urban mobility systems should be evaluated not only in terms of traffic performance, but also in relation to their ability to withstand disruptions, maintain safe operation and adapt to changing conditions. However, despite the growing literature on smart and sustainable mobility, fewer studies directly combine this perspective with comparative risk assessment based on specific urban road hazards and their severity. This is particularly visible in studies concerning Polish cities of different sizes (Hawlena-Gądek and Wróbel 2020; Sudhakaran et al. 2025; Bustos et al. 2021; Tang et al. 2020; Sales et al. 2024; Antczak and Wiaderny 2024; Gulc and Budna 2023).

Therefore, the present study adopts a risk-based perspective on sustainable road mobility and links official road incident data with user perceptions of safety. This approach makes it possible to identify critical hazards affecting different dimensions of urban transport and to interpret transport safety not only as a technical issue, but also as a strategic condition of greener, safer and more resilient cities.

3 Materials and methods

3.1 Research design, Study area and empirical material

The study adopted a mixed-method research design combining qualitative and quantitative elements. The analytical framework integrated three complementary components: (1) a review of the literature on sustainable urban mobility, road safety and transport risk, (2) secondary statistical data on road incidents and accident causes, and (3) primary empirical data collected through an online questionnaire addressed to urban road users. In the source material, the temporal scope of the study was defined as the period from June 2024 to January 2025, while the spatial scope covered four Polish cities differing in size and transport characteristics: Krapkowice, Opole, Wrocław and Warsaw. The subject scope included drivers, pedestrians, cyclists and passengers, and the object scope covered such elements as road safety, road and cycling infrastructure, signage, lighting, traffic organisation and user behaviour.

The research logic was sequential and consisted of five stages. First, the study area and the catalogue of urban transport hazards were defined on the basis of literature and the substantive assumptions of the project. Second, official road safety statistics were collected and organised in order to identify the empirical frequency of selected accident causes and traffic-related events. Third, an online survey was carried out among users of the transport systems in the analysed cities in order to capture the perceived severity of individual hazards. Fourth, both data streams were integrated in a matrix-based Preliminary Hazard Analysis (PHA), where probability and severity were combined into a synthetic risk value. Fifth, the results were interpreted in the context of sustainable mobility and used to formulate practical recommendations for urban transport policy.

The empirical material covered four cities representing different urban scales and transport conditions. Krapkowice represented a smaller urban centre with a population of 15,282; Opole represented a regional capital with 126,077 inhabitants; Wrocław represented a large metropolitan city with 669,564 inhabitants; and Warsaw represented the capital city with 1,862,402 inhabitants. This configuration was adopted in order to compare risk patterns in cities characterised by different traffic volumes, levels of infrastructural complexity and degrees of transport-system maturity.

Two basic groups of empirical material were used. The first group consisted of official road safety statistics, described in the source study as police data on accidents, collisions, dangerous locations and accident causes, including weather-related factors. These data formed the basis for estimating the probability of occurrence of selected hazards. The second group consisted of questionnaire data collected using Google Forms. In the source material, the questionnaire was described as containing 19 questions, including closed-ended questions, open-ended questions and demographic items. At the same time, the working dataset used for risk calculations was more detailed and operationalised the survey in three matrix blocks covering hazards related to general road transport, cycling and car transport.

3.2 Survey procedure and sample selection

The survey was conducted online using Google Forms and distributed among users of urban transport systems in the four analysed cities. From a methodological point of view, the sampling procedure should be described as non-probability purposive-convenience sampling with a territorial criterion. In practice, this means that respondents were intentionally recruited from the selected cities, but participation depended on voluntary response to the online questionnaire. Such a procedure is appropriate for exploratory urban mobility studies, especially when the aim is to compare perceived safety problems across cities and user groups rather than to estimate population parameters with full statistical representativeness.

The selection procedure can be reconstructed step by step as follows. First, the authors defined the four cities to be included in the analysis. Second, the questionnaire was prepared in an online form and structured around a predefined list of transport hazards. Third, the link to the questionnaire was distributed to potential respondents representing different categories of road users. Fourth, the returned questionnaires were verified and aggregated into a final analytical dataset. Fifth, descriptive statistics were calculated and then used as the basis for the severity assessment in the PHA matrix. The basic characteristics of the sample and the analysed cities are presented in Table 1.

Table 1. Sample and city characteristics

Category	Variable	Value
Survey sample	Total number of respondents	**568**
Age structure	Below 18 years / 18-26 years / 27-35 years / Above 36 years	**5% / 57% / 21% / 17%**
Gender	Women / Men	**58% / 42%**
City-specific sample parameters	Krapkowice / respondents (n) / population / confidence level / maximum error	**19% / 15,282 / 95% / 9%**
	Opole / respondents (n) / population / confidence level / maximum error	**21% / 126,077 / 95% / 9%**
	Wrocław / respondents (n) / population / confidence level / maximum error	**27% / 669,564 / 95% / 8%**
	Warsaw / respondents (n) / population / confidence level / maximum error	**33% / 1,862,402 / 95% / 7%**

Source: Own elaboration based on the survey results and the adopted study area.

The source material also included a simple sample-size adequacy check for each city at a 95% confidence level and an assumed fraction of 0.5. The reported maximum sampling error was 9% for Krapkowice, 9% for Opole, 8% for Wrocław and 7% for Warsaw. These values confirm that the empirical material should be treated primarily as exploratory and comparative rather than fully representative, especially in relation to the larger cities. For this reason, the conference version of the paper should avoid overgeneralisation and instead emphasise pattern identification and relative comparison of risk factors.

3.3 Structure of the research instrument

The questionnaire was designed to capture both the behavioural and infrastructural dimensions of urban mobility risk. In its analytical form, the instrument included three hazard blocks assessed on a five-point Likert scale, where 1 indicated a low impact on danger and 5 indicated a high impact on danger. The first block referred to general road transport risk in the city and included 30 hazards. The second block referred to cycling-related risk and also included 30 hazards. The third block referred to car-transport risk and again included 30 hazards. In total, the analytical matrix covered 90 hazard indicators, supplemented by questions on transport habits, perceived road safety, congestion, parking accessibility, visibility, infrastructure quality and basic socio-demographic characteristics. The questionnaire also included open questions that allowed respondents to indicate additional hazards not included in the predefined catalogue.

In addition to the hazard blocks, the survey included behavioural and contextual questions. The source material shows that 67% of respondents used road transport daily, 24% several times a week, 5% several times a month, and 4% declared that they did not use it regularly. This is important for interpreting the survey results, because the sample was composed mainly of frequent users of urban road systems and therefore reflected everyday mobility experience rather than incidental contact with transport infrastructure.

3.4 Operationalisation of variables

The key methodological assumption was that urban transport risk can be expressed as a function of two components: the probability of occurrence of a given hazard and the severity of its consequences. Accordingly, the study used the classical relation:

$$R = P \times S \qquad (1)$$

where R is the risk level, P is the probability score, and S is the severity score. The risk assessment was carried out using a five-level scale for both probability and severity, which produced a theoretical risk range from 1 to 25.

The severity component (S) was derived directly from the survey results. For each hazard, the average score assigned by respondents was calculated, and the result was rounded to two decimal places. In the source study, this was described as the weighted average of the ratings assigned to a given factor. In practice, this means that hazards perceived by respondents as more dangerous obtained higher severity values. For example, in the working calculation sheets, selected road-transport hazards obtained severity values close to the upper part of the scale, such as 3.97 for non-compliance with traffic rules, 3.89 for excessive speed and 4.07 for driving under the influence of alcohol or drugs.

The probability component (P) was based on official incident statistics. In the working analytical tables, the number of occurrences of a given event or cause was first related to the total number of recorded cases in the reference dataset, and this proportion was then transformed onto a 1-5 scale. Next, a discrete probability class was assigned for use in the risk matrix. This procedure allowed the model to connect empirical event frequency with perceived hazard severity. As a result, hazards such as poor road signage, excessive speed or congestion obtained higher probability classes than rare technical or incidental events. The approach therefore combined objective occurrence patterns with subjective safety perception.

3.5 PHA risk assessment procedure

The final stage of the methodology was the application of Preliminary Hazard Analysis (PHA), understood in the source material as a matrix-based and inductive method used for qualitative risk estimation. The practical procedure consisted of six steps. First, the analytical scope was defined, including the transport environment and the list of hazards. Second, all relevant hazards were identified and grouped into thematic categories such as infrastructure, visibility, weather, traffic organisation and user behaviour. Third, each hazard was assigned a probability value (P) based on official statistics. Fourth, each hazard was assigned a severity value (S) based on survey responses. Fifth, the final risk value (R) was calculated as the product of P and S and then positioned in a matrix. Sixth, the matrix was interpreted in order to identify hazards requiring priority intervention.

The matrix layout was standardised. The horizontal axis represented probability (P = 1-5), while the vertical axis represented severity (S = 1-5). Each cell of the matrix represented the product of these two dimensions. In interpretative terms, lower values represented acceptable or low-priority risks, while higher values represented significant or critical risks that should be addressed first in transport policy and infrastructure planning. This structure enabled the comparison of risks not only across hazard categories, but also across transport modes.

3.6 Analytical output and interpretation

The methodology generated three parallel sets of results: one for general road transport risk, one for cycling risk and one for car-transport risk. For each set, separate tables were prepared for probability, severity and final risk values, followed by a risk matrix. In the road-transport block, the highest risk values in the working tables were associated with such hazards as poor road signage (R = 16.10), excessive speed (R = 15.56), traffic congestion / excessive number of vehicles (R = 12.52) and non-compliance with traffic rules (R = 11.91). In the cycling block, particularly high values were obtained for lack of dedicated cycle paths, excessive vehicle speed and unsafe driver behaviour toward cyclists. This demonstrates that the analytical procedure was able to identify not only general safety deficits, but also mode-specific threats relevant to sustainable urban mobility.

3.7 Methodological limitations

From the perspective of scientific transparency, several limitations should be stated explicitly. First, the survey sample was unevenly distributed across cities which reduces the comparability of city-specific results. Second, the online form and voluntary participation introduced self-selection bias. Third, the severity component reflected perceived risk rather than directly measured accident consequences. Fourth, the study should be interpreted as exploratory because the maximum sampling error reported for the larger cities remained high. Nevertheless, the combination of official statistics and user perceptions considerably strengthens the analytical value of the study and makes the results useful for diagnosis and planning in the field of sustainable and safe urban mobility.

4 Results

The results indicate that the analysed urban transport systems are affected by recurring behavioural, infrastructural and organisational hazards. Across the four cities, the most important risks were associated with excessive speed, poor road signage, congestion and non-compliance with traffic regulations. These factors appeared consistently in both the general road transport and car transport dimensions, which suggests that the main safety deficits are systemic rather than incidental.

4.1 General road transport risk

In the general road transport block, the highest risk values were recorded for poor road signage (R = 16.10), excessive speed (R = 15.56), traffic congestion / excessive number of vehicles (R = 12.52), non-compliance with traffic rules (R = 11.91) and aggressive or inappropriate driver behaviour (R = 11.67). These results indicate that the most critical risks in urban road mobility result from the combined influence of infrastructural deficiencies and unsafe user behaviour.

The severity assessment showed that the most dangerous factors in perceived terms included driving under the influence of alcohol or drugs (S = 4.07), non-compliance with traffic rules (S = 3.97) and excessive speed (S = 3.89). However, the final risk ranking shows that frequent hazards such as signage problems and congestion may be more important at the system level than less frequent but highly severe events.

4.2 Cycling-related risk

In the cycling dimension, the highest overall risk value was assigned to lack of dedicated cycle paths (R = 17.95). Other major hazards included excessive speed of motor vehicles (R = 14.40), unsafe driver behaviour toward cyclists (R = 11.61) and unsafe behaviour of other cyclists (R = 11.16). This pattern shows that cycling safety depends primarily on infrastructure continuity and the quality of interactions between cyclists and motorised traffic.

The highest perceived severity values were associated with unsafe driver behaviour toward cyclists (S = 3.87), pedestrians entering cycle paths (S = 3.86) and excessive vehicle speed (S = 3.60). The results suggest that the development of cycling as a sustainable urban mode is still limited by both physical and behavioural barriers

4.3 Car transport risk

The car transport block showed a similar structure to the general road transport results. The highest risk values were recorded for poor road signage (R = 16.55), excessive speed (R = 15.88), traffic congestion / excessive number of vehicles (R = 13.08), non-compliance with traffic rules (R = 11.97) and aggressive driver behaviour (R = 11.58). In addition, adverse weather conditions such as rain, snow or fog reached a relevant risk level (R = 10.08).

The perceived severity scores were highest for driving under the influence of alcohol or drugs (S = 4.06), non-compliance with traffic rules (S = 3.99) and excessive speed (S = 3.97). This confirms that car-based urban mobility is affected by both direct behavioural threats and wider operating conditions that reduce safety and travel predictability.

4.4 Synthesis of results in the context of sustainable urban mobility

When the three analytical blocks are considered together, three conclusions emerge. First, unsafe user behaviour remains a critical risk category across all transport dimensions, especially in relation to speeding and failure to comply with traffic rules. Second, infrastructure deficits play a major role, particularly in relation to road signage and cycling infrastructure. Third, congestion and weather conditions increase the background level of transport risk and may intensify the effects of other hazards. The most critical hazards identified in the study are summarised in Table 2

Table 2. Top-ranked transport risks identified in the PHA assessment

Transport dimension	**Hazard**	**Probability (P)**	**Severity (S)**	**Risk level (R = P × S)**
General road transport	Poor road signage	5	3.22	**16.10**
	Excessive speed	4	3.89	**15.56**

	Traffic congestion / excessive number of vehicles	4	3.13	**12.52**
	Non-compliance with traffic rules	3	3.97	**11.91**
	Aggressive / inappropriate driver behaviour	3	3.89	**11.67**
Cycling transport	Lack of dedicated cycle paths	5	3.59	**17.95**
	Excessive speed of motor vehicles	4	3.60	**14.40**
	Unsafe driver behaviour toward cyclists	3	3.87	**11.61**
	Unsafe behaviour of other cyclists	3	3.72	**11.16**
Car transport	Poor road signage	5	3.31	**16.55**
	Excessive speed	4	3.97	**15.88**
	Traffic congestion / excessive number of vehicles	4	3.27	**13.08**
	Non-compliance with traffic rules	3	3.99	**11.97**
	Aggressive / inappropriate driver behaviour	3	3.86	**11.58**

Source: Own elaboration based on the PHA risk assessment results.

The results therefore confirm that sustainable urban mobility cannot be treated solely as a matter of modal shift or technological modernisation. In the analysed cities, the ability to create greener and more resilient transport systems depends directly on reducing those risks that discourage safer behaviour, undermine active mobility and generate instability in daily urban travel. In practical terms, the findings point toward the need for combined interventions in traffic calming, signage quality, cycling infrastructure, intersection safety, lighting and user education.

5 Discussion

The results show that sustainable urban mobility in the analysed cities is strongly influenced by the interaction of behavioural, infrastructural and organisational factors. The identified risk structure indicates that urban safety problems do not result from isolated events, but from recurring conditions embedded in the daily functioning of transport systems. In this context, sustainable mobility should be understood not only as a matter of reducing emissions or promoting alternative modes, but also as the ability to provide predictable, safe and low-conflict movement for different user groups. A particularly important finding is the dominant role of behavioural risk. Excessive speed, non-compliance with traffic regulations and inappropriate driver behaviour ranked among the most critical hazards in both the general road transport and car transport dimensions (Iannacci, Chari &Papagiannidis 2025; Bokolo 2025). This suggests that even where infrastructure improvements are introduced, their effects may remain limited if they are not accompanied by speed management, enforcement and user-oriented safety measures. Behaviour therefore appears as a central factor shaping both perceived and actual transport risk.

The identified pattern is consistent with recent studies indicating that urban mobility safety depends on the combined influence of infrastructure, regulation, user behaviour and adaptive transport management rather than on isolated corrective measures (Anastasiadou & Kehagia, 2025; Iannacci et al., 2025).

The study also confirms the structural importance of infrastructure quality. Poor road signage was one of the highest-ranked hazards in road and car transport, while the lack of dedicated cycle paths emerged as the most critical problem in the cycling dimension. These findings indicate that infrastructure deficiencies reduce the legibility (Sudhakaran et al. 2025; Elassy at. al. 2024; Magkafas et al. 2025), continuity and safety of urban mobility systems. In particular, the cycling-related results suggest that active mobility cannot develop effectively where cyclists remain exposed to mixed traffic without adequate spatial protection. Another important issue is the role of congestion and adverse operational conditions (Anastasiadou and Kehagia 2025; Likewise, Jurak et al. 2025). Traffic congestion was among the most significant risks in the motorised transport dimensions, while weather and visibility-related factors increased the background level of vulnerability. This means that urban transport risk should be interpreted more broadly than accident occurrence alone. Conditions that reduce flow stability, increase stress and lower route predictability may also weaken the overall sustainability of urban mobility by discouraging safer and more efficient travel choices (Jurak et al. 2025; Tang et al. 2020). This is particularly important in the case of cycling, where the absence of continuous and protected infrastructure may limit both actual safety and the willingness to choose active mobility in everyday travel (Sudhakaran et al., 2025; Bustos et al., 2021).

From a practical perspective, the findings indicate that effective risk reduction requires integrated action rather than isolated interventions. Measures aimed only at infrastructure modernisation, behavioural education or traffic control are unlikely to be fully effective when implemented separately. The results point instead to the need for combined policies linking clearer road organisation, safer street design, speed reduction, better cycling conditions and more responsive traffic management.

At the same time, the study should be interpreted as an exploratory comparative diagnosis. The uneven city distribution of respondents and the survey-based severity assessment limit the possibility of strong generalisation at the city level. Nevertheless, the applied framework made it possible to identify critical hazard patterns and to distinguish between highly severe and highly frequent risks. This gives the study practical value for urban transport planning and provides a useful basis for more detailed future analyses.

6 Conclusions

The main objective of this study was to determine the level of road transport risk in selected Polish cities and to indicate actions that could improve safety and the overall functioning of urban mobility systems. This objective was achieved through the integration of official road incident data, survey responses collected from road users and a matrix-based PHA assessment applied to four cities differing in size and transport characteristics: Krapkowice, Opole, Wrocław and Warsaw. The adopted research design made it possible to identify the most important categories of transport hazards and to assess them not only in terms of occurrence, but also in relation to their perceived severity.

The results showed that the most significant threats to safe and sustainable urban road mobility were related to excessive speed, poor road signage, congestion, non-compliance with traffic regulations and inappropriate behaviour of road users. In the cycling dimension, the lack of dedicated cycle infrastructure emerged as the most critical factor, which indicates that the development of active mobility still faces structural barriers in the analysed urban environments. The findings also suggest that urban transport risk is shaped not by a single isolated factor, but by the cumulative interaction of infrastructure deficits, behavioural problems and traffic pressure. This gives the study practical value, because it points to areas where interventions may generate simultaneous safety and mobility benefits.

An important conclusion of the study is that improving urban transport safety requires a combined rather than fragmented approach. Measures focused only on infrastructure, only on education or only on traffic regulation are unlikely to produce sufficiently durable effects when implemented separately. The identified risk structure indicates that cities should simultaneously improve the readability and quality of road infrastructure, reduce exposure to speed-related hazards, support safer conditions for cyclists and strengthen traffic management in areas affected by recurrent congestion. In this sense, the study confirms that road safety should be treated as an integral part of sustainable urban mobility planning rather than as a separate technical issue.

At the same time, the results should be interpreted with caution due to several methodological limitations. First, the survey component had an exploratory character and was based on voluntary online participation. Second, the distribution of respondents between cities was uneven, with a clear predominance of one local group, which limits the strength of direct inter-city comparisons. Third, the severity component of the assessment reflected perceived risk rather than direct clinical, social or economic consequences of specific incidents. Finally, the analytical model simplified complex urban transport conditions into a probability-severity framework, which is methodologically useful for comparison and prioritisation, but does not capture all contextual dependencies of real traffic systems.

These limitations open several directions for further research. Future studies should use larger and more balanced samples for each city in order to improve the comparative value of the results. It would also be beneficial to extend the analysis with spatial methods, especially GIS-based identification of high-risk locations, and with longitudinal data that would allow changes in transport risk to be tracked over time. Another important direction would be to differentiate more precisely between user groups and travel purposes, for example by separating daily commuters, cyclists, pedestrians and public transport users in greater analytical detail. Further research could also examine the impact of specific interventions, such as traffic calming, ITS implementation, cycling-network expansion or parking-policy changes, on both objective safety indicators and perceived mobility quality.

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