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Understanding the Factors Affecting Traffic Danger for Children: Insights From Focus Group Discussions

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Abstract

Children's safety on urban roads is a critical concern with young pedestrians and cyclists being among the most vulnerable groups to traffic-related dangers. The prioritization of motor vehicle traffic in road infrastructure poses significant risks to child pedestrians and cyclists navigating city streets. Furthermore, children's independent mobility has been restricted due to traffic danger and their parents' concerns about it. Given the important implications of this issue, a serious gap was identified in that no measure of traffic danger exists, with outcomes (e.g., collisions) being used as a proxy. Identifying factors contributing to traffic danger, how they interact, and how they impact traffic are imperative to identify where mitigation is needed to address these problems. This article delves into the complexities of traffic risks for children, focusing on intersections and streets. Six focus groups, including experts (n = 3), parents (n = 2), and children aged 8 to 12 (n = 1), were conducted to gather insights on factors impacting traffic danger. Thematic analysis revealed eight key themes, highlighting the importance of addressing traffic volume, speed, vehicle size, road design, driver behavior, visibility, and land use. These findings contribute to a comprehensive framework for understanding traffic danger for children. Additionally, the article examines how stakeholders' perspectives align with standard measures of traffic danger in the literature.

Keywords

children; focus group; qualitative analysis; traffic danger

1. Introduction

Children's traffic safety is of great importance as traffic fatalities continue to be a primary cause of death (WHO, 2023). Young pedestrians and cyclists are particularly vulnerable to traffic danger, so all factors contributing to the problem need to be examined (Cloutier et al., 2021). It is important to note that generally two types of research have been conducted on traffic danger for children (Amiour et al., 2022): the first examines the relationship between traffic and context (including road characteristics, land-use, etc.) on child pedestrian and bicycle collisions (objective safety); the second examines the perception of danger by parents and children for active transportation (subjective/perceived danger) which often limits their right to independent travel. However, although associations between various factors and *outcomes* of traffic danger (e.g., collisions, injuries, death) exist, no measure of traffic danger exists. Without a measure of the problem, we must rely on (thankfully) infrequent occurrences such as collisions as a proxy. This is akin to measuring weight gain (an outcome), but not having a measure that relates to what causes it (e.g., calories, physical activity). Further, it relies on exposure in that if children are removed from such dangerous locations a collision cannot happen. It is not that the street or intersection is safe, but that it is so dangerous that children's right to travel has been eliminated (similar arguments can be seen in the work by Hillman et al., 1990).

Research on traffic danger primarily focuses on adult safety and neglects children's needs and particular characteristics. In previous studies, the primary focus has been on experts' perspectives regarding traffic danger often neglecting the viewpoints of children and their parents. This article presents the perspective of experts and the perceptions of parents and children on traffic danger in order to identify criteria that should be considered when developing a measure of traffic danger. A qualitative approach is taken to better understand the complexities of traffic danger for children. The insights derived from focus group discussions are used here to unravel the complexities surrounding this issue and to better understand the traffic danger imposed on children. It should be noted that this research is part of a larger project that will develop a multi-criteria-decision-aiding tool for assessing traffic danger in cities that considers children as residents with the right to independent travel.

2. Literature Review

Traffic danger is a significant concern for public health with millions of fatalities globally each year with children being particularly vulnerable. In Canada, it resulted in 1,768 deaths in 2021 (Transport Canada, 2021). Among these fatalities, 15.8% were pedestrians and 6.7% were youths aged 4–19. Besides physical harm, traffic danger also restricts children's independent mobility, impacting their societal participation (Mitra, 2013). Understanding the factors that create traffic danger is crucial (Xu et al., 2020).

There are several factors that influence traffic danger, including the built environment, infrastructure design, and traffic characteristics. Some examples are traffic volume, speed, and presence of conflict points resulting from street design (Smith et al., 2020). Recent reviews have shown that the built environment significantly influences children's collision risk (Abdollahi et al., 2023; Amiour et al., 2022; Cloutier et al., 2021; S. Richmond et al., 2022). Factors such as pedestrian density, road density, crossing major roads, and mixed land use all affect injury frequency. Additionally, the design of intersections, the presence of pedestrian crossings, and the availability of safe footpaths are crucial elements that impact children's traffic safety. For instance, S. Richmond

et al. (2022) concluded that road features like traffic calming measures, adequate lighting, and proper signage can significantly mitigate traffic danger for children.

Many studies in the field of child pedestrian safety have overlooked the perspectives of children themselves concerning their own safety. Including children's perspectives in safety research is important, as their unique viewpoints can contribute to a more comprehensive understanding of traffic safety and hazard identification (Meir et al., 2015).

Studies indicate that children's active mobility is shaped by parental views on traffic safety and neighborhood conditions (Mitra et al., 2014). In Australia, focus group discussions with children and parents underscored the importance of family routines, neighborhood characteristics, social norms, and safety in shaping independent mobility experiences (Crawford et al., 2017). That research identified traffic danger as a key concern by parents, but did not investigate what exactly is traffic danger from their perspective or from the children's perspective. Although traffic danger is often given as a reason to restrict children's independence, the factors driving parental perceptions of traffic danger remain inadequately explored. Research has identified disparities between objective traffic danger measures and the perceptions of parents and children revealing a gap in understanding (Amiour et al., 2022).

The complexity of traffic danger for children is evident in the literature (Yannis et al., 2020). However, knowledge on children's and parents' perspectives typically only mentions traffic danger without much nuance. Further, studies on traffic danger focus on the outcomes such as collisions or training children to deal with traffic (Miskolczi et al., 2023), but not on what creates traffic danger. When examining such an issue it is important to include the individual directly impacted, especially if they are a vulnerable group. To get at the complexity of traffic danger multiple perspectives will be gathered including those of experts, parents, and children. The study sought to gain understanding of participants' views and lived experiences in relation to traffic danger. Children as vulnerable users, parents as adults attuned to the dangers imposed on children, and traffic experts as adults with specialized knowledge.

In order to understand the details of traffic danger for children, a number of perspectives must be explored. These perspectives include different groups of stakeholders: children are a key vulnerable user, parents are the adults most likely attuned to dangers for children, and traffic experts have professional experience and knowledge on the subject. The perspectives of these groups are sought through focus groups as qualitative methods are an appropriate means to investigate individual and group attitudes, beliefs, and perceptions (Stewart & Shamdasani, 2014). Focus groups are a powerful tool for gaining insight into the nuances of traffic danger for children (Agran et al., 2004; Stewart & Shamdasani, 2014). Focus groups are open in nature, allowing unknown opinions to emerge, both from individuals and from groups. In traffic safety studies, focus group discussions have proven to be a valuable tool for gaining insights from these different stakeholders (Adler et al., 2019). The use of focus groups is an effective and convenient way to collect data about the perceptions, attitudes, and beliefs of children, youths, and parents (Adler et al., 2019).

The objectives of this article are (a) to identify the specific factors that contribute to traffic danger for children as identified by children, parents, and traffic experts; (b) to explore the differences and similarities among these key stakeholder groups; and (c) to examine how their understanding of traffic danger aligns with or diverges from the established knowledge base.

3. Methodology

Structured focus groups were conducted separately with 8 experts of a variety of backgrounds, 14 children (between the ages of 8 and 13) and 12 parents. Children aged 8–13 were chosen as this is often the age range in North America when many children begin to conduct independent trips (Cervesato & Waygood, 2019), thus making their experience with traffic more pertinent as parents likely judge traffic when escorting them when they are younger. Focus groups serve as a valuable qualitative method to gather these perspectives, allowing for the emergence of unknown opinions (Adler et al., 2019). They offer a convenient means to collect data on the perceptions, attitudes, and beliefs of children, parents, and experts, providing detailed insights into the phenomenon under study. The qualitative analysis process was divided into four steps, summarized in Figure 1.

3.1. Design

Focus groups were conducted across three participant categories: experts, parents, and children. Each was queried about factors impacting children's traffic safety with follow-up questions designed to delve into the interactions between these factors. Questioning strategies tailored to each group helped elucidate these influences. The experts began with general inquiries following an introductory overview, while parents received a presentation on objectives, transitioning from broad questions to more localized concerns about their neighborhoods. The children's session involved a child-friendly presentation and concrete questions simplified from pilot testing feedback. The questions progressed from general to specific to better identify traffic danger elements that were supported by examples. Ethical approval was granted by the research ethics committee of Polytechnique Montréal (Application No.CER-2223–63-D).

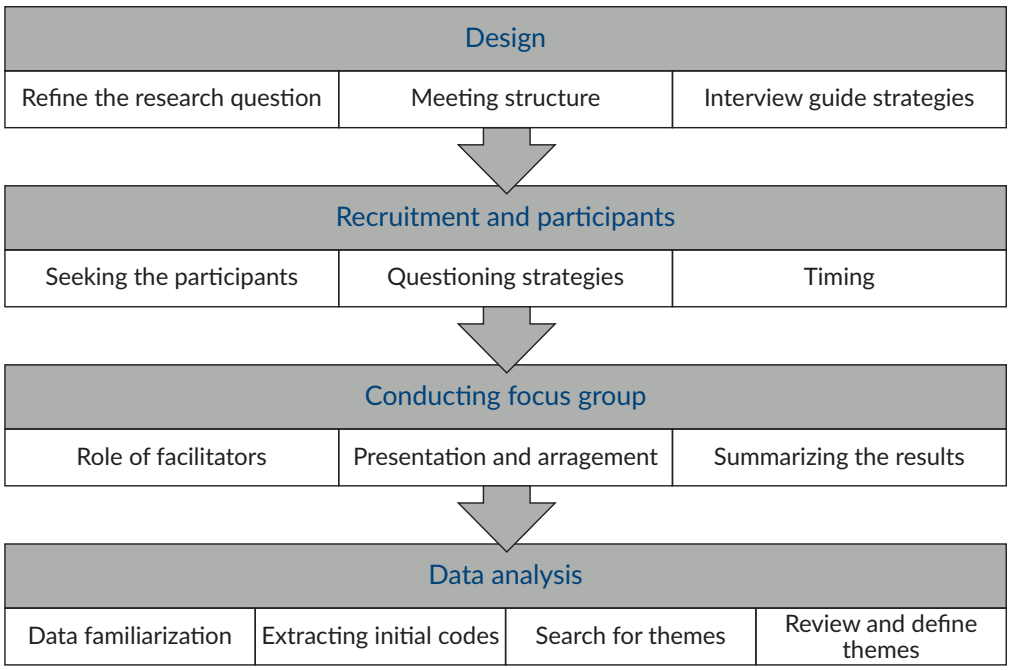

Figure 1. Overview of the methodology.

Three different questioning strategies and interview guides were developed. The experts' focus groups were each three hours long and started with an introduction to the project, the objectives, and the method. Then, two main questions were asked to them:

- "In general, what are the important factors that influence traffic danger for children?"
- "Are there other factors that specifically affect children's traffic danger?"

For the parents' focus groups, we prepared a simple presentation (both in French and English) containing: an introduction to the project, an explanation of the objectives, and a list of questions. The questions for the focus groups with parents and children were tested with parents and children not involved in the study. The questions and focus group approach were modified following that step. Our approach with these non-experts started with more general questions, then more specific questions were asked related to their neighborhood and surrounding area to help them focus on concrete examples. The parents' focus groups were 1.5 hours in length. The questions were as follows:

- "What are the important factors that influence traffic danger for children?" (That question was asked to first gather general ideas of what contributes to creating traffic danger);
- "Do you know any dangerous streets in your neighborhood?" (This was asked to focus parents on a concrete example that they are familiar with to facilitate the next question);
- "What about crossing that street? Are there any factors that can prevent your children from crossing a specific street?" (This question was asked to focus individuals on traffic danger in the street as children will enter streets whether to cross or fetch an item);
- "Are there any changes that can be made to make that street safer?" (This was asked to both help identify issues not previously identified, but also to know what parents thought would make streets safer);
- "Imagine a safe street *without* sidewalks. Tell us what can make this street safe enough for your child to walk there without an adult?" (This question was asked to further focus the parents on traffic danger in that public space).

For children, we prepared a presentation for children and tested it with children. Following the test, adjustments were made to better explain the objectives and elicit diverse responses. The questions were concrete, specific, and easy to understand (according to the children). The focus group discussions were 1 hour with children. Following an introduction that said the purpose was to talk about traffic danger, they were asked these questions:

- "Are there streets you avoid in your neighborhood? Or streets that you aren't allowed to use? Tell us about that street." (This approach was used to focus the children on a concrete example they would be familiar with);
- "Imagine a street that there would be no worries if you walked on it. Tell us about that street." (This question was used to elicit responses of what a safe street was from the perspective of the children);
- "Now, imagine if there were no sidewalks. Tell us about how that street could be safe for you to walk and use." (This question was asked to encourage the children to think about the traffic danger on the street).

3.2. Recruitment and Participants

Various recruitment methods were tailored for each stakeholder group. Experts were invited via online platforms like X and mailing lists of transport professionals. Parents of children aged 7–14 and children aged 8–13 were specifically recruited for their respective focus groups. At the age of 8–13, children start to gain a better understanding of road safety and can realistically estimate risks (Cieśla, 2021). This age range is critical as children begin traveling independently and face unique traffic safety challenges (Schoeppe et al., 2014). We focused on this age group to capture children's direct experiences as pedestrians learning to be independent. This allows us to understand the safety concerns and developmental considerations of both younger, more dependent children and older, more independent children. For parents, the age range of their children was 7–14 as parents of younger children (7 years old) are preparing their children to be independent or will be able to think about traffic danger for their children and parents of children who are older (14 years old) are able to reflect back to that transition from dependent to independent. In Montreal, recruitment involved posting flyers in English and French on neighborhood Facebook pages and distributing paper flyers with QR codes for registration in public areas. An incentive of $30 was offered to each participant, both parents and children.

The focus groups were held online using the Zoom application between May and June 2023. In total, six focus groups were held: three with experts (n = 8 experts primarily in English as they were from various areas of North America), two with parents (one in French n = 9, one in English n = 3), and one with children (in French, the dominant language in Montreal n = 14). A total of eight boys and six girls were in the children's group, with five aged 8–9, seven aged 10–11, and two aged 12–13. Parent groups involved three men and nine women across two sessions. As for experts, they came from different fields including engineering, education, planning, public health, and non-governmental organizations (NGOs).

3.3. Conducting the Focus Groups

Focus groups were led by the first author with assistance from a native speaker of English or French and senior researchers who provided guidance. Participants were informed that the discussion would be recorded and an assistant took notes in case of any technological issues. An online whiteboard with "sticky-notes" via MIRO was utilized to foster diverse opinions. Once the participants became accustomed to using sticky-notes, they were prompted to respond in "private mode" to minimize the influence of others' answers initially. After this initial phase, all responses were shared and discussed openly, and any ambiguities were addressed (i.e., why did they think it influenced traffic danger? Is it a positive or negative influence?). Following this, another round was conducted to capture any additional factors potentially sparked by others' contributions. An illustration of the online whiteboard can be found in Figure 2. Different colors relate to different participants.

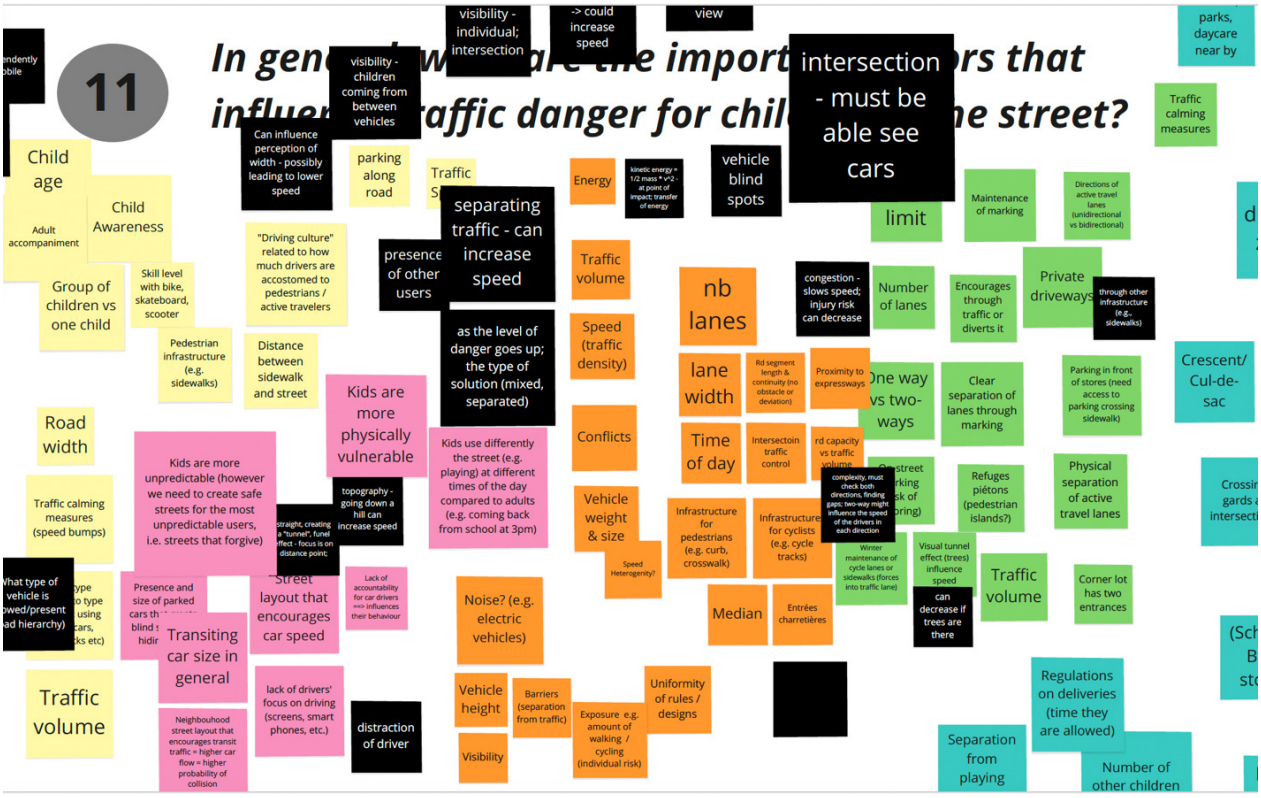

Figure 2. Example of MIRO screen during a meeting with experts.

3.4. Data Analysis

Considering our emphasis on uncovering themes concerning traffic danger for children, a thematic analysis represents the best way to analyze the focus group content. A thematic analysis is the process of identifying patterns or themes within qualitative information (Maguire & Delahunt, 2017). Our methodology comprised four steps that are described next.

3.4.1. Familiarization With the Data

Initially, audio recordings were transcribed and meticulously reread to ensure that we understood the information completely. As a result of this immersion, participants' perspectives were better understood which paved the way for future analysis.

3.4.2. Development of Initial Codes

Data were organized into meaningful segments to reduce the extensive information into manageable chunks. Participants' inputs and discussions were examined for potential keywords. Which stakeholder group(s) (parents, children, or experts) mentioned the keyword was noted as well. This step is illustrated in Figure 3. Having a positive sign next to the keyword means that it increases traffic danger, while having a negative sign means that it decreases traffic danger. The use of these keywords as codes helped to identify themes.

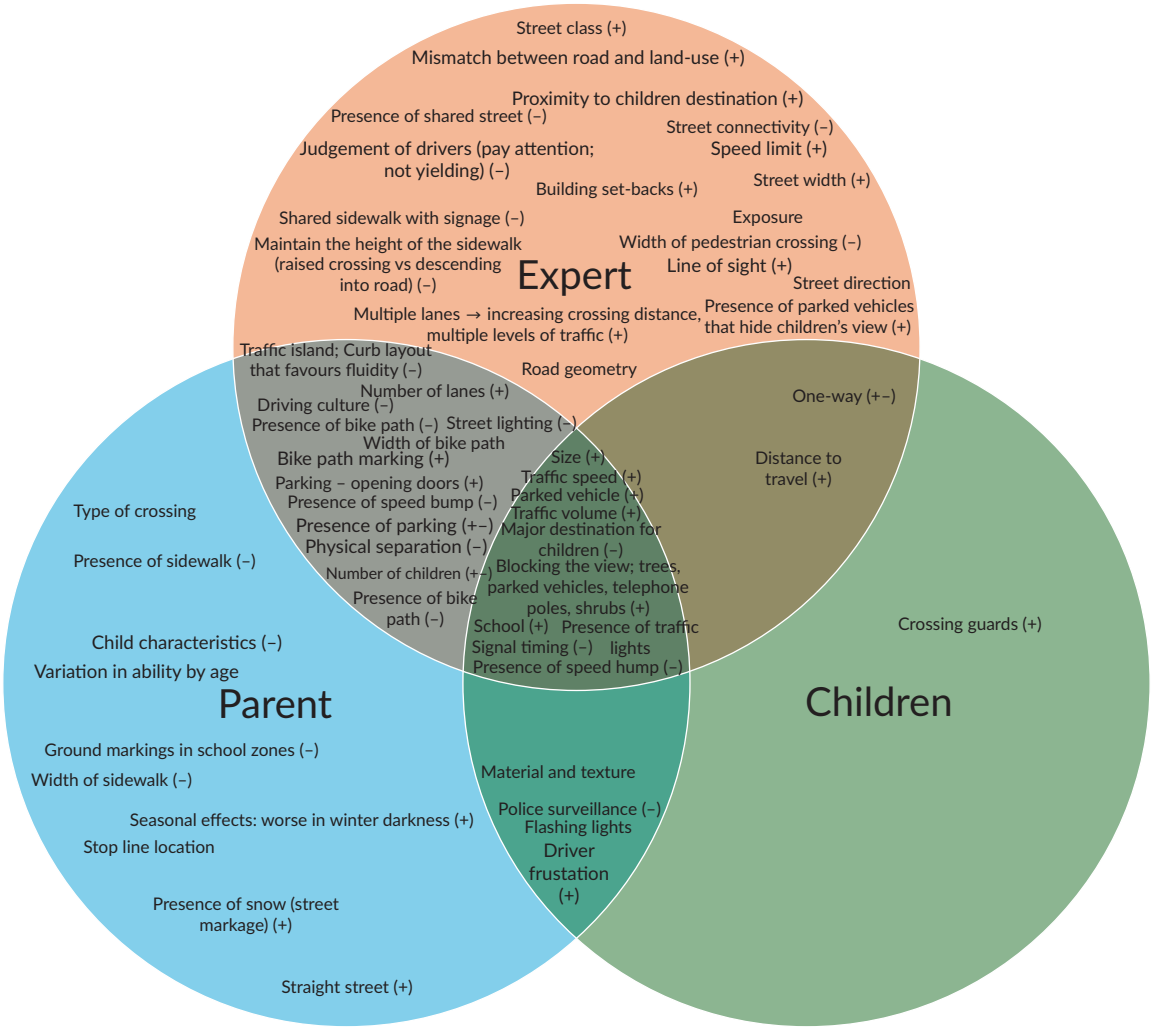

Figure 3. Keyword identification by stakeholder type.

3.4.3. Search for Themes

Eleven main themes emerged from the focus group discussions. Their impacts on traffic danger were assessed as positive, negative, or both. Codes were grouped into themes based on similarities. For instance, codes related to traffic volume and vehicle speed were combined into a theme named "traffic characteristics." Figure 4 illustrates the classification of these preliminary themes and sub-themes.

3.4.4. Review and Defining Themes

The next step involves a detailed review and refinement of themes identified in Step 3. Each theme's codes are closely examined to ensure that they are categorized correctly with special attention to overlaps. For example, if a code fits multiple themes, its placement is carefully considered. This phase may also uncover new insights such as design characteristics that impact children's traffic safety. New insights might prompt the creation of new themes to address previously unnoticed connections. This step defines the final themes from Step 3 findings and considers the relationships between classes. For example, interconnected factors like speed and traffic volume are combined into a single theme. The objective is to establish a coherent and meaningful

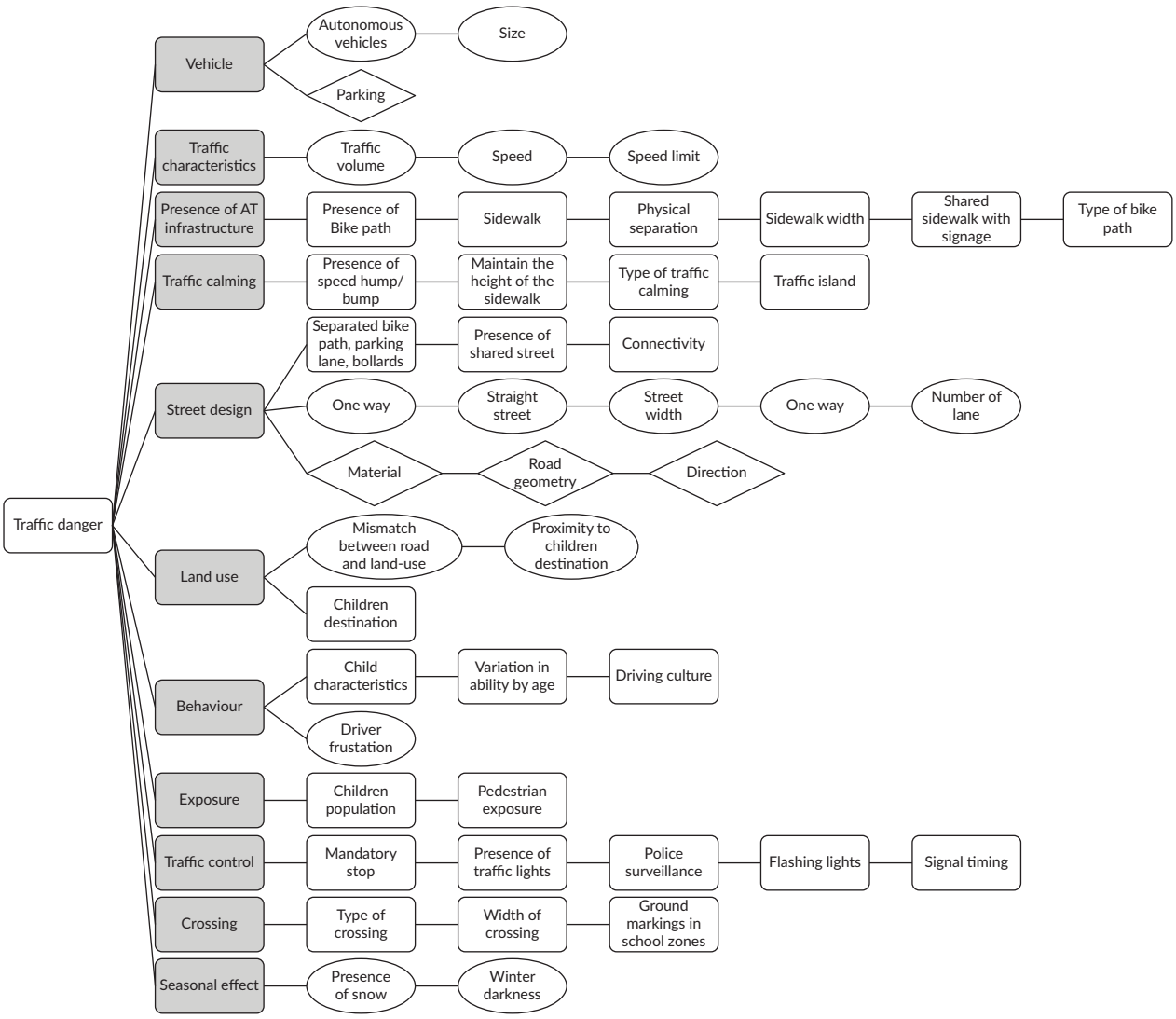

Figure 4. Preliminary themes and their effect on traffic danger (positive effect in circle, negative effect in square, both positive and negative effect in lozenge).

thematic structure that captures the complexities of the research topic. Figure 5 shows final themes as follows: traffic characteristics, infrastructure/design characteristics, vehicle characteristics, behavioral characteristics, visibility, land use, seasonal effect, and exposure.

Based on discussions with our participants, particularly the expert group, several key points related to exposure were highlighted. This theme is mainly associated with crash risk, indicating that a higher number of child pedestrians can increase the risk of a collision resulting in an injury or death. Additionally, it is critical to note that traffic danger, exposure, and seasonal effects are all significant factors influencing the risk of injury in children.

Exposure directly impacts crash likelihood. A higher number of child pedestrians in an area correlates with an increased risk of injuries. The severity of injuries is significantly affected by traffic danger which consists of several components and is the main focus of this research. Seasonal effects also play a crucial role in

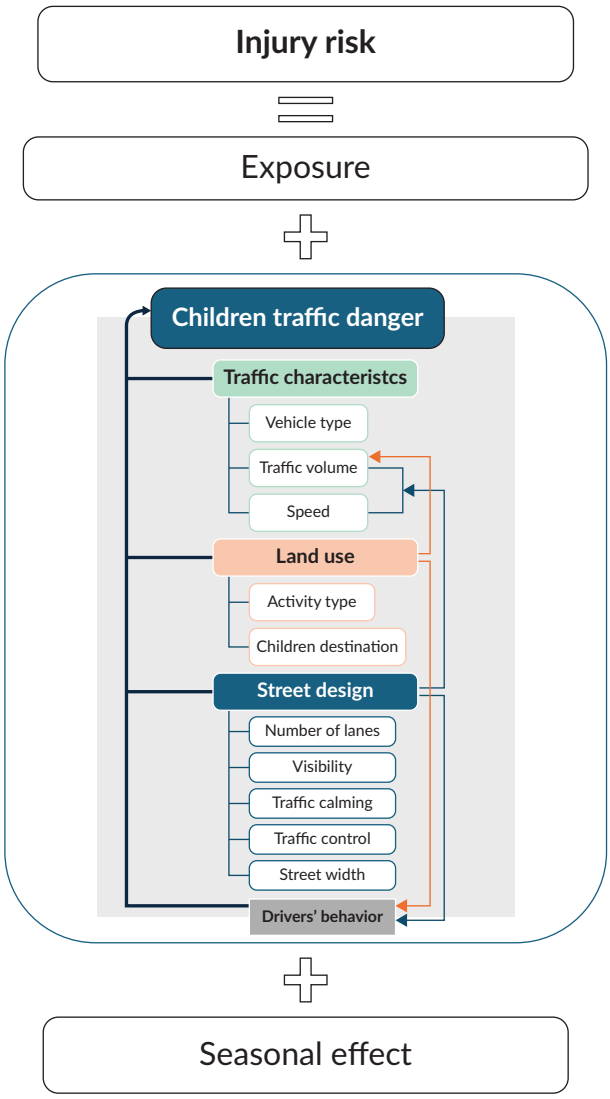

Figure 5. Themes and sub-themes highlighted during workshops on traffic danger for children.

shaping the risk profile for child pedestrians. Seasonal variations impact all aspects of traffic danger and exposure, with changes in weather conditions, daylight hours, and seasonal activities altering the risk profile. Understanding the interplay between these elements—exposure, traffic danger, and seasonal effects—is essential for developing effective strategies to enhance child pedestrian safety.

4. Results

In this section we outline themes discussed by each stakeholder group in the focus groups and offer selected responses to illustrate their perspectives. The results of the focus group discussions are summarized in Table 1. It should be noted that "consensus variables" are those on which all stakeholder groups have the same opinion. Non-consensus variables are those on which stakeholders have differing views or are mentioned by only one of the stakeholder groups.

Table 1. Summarized results.

Theme	Consensus Variables perceived to influence children traffic danger	Non-consensus variables (no consensus on their influence on children traffic danger) or only mentioned by one group (which group is named)
Traffic characteristics	Traffic volume Speed	Importance of traffic volume at intersection Importance of speed in street segment
Infrastructure design characteristics	Street width Intersection design Traffic calming Traffic control Active transport infrastructure	
Vehicle characteristics	Presence of trucks	Autonomous vehicles
Behavioral characteristics	Driver's behavior	Children's behavior
Visibility	Position of vehicle	Importance of street design
Land use	Relevance of school zone	Other destinations
Seasonal effect		Daylight hours in the winter
Exposure	Pedestrian volume	

4.1. Traffic Characteristics

Participants in all focus groups agreed that speed and traffic volume are the most important factors regarding traffic danger for children:

> The biggest effect is traffic speed and volume. Other factors might just be an additional factor, but I wouldn't consider them as the main factor. (Expert, public health specialist)

> To reduce the consequences of the collision, it is necessary to ensure that the speed is reduced. (Father of three children)

> It's dangerous to cross because people driving on the road drive fast and it's scary. (Girl, 10-years-old)

Some experts argued that traffic volume and speed vary based on location: vehicle speed is seen as crucial between intersections (street segments), while traffic volume is what primarily determines traffic danger at intersections.

4.2. Infrastructure Design Characteristics

There are many sub-themes in this theme and numerous street and intersection designs were discussed, especially in the expert meetings, including street width, number of lanes, street class at intersections, type

of traffic control, one-way streets, presence of traffic calming measures, and bike paths. Intersections and street segments were dealt with in separate meetings with the experts:

> For a child crossing a two-way street, it might be difficult to assess gaps. At the same time, two-way streets may encourage slower speeds. (Expert, NGO representative)

> Adding a median [also known as a traffic island] on a street is effective because it reduces roadway width. Any measure that reduces road width is effective [to reduce traffic danger]. (Expert, engineer)

Experts also noted the difference between traffic control measures as a crucial factor:

> Fundamentally, a traffic light allows, for half the time, vehicles to go through at speed. This is one of its key purposes. Whereas with a stop sign, all vehicles should come to a stop or near stop. Death is more likely at a traffic light as a result. (Expert, engineer)

According to parents, characteristics of the intersection are important: street width, type of traffic control, and presence of pedestrian crossings. Parents talked about the difference between pedestrian signals' protected phase and other situations:

> What is dangerous is when the pedestrian light is at the same time as traffic. We have seen it....The pedestrian light should have priority...and cars cannot turn on the pedestrian light. This was not the case before, and it was very dangerous. (Mother of two children)

Finally, children mentioned a variety of design characteristics such as street class, traffic control measures, and active transportation infrastructure. They also often compare how different design affects traffic volume and speed:

> When it's small streets and there are stop signs, it feels like it's safe. There are fewer cars that pass quickly. (Girl, 8-years-old)

> I prefer one-lane streets. Because four-lane streets are often highways, and there, cars go much faster. (Boy, 11-years-old)

4.3. Vehicle Characteristics

According to all participants, the presence of bigger vehicles and trucks increases the danger level for children on the street and at intersections. All participants, but especially parents and children, strongly believe trucks are more dangerous than other vehicles:

> Due to vehicle size increases, SUVs have larger blind spots that can hide the pedestrian. The measures that work today may not work in the future. (Expert, urban planner)

> If the child is still small, perhaps if it's a truck or a vehicle that's higher, he [the driver] won't be able to see the child. (Mother of 8-year-old boy)

> This is what scares me most: trucks passing by. (Girl, 10-years-old)

> Some cars are very big and can't see us even if there are lights. (Girl, 8-years-old)

Experts also brought up electric vehicles as part of this theme. According to them, given their quiet operation, children may be less likely to notice their presence, posing a potential safety concern. Additionally, experts expressed concerns primarily about the safety and reliability of autonomous vehicles, highlighting potential issues in their ability to navigate complex traffic situations and respond to unpredictable human behavior.

4.4. Behavioral Characteristics

Despite many design characteristics being mentioned by all focus group participants, discussions about traffic danger led to comments about driver and child behavior, particularly at the parents' and children's focus groups. Parents also felt that children needed to be made aware of traffic danger through education. Participants in both the parents' and children's focus groups discussed the importance of drivers observing road safety rules, especially traffic lights, stop signs, and speed limits:

> There is a crossing guard next to my school. But it's still dangerous—It's a big street in Montreal and cars run red lights. (Girl, 11-years-old)

The experts did not mention behavioral factors other than the influence of active transport users on driver's behavior:

> The presence of other active transport users teaches people that this is to be expected and makes drivers more aware. (Expert, NGO representative)

4.5. Visibility

Another theme mentioned mainly by experts was (a lack of) visibility. For street segments, visibility should be lower. Narrowing how far a driver can see will naturally lead them to drive slower. However, at intersections, it was argued that children are less visible to drivers because of their height, especially when obstacles are present like trees and parked vehicles in the street:

> Buildings and trees can make pedestrians less visible. (Expert, engineer)

Visibility concerns by parents are mainly explained by the size and positioning of vehicles, as well as how parked vehicles can obscure the visibility of their children to other drivers. They, as well as experts, mentioned the importance of changing infrastructure to improve visibility, especially for smaller children:

> Where the crosswalk was elevated, it allows the child to be higher and to be seen, at that time. (Mother of 8-year-old boy)

> You can also design intersections so that crossings are level with sidewalks. This will increase pedestrian visibility. (Expert, urban planner)

4.6. Land Use

Land use was cited by experts as a factor affecting traffic danger for children. Since school is a primary destination for children, it was much discussed. Several opposing views were expressed about how school presence affects traffic danger for children:

> Land use plays a role. Presence of schools and more commercial areas cause more pedestrian use and a mismatch between land use and road design can be an issue. (Expert, urban planner)

> In the commercial area, the danger is more about the maneuvers of vehicles than the amount of pedestrian. (Expert, engineer)

Parents and children did not explicitly mention the influence of land use, but parents discussed the relevance of school zones:

> The school zones are so small! A child walks more than a school zone to go to school. School zones are like 300 meters before school, it's useless. My daughter walks a kilometer to school. She crosses areas of 50 [km/h]. (Mother of two children)

4.7. Seasonal Effect

Another factor mentioned mainly by parents is the seasonal effect. The main issue is related to sidewalk maintenance in winter and changing visibility due to fewer daylight hours in the winter. Furthermore, some participants in the expert group emphasized the importance of renewing street markings quickly after the winter. This factor was not mentioned by children:

> In winter, the biggest concern is how dark it is. You've got early nights, late mornings, and children going to school in the dark. That's a big issue. (Expert, urban planner)

4.8. Exposure

Parents argued that more children walking in the neighborhood might enhance safety, while experts debated exposure, acknowledging its technical complexities with respect to traffic danger:

> The amount of exposure [to cars] and the amount of walking is a factor when you think about the risk of injury. (Expert, public health specialist)

4.9. Interactions

Another key outcome of this research is that the influences of the various factors are not always linear and often interact, meaning that they should not be considered in isolation. For example, "Does more traffic always increase traffic danger?" The experts' response was "No," as a lot of traffic moving slowly does not create the same risk of injury or death as less traffic moving quickly. As such, traffic volume and speed should be considered together. Other examples were that speed limits and the number of lanes should be considered together as more lanes (and wider lanes) can facilitate higher speeds.

5. Discussion

This study explored the multifaceted factors that influence traffic danger for children through separate focus group discussions involving experts, parents, and children. Stakeholder groups all agreed that traffic volume and speed play a crucial role in contributing to traffic danger for children. This result is supported by previous literature demonstrating the critical importance of addressing these variables to mitigate children's road safety risks (Cloutier et al., 2021). However, despite agreeing on this issue, discussions among experts revealed divergent views on the importance of speed depending on if one is considering intersections or street segments. In previous studies, speed had a great impact on children's traffic danger (Cloutier et al., 2021; Rothman et al., 2014), but occasionally their results differed at intersections. As an example, a study by Bennet and Yiannakoulias (2015) found no relationship between pedestrian-motor vehicle collisions and speed at intersections. Various viewpoints highlight the complexities of the issue, which emphasizes the multifaceted relationship between road design and traffic behavior.

All focus groups recognized the safety hazard posed by larger vehicles such as SUVs and trucks for children. Recent research supports this concern, highlighting the role of vehicle design in traffic danger (Cloutier et al., 2021). These larger vehicles often have substantial blind spots, affecting whether those outside the vehicle are visible to the driver. As children are smaller this can mean that such vehicles are endangering children more. Other studies connect larger vehicles with children's injury severity (Rothman et al., 2014). A holistic approach that integrates considerations for those outside the vehicle into vehicle design is needed to address the danger for pedestrians, particularly children. Implementing greater restrictions such as speed regulators and sensors for larger vehicles is necessary to mitigate the risk. Additionally, studies recommend equipping large vehicles with pedestrian/cyclist detection systems, side underrun guards, and blind spot cameras/sensors to improve safety (Shladover, 2021). Intelligent transportation systems that use sensors and cameras to detect pedestrians and automatically apply brakes have also shown promise in reducing collision risks (Oladimeji et al., 2023).

According to our participants, street and intersections design have an influence on children's traffic danger. Several factors were considered including street widths, intersection designs, traffic control measures, as well as infrastructure that supports active transportation. While previous studies have found a correlation between road/intersection design characteristics and traffic danger (S. A. Richmond et al., 2022), our study highlights the importance of evaluating this relationship along with traffic characteristics like speed and volume. For instance, to evaluate the impact of street width on safety risks, it is necessary to consider the speed and volume of traffic on that street simultaneously. There may be significant differences in the safety implications of a wider street based on whether vehicles are traveling at low speeds in heavy traffic versus at higher speeds in light traffic. Using this multi-dimensional approach allows a deeper understanding of the risk factors and allows the development of more contextually relevant solutions when compared with viewing design elements in isolation.

Experts highlighted visibility concerns caused by parked vehicles and other obstructions (like buildings) which can obstruct drivers' view of children at intersections. Studies show that barriers to children's visibility at intersections decrease safety (Schofer et al., 1995). However, the experts also noted that limiting driver visibility on road segments could potentially reduce traffic danger by decreasing speeds and focusing the driver's attention closer. While better visibility at intersections may improve safety, wide-open roads can

encourage speeding. It is clear that visibility is crucial in design and planning, but its impact on safety varies depending on whether one is assessing a road segment or an intersection.

Both driver and child behavior were emphasized as key factors contributing to traffic danger in the discourse. However, it was clear that children's behavior related to suffering risk, whereas driver behavior created traffic danger and greater risk. This illustrates the inherent relationship between road users' actions and children's safety. Children highlighted how driver behavior was scary and dangerous when they disobeyed rules, drove quickly, and operated large vehicles. Parents also discussed driver compliance to road rules and speed limits as important, but also talked about teaching children about road safety. On that latter point, a review of educational interventions for pedestrians (14/15 were for children) found no improvement on safety (Duperrex et al., 2002). In fact, research does not show that children's educational interventions reduce actual traffic danger (Akbari et al., 2021). In addition, children's perspectives on drivers who do not adhere to rules highlight the importance of reorienting the conversation towards the danger imposed rather than just the danger suffered. Overall, in consensus with Vision Zero (a traffic safety vision that aims for no deaths or severe injuries), the focus should be on designing safe systems rather than blaming individuals (Kim et al., 2017), especially those who are not creating the danger.

While previous studies have demonstrated the influence of land use types on traffic danger (Abdollahi et al., 2023; Ewing & Dumbaugh, 2009), our study suggests evaluating the relationship through the lens of pedestrian-vehicle interactions and levels of exposure. Certain land uses like schools or commercial areas can directly increase the number of pedestrians on surrounding streets, heightening their exposure to vehicles and potential conflicts. A more detailed study would be necessary to fully understand how specific land use contexts affect pedestrian behavior, traffic patterns, and the nature of their interactions with vehicles and ultimately affecting risks of injury or death.

The results suggest that a Multi-Criteria Decision Analysis (MCDA) method can be effectively utilized to incorporate stakeholders' insights as a crucial input in traffic danger assessments. Implementing MCDA allows for the inclusion of the relative importance and, in some instances, the non-linear nature of variables in these assessments. While some studies on traffic safety have employed MCDA methods (Alemdar et al., 2020; Stević et al., 2022), these studies often did not directly consider the input of vulnerable stakeholders. Furthermore, they primarily focused on prioritizing a limited number of streets related to their objective which limits their ability to comprehensively examine a city's network of streets.

6. Limitations and Future Research

A significant challenge in this research was securing reliable participants for the parents and children's focus groups. Participants needed to be available for an hour or more. The initial approach led to undesirable outcomes. In the parents' group, about half showed interest only due to the incentive and were not actively engaged. In the children's group, despite prior instructions for camera activation to verify participants' ages, reluctance to do so caused uncertainties, resulting in one session's cancellation. This problem was absent in the French groups, which included participants previously involved in related research. To address these issues, we suggest not mentioning financial incentives in initial (public) invitations and instead expressing gratitude post-participation to ensure genuine interest in the research. Furthermore, scheduling conflicts prevented the participation of key experts like police officers and policymakers, affecting the study's outcomes.

A strength of this research was the direct involvement of children and parents and the ability to gather information from them about traffic safety. However, only one focus group was carried out with children who were primarily based in Montreal, so it is not known how generalizable the results might be. The context of smaller urban centers or different driving cultures might elicit new or contrasting opinions. Furthermore, the random selection of participants and the mixed gender make-up of the groups may have had an impact on how participants answered focus group questions. Including individuals of different genders in the discussions likely introduced a diverse range of perspectives, experiences, and communication styles, which could have influenced the dynamics of the conversation. The researchers, however, tried to promote a non-threatening, confidential atmosphere that encouraged open dialogue among participants in the focus groups.

Our research focuses on understanding the factors that influence traffic danger based on the perspectives of stakeholders. The primary objective is to develop a comprehensive methodology for assessing traffic danger at a granular street-by-street level to enable cities to identify areas where traffic danger may be limiting children's independence. While we recognize that new technologies such as interactive applications and simulations can play a significant role in educating children about traffic danger, our purpose is to measure the source of the problem: traffic danger. As in all such research, it is not possible to identify every potential factor, and our research results are limited to the discussions among participants. Not all children will have experienced travelling alone and technologies that help children better understand traffic danger (Trifunović et al., 2024) could be used to test whether this impacts perceptions of what creates the threat of injury.

7. Conclusion

This article examined the intricate factors influencing traffic danger for children, using insights from experts, parents, and children gathered through focus group discussions. Thematic analysis revealed underlying patterns regarding traffic danger for children. Several themes were consistently discussed by all three stakeholder groups: traffic speed, traffic volume, trucks, and large vehicles, and how road design can increase or mitigate traffic danger. Other potential influencing factors such as land use, education, seasonal effects, and exposure were mentioned but were not felt to have the same level of influence.

Each stakeholder group contributed uniquely to the outcomes. Children expressed more concerns about driver behavior and traffic. This highlighted larger streets as being more dangerous and how adults' actions in vehicles are a source of danger. They often relied on emotions to articulate their experiences. Parents provided insights on reduced visibility from inside vehicles, the size limitations of school zones, and the illegal or dangerous behavior of other parents driving their children to school. Experts delved into a broader range of influences that focused on how street design can exacerbate or mitigate dangerous conditions. They also discussed contextual factors like land use that were seen as related more to exposure than increased danger. Another key takeaway was that many factors had non-linear impacts and interact with other factors so they should not be considered in isolation.

The results support context-specific design interventions. They emphasize how human behavior and road design are interconnected and impact traffic danger. It emphasizes the need for tailored interventions in areas frequented by children, especially outside school zones. This research contributes to the ongoing discourse on child road safety and helps guide future efforts to create safer and more child-friendly urban

environments. To ensure child safety in transportation, physical design and human behavior must be integrated. A collaborative approach is essential to ensuring a safe and sustainable road environment where children's safety is prioritized over drivers' convenience preferences. Due to the multifaceted nature of this problem and the potential interactions between different factors, future research should explore these dynamics and prioritize these key themes. Adopting a multi-criteria evaluation approach could enhance the assessment of traffic danger. In addition, evaluating interventions through discussions with vulnerable users and evidence-based policymaking are crucial.

The findings from this study can be directly applied to enhance urban planning and traffic safety measures. Urban planners and policymakers can use these insights to design safer street environments that prioritize child safety. For instance, implementing traffic calming measures, improving visibility at intersections, and ensuring safe crossing points near schools can significantly reduce traffic danger for children. Moreover, this research underscores the importance of involving diverse stakeholders, including children and parents, in planning and decision-making processes to ensure that the implemented solutions address the real-world concerns and experiences of the most vulnerable road users.

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Conflict of Interests

The authors declare no conflict of interests.

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