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Child Bicyclist Perspectives on Danger and Injury Circumstances in the Built Environment

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Abstract

Danger perception and the built environment are associated with injury risk in adult bicyclists, but limited research exists related to child bicyclists. Our pilot study describes child bicyclist perspectives on safety in the built environment. Participants were children who came to the Alberta Children's Hospital emergency department with a bicycling injury sustained on public property. Research team members interviewed participants about their injury circumstances (n=26). This research is based on thematic analysis of their responses to the open-ended interview questions. The risks children perceived were obstructions, debris, grade, visibility, and risky behavior. Fear of perceived danger in the environment influenced participants' bicycling experiences. The results inform child-contextual understanding of the built environment.

Keywords: pediatric injury, bicycling, children, built environment, perceived risk

Background

Bicycling is an environmentally sustainable way for children to travel, and the physical activity decreases their risk of multiple chronic illnesses (Sallis, Floyd, Rodríguez, & Saelens, 2012). A child, in this paper, refers to anyone 17 years or younger. In Canadian municipalities, use of active transportation such as bicycling is quite low, with 60 percent of parents reporting they drive their children to school every day (Active Healthy Kids Canada, 2014). This may be partly due to the high injury risk associated with active transportation in Canadian cities; child bicycling injuries alone make up 6 percent of all injury-related Emergency Department (ED) visits in Canada, with over 900 hospitalizations and 20 child deaths occurring annually (Safe Kids Canada, 2007 CIHI, 2017; Parachute, 2016).

Optimizing the built environment (CDC, 2011) to facilitate active transportation has been shown to promote bicycle use and improve safety (Carlson et al., 2014; Reynolds, Teschke, Harris, Winters, & Cripton, 2009). For example, infrastructure features such as road type, intersection status, bicycle lanes, and hill grade can affect the risk of injury in adult bicyclists (Teschke et al., 2012). Research in this area has primarily been concentrated on adult bicyclists, even though children are more likely to bicycle than adults and have a greater burden of injury (Ramage-Morin, 2017; CIHI, 2017). It is important to understand children's bicycling habits and built environment perceptions because past research has shown that children have diverse perspectives on their modes of transportation, play, and parental influence (Zwerts, Allaert, Janssens, Wets, & Witlox, 2010). Information on youth bicycling behavior could yield insights on built environment design to decrease the incidence of injury among this population.

Understanding bicycling behavior and perception in adults has shown to be valuable information for determining their injury risk, but again, little information is known about how a child's perception of the built environment influences their behavior and injury risk. Perception, or the individual's assessment of situational danger (Cloutier, Bergeron, & Apparicio, 2011), may act as a mediating factor between the environment and injury risk for children (Cho, Rodríguez, & Khattak, 2009). Past literature shows that if an adult rider perceives danger, they may adjust their behavior to cycle more cautiously (Cho et al., 2009). In addition to the gap in knowledge in child bicycling behavior, much of the research in this area on built environment and injury risk and uptake of active transportation is quantitative (Law, Petrenchik, King, & Hurley, 2007; Romanow et al., 2012). While quantitative analyses are important for determining statistical relationships and making inferences about causality, understanding the qualitative perspectives and lived experiences of bicyclists is important to contextualize these findings. Children's bicycle habits and behavior both differ, influence, and are influenced by those of adults, particularly parents (Zwerts et al., 2010). Understanding children's perceptions of the built environment provides useful information for future study design with this population and stakeholders in urban planning. Qualitative analysis of child perceptions of the built environment is valuable to understand how these perceptions relate to injury risk, and to advise future research evaluating child bicyclist behavior. Therefore, the purpose of this study is to explore perspectives on injury circumstances and the built environment for child bicyclists.

Method

Design

This investigation was the pilot of a larger case-crossover study by Hagel and colleagues (2019) to identify built environment features that influence child bicyclist injury risk. Participants were children who came to the Alberta Children's Hospital emergency department with a bicycling injury sustained on public property. A research team member asked each participating child about the built environment at the site where his or her injury occurred as well as two additional randomly selected (control) sites along their route. The rationale for randomly selecting control sites along the child's own route was to contrast environmental features where the child was previously bicycling without injury to the site where they were injured. The objective of the larger study was to compare the characteristics of the injury site with the randomly selected sites for each child (i.e., within-subject comparisons). The interviews involved mostly structured questions with fixed-choice responses, with some open-ended questions requesting further detail to understand the child's bicycling experiences. The data for this paper are based upon these open-ended questions.

Recruitment

Following ethical approval by the Conjoint Health Research Ethics Board at the University of Calgary, we recruited children younger than 18 years old reporting to the Alberta Children's Hospital Emergency Department (ED) with an injury sustained while bicycling on public property (including sidewalks, roads, pathways, parks, trails, etc.) between July 11 and September 22, 2017. Exclusion criteria included: injuries sustained outside Calgary city limits; on private property; on a tricycle or motorized bike; while trick riding; racing or participating in a mass bicycling event; fatal injuries, and; if the child and/or their parents did not speak English and/or recall details of the bicycling route. Parents did not have to be present for the injury event to participate in the interview as support for the child. Volunteer research assistants in the ED screened participants based on these criteria, and if eligible, had them complete a Consent to Contact form. A study team member followed up over telephone or e-mail to enroll them and schedule an interview.

Interviews

Semi-structured interviews were scheduled with participants between two weeks and two months post-injury. Parents were encouraged to be present and assist in the interviews; however, the children themselves were the participants. We included comments from parents in our analysis, as both comparisons to the child's point of view and supplementary for information purposes (especially for children younger than 5, and when the parent was present during the interview). Additionally, there is research that shows that parental perspectives heavily influence child perspectives on injury and safety in the built environment (Gülgönen & Corona, 2015).

Participants provided information on the bicycling route they had taken when they were injured, the location where the injury took place, and two randomly selected

control locations chosen by research team members along the child's route before their injury occurred. One of the control locations was randomly selected, and the second control location was randomly chosen, but then matched to the nearest intersection. The interview contained open-ended questions about the participant's bicycling experience, perceived safety at the injury location and route, description of the injury event, and general demographic details.

The primary researcher responsible for conducting qualitative analyses was present to conduct every interview. A second coder was present for two interviews to familiarize themselves with the interview process. All interviewers were instructed to record in writing participant responses as verbatim as possible. As this study and questionnaire were originally designed to be structured and quantitative with open-ended questions being supplementary, the interview was not designed for qualitative analysis and therefore not audio recorded.

Analysis

The Braun and Clarke (2006) method of thematic analysis was used to analyze the qualitative data. Thematic analysis is a method of identifying patterns and themes in qualitative data that is based upon grounded theory, but without the strict theoretical frameworks required for grounded theory analysis. Thematic analysis, specifically the Braun and Clarke method, is a reliable framework for analysis that is easier to apply to simpler data sets and can be integrated into spatial analysis later in our broader study program (Braun & Clarke, 2006; Hagel et al., 2019; Loebach & Gilliand, 2010). We analyzed the data in five phases, drawing from the open-ended questions asking how the child got hurt and what they perceived as safe or unsafe on their bicycling route. Phase one included attending interviews, inputting all data into REDCap—a data entry platform (Harris et al., 2009), re-reading participant responses, and transferring data into a comprehensive document. Manual coding in phase two involved going through all participant responses and underlining key words and phrases (codes) describing either how the child was feeling or a factor in their injury/safety. Initial themes were developed in phase three by labelling codes reflecting similar circumstances in consistent colors for visual linking before deciding on defining words for each theme. In phase four, we further reviewed and refined the themes through the creation of a mind-map of all codes. In phase five, we further grouped similarities in repeating codes and themes and labeled them as sub-themes. Throughout, a team of two worked on coding with check-ins to facilitate inter-coder reliability. We kept thorough records of each step of analysis . As parents were encouraged to assist in the interview, their responses were included in the analysis.

Results

During the four-month study period, 142 injured bicyclists were screened, 66 were eligible, and 26 were enrolled in our study (39 percent of eligible participants). Table 1 lists the demographic characteristics of our study sample. There was a similar distribution across all age ranges. Males constituted 73 percent of participants (19/26), and 68 percent (17/26) came from households with a self-reported median annual income of ≥$80,000. The majority (69 percent; 18/26) of participants felt they were experienced bicyclists.

Table 1. Demographic characteristics of study sample

Variable	Response	Number	%
Sex	Male	19	73
	Female	7	27
Age	0-4 years old	4	15
	5-9 years old	8	31
	10-12 years old	7	27
	13-17 years old	7	27
Median household income (2016)	Under $15,000	1	4
	$15,000-$29,999	1	4
	$30,000-$49,999	2	8
	$50,000-$79,999	1	4
	$80,000-$119,999	6	24
	$120,000 or more	11	44
	Do not know	3	12
Do you consider yourself to be an experienced bicyclist?	No	5	19
	Yes	18	69
	Somewhat	3	12

Table 2 summarizes characteristics of the participants' injury circumstances and trip. The average trip length was 0.74 kilometers, ranging from 0.09-2.74 kilometers. The most common purpose for bicycling was recreation (50 percent of trips). Almost half (42 percent) of participants' injuries resulted from a collision with an obstruction in the form of a motor vehicle, person, or object physically blocking the route. No participants were brought to the ED in an ambulance or hospitalized. Over half of participants (62 percent) had upper extremity injuries such as abrasions, fractures, or sprains.

Table 2. Characteristics of injury circumstances and bicycle trip

Variable	Response	Number	%
Collision (motor vehicle, person, object, obstruction)	No	15	57.69
	Yes	11	42.31
Ambulance	No	26	100
	Yes	0	0
Hospital admission	No	26	100
	Yes	0	0
Trip distance (km)- Average	.737		
Trip distance (km)- Range	.086 – 2.74		

In exploring injury circumstances and perceived dangers for children using the thematic analysis, three major themes emerged: External Parties, Environment,

and Self. These results were visualized through thematic mind map exercises (summarized in Table 3) as per phase four of Braun and Clarke's method of thematic analysis (2006).

Table 3. Themes, sub-themes, and associated codes from qualitative results

Major Themes	Sub-Themes	Associated Codes
External Parties	Pedestrians	high traffic; people in way; lot of people; walking; go around people
	Negligence	"need to be more aware"; obstruction; ignoring
	Automobiles	busy road; parked cars; new drivers; fear of cars; high traffic; speeding
Environment	Design	no sidewalk; too narrow; need more signage; sharp turns; designed for cars, not bikes
	Debris	sticks; rocks; pinecones; leaves; gravel; bumpy; garbage
	Obstruction	storm drain; post box; "in the way"; object in path; curb; tree; ramp
	Grade	not level; steep; big hill
	Visibility	sharp turn; too many trees; can't see; dark; shady; can't see around bend
Self	Fear	scared; panic; going too fast; lost control; distracted; freaked out
	Risky Behavior	no pedals; no helmet; jumping; standing on bike; riding; toddler bike; racing; no hands; swerving
	Self-Blame	"my fault"; dangerous; silly; distracted
	Inexperience	teaching how to bike; just learning; not good biker; too young; training wheels

Theme: External Parties

The theme of external parties referred to the presence of external persons such as motor vehicle drivers or pedestrians, who through interacting with the participant, contributed to the injury event. Two (8 percent) injuries involved a collision with a motor vehicle, however 9/26 (35 percent) of participants mentioned motor vehicles being around that indirectly contributed to their injury (due to swerving around, having to stop too fast, etc.). The possibility for interaction with motor vehicles, especially during times of high traffic volume, increased feelings of fear of injury in children. This interaction led to increased fear of being on the road, and more frequent bicycling on the sidewalk or separated paths, especially for children less than 9 years old or just learning to bicycle. When talking about bicycling on sidewalks or paths, participants cited interactions with pedestrians being more common. In injury circumstances, participants felt pedestrians were

"in the way," forcing bicyclists to collide with them or swerve off-course. Motor vehicles and pedestrians were both seen as a threat to safety and an obstruction that negatively affected maneuverability.

Some participants felt that drivers and pedestrians were exhibiting negligence (i.e., inattention, ignorance, or lack of prudence resulting in harm) by not making efforts to be aware of children, with drivers failing to stop for bicyclists, and pedestrians failing to move out of the way when children rang their bicycle bells. A participant said that "people need to be more aware of kids biking" and there needs to be more pavement just for bicyclists (Participant #25). Two parents (8 percent) called for signage to be added to paths to alert others of child bicyclists in the area (Participants #5 and #24). Motor vehicle driver inattention was cited multiple times with participants stating that "new drivers are a problem" because they do not pay attention or noting that the presence of motor vehicles increased fear and risk.

Theme: Environment

The participants' perceptions of dangers in the built environment were related to visibility, grade, obstructions, and design. Participants or their parents were concerned with visibility on the route, whether a turn was too sharp, poor lighting, or obstructions in the child's line of sight.

Visibility became an issue when intersections were designed in such a way that cars or bicyclists could not see each other. As previously noted, parents called for signs to be placed to warn drivers and pedestrians to watch for kids on their bikes, or alternatively, to warn children on their bikes about upcoming obstructions or turns. Other obstacles included trees or sharp turns obstructing a child's view of the path, especially if they were going down a hill or were going too fast for their skill level.

At injury sites, children frequently described going down a "really big hill," and ending up going "way too fast" (Participant #17). Closely associated with these statements was the feeling of "losing control" of the bicycle prior to injury. Ten out of 26 (38 percent) participants mentioned that they were going "too fast" in their injury circumstance description, and 11 out of 26 (42 percent) mentioned they were going downhill at the time of their injury. Parents and children perceived hills or steepness to be difficult for young cyclists to maneuver. The above two sub-themes, visibility and grade, were those most closely associated with feelings of fear for children while bicycling, resulting in the child referring to loss of control of the bike due to speed or feelings of panic.

An obstruction—an object physically blocking the path or route of a bicyclist—can include hedges, trees, mailboxes, posts, ramps, debris, and/or drains. The most common obstruction with which participants struggled was hitting or transitioning on/off a curb. One participant noted that the distinction between "curbs with sharp edges" or soft edges (i.e., non-mountable vs. mountable curbs) affected bicycling difficulty (Participant #11). Another sub-theme related to obstruction was debris on the route, which children perceived as a main agent of danger; small gravel,

rocks, leaves, and pinecones were mentioned the most. Young children (less than five) in particular noted debris such as single pinecones or a couple of small rocks, which parents otherwise noted as insignificant, as being scary. Swerving away from debris was reported as a major factor in many injury events.

Design of the route was often brought up as hazardous, especially by the parents. Infrastructure that had child cyclists interacting closely with motor vehicles, either on the road or at an intersection, were areas where parents and children would exercise increased caution. Other concerns like pathways being too narrow or having sharp turns were also repeatedly mentioned. Neighborhoods, roads, or intersections being designed for vehicles and not for bicyclists were common complaints.

Theme: Self

Nine out of 26 (35 percent) children blamed themselves for their injury, with one child stating that "it wasn't the site that was unsafe, it was my fault that I messed up and fell" (Participant #2). The most common reason for self-blaming was risky behavior. The most common instance of risk-taking was the child riding their bicycle with no hands on the handlebars, but also included standing on the bicycle, racing with a friend, riding with one hand on the handlebars, "doing swervies" (Participant #19), ignoring what their parents told them about bicycling safety, or purposively riding an improperly sized bike.

Some parents felt the main risk was that participants were inexperienced bicyclists, having just learned how to bike or had their training wheels removed recently if they were young (less than 9). Most child participants themselves felt that they were experienced bicyclists (18/26; 69 percent) and rarely blamed their skill for their injury event; rather, they pointed to the situation or risk-taking behavior in which they engaged. This was a point of contention between several participants and their parents.

Discussion

The objective of this study was to explore perspectives on injury circumstances and the built environment for child bicyclists. The study sample demographics were representative of the typical bicycling population in Canada, which is predominantly male and relatively high-income (Ramage-Morin, 2017). We uncovered three major themes describing children's perspectives on bicycling, including the influence of external parties, the environment, and themselves as bicyclists. In Teschke et al.'s (2012) study, most injuries were from a collision and motor vehicle-related, contrary to few of the cases in our study being collisions and only two being related to motor vehicles. Most collision injury events in this study were reported with objects such as posts, curbs, or trees in descriptions of injury circumstance. Either swerving away from or hitting an obstruction were the dominant injury circumstances reported by the participants. Related to the assertion of Cho and colleagues (2009), increased perception of danger surrounding motor vehicles could have caused the bicyclists to ride more cautiously, resulting in fewer motor-vehicle injuries. Children in our study may also be less experienced in navigating environmental obstructions or bicycling in different types of locations than Teschke

and colleagues' (2012) research.

A common theme in children's descriptions of their injury was the sense of fear causing them to panic, react with less logic, and lose control of the bicycle. Fear was reportedly caused by some features of the built environment such as a steep hill grade, high speed, debris, or sharp turns. These reactions were more common for new bicyclists and those younger than 12 years old. The perspectives of parents provided useful context to why the child was fearful, reflecting past qualitative literature that explored the influence of parental safety concerns in shaping children's perceptions of their experience in urban centers (Gülgönen & Corona, 2015). Research by Teschke and colleagues (2012) found similar fears, particularly hill grade and speed, to be significantly associated with injury risk in adults. Currently no other literature on the subject with children exists, and therefore adults are reasonable comparators at this time. Based on past research with adult bicyclists, perception of the built environment can be a mediator between the built environment and injury risk (Cho et al., 2009). It is possible this same phenomenon occurs with children, with fear mediating the relation between the built environment and injury. The Teschke et al. (2012) study is currently being replicated with children by members of our research team and expanded nationally to three other municipalities in Canada (Hagel et al., 2019).

Another thematic area to note was the perception of others versus the child bicyclist in the context of the built environment. The behaviors, notably negligence, of other pedestrians or drivers were cited to be a major concern for child safety and their use of active transportation.

Indeed, past research by Cloutier and colleagues (2011) shows that parents limit their children's active transportation to school due to safety issues, especially relating to cars. The child bicyclists in the current study expressed differing sentiments about motor vehicles and pedestrians: cars were regarded with fear, while pedestrians were annoying, "in the way" (Participants #23, #25, #26), and a nuisance for bicyclists.

It was also very interesting to see how child bicyclists perceived themselves in their environments. The participant was likely to blame *themselves* for their injury if they were being risky or "silly"—an unexpected finding, especially for younger children. This implies that children are aware that their behaviors may be dangerous or increase their chances of injury, but will undertake them anyway (examples in our sample included riding with no hands on the handlebars, no feet on the pedals, racing, or standing up on the bicycle). Although we are not suggesting that a bicycle is a toy, these results suggest the importance of taking children's playing and risk-taking behavior into account when considering built environment design. Urban bicycling courses tailored towards children or bicycling safety courses for children which try to limit risky playing, have shown varying results in the literature as to their effectiveness in preventing risk-taking behavior (Richmond, Zhang, Stover, Howard, & Macarthur, 2014). Although it is difficult to alter children's risky behavior, we may be able to alter the built environment to minimize harm. For example, traffic calming and safer built environment design

have been shown to reduce harm to child bicyclists through traffic calming features or simply moving features like bus stops away from parks and playgrounds (Retting, Ferguson, & McCartt, 2003). Urban planners, especially in local neighborhoods where most children bicycle, should incorporate into their built environment designs the inevitable tendency for kids to practice unsafe behaviors involved in everyday "fun." Although we did not examine peer influence (i.e., cycling with parents versus other children) on risk taking behavior in our analyses, this may be an interesting area of future research.

Another note on self-blaming was that if the participant cited themselves as the reason for their injury, it was almost always about their risky behavior and not their cycling experience. Most children claimed to be experienced cyclists, even when their parents disagreed or the participant had recently learned how to bicycle. The above findings indicate that children are aware of their risk-taking, but may overestimate their skill level as a bicyclist. This finding is potentially a reflection of the Dunning-Kruger effect in psychology, where individuals of low ability or skill tend to overestimate their competencies (Kruger & Dunning, 1999). The Dunning-Kruger effect occurs because people, in this case child bicyclists, lack the experience to critically analyze their abilities. It should be noted that the Dunning-Kruger effect has primarily been studied with individuals of the same age and group (e.g., students in a class), and little research has compared children's perception of their own ability with older age groups. Further research in this area should be performed to measure this effect empirically.

Our limitations concern the recruitment method and generalizability of qualitative results. There was significant loss-to-follow-up between the consent to contact and enrollment periods, possibly because research team members were only phoning to follow up with potential participants during working hours. Additionally, we only recruited from the hospital ED, possibly missing children in the intensive care unit or trauma ward or those with injuries not deemed to require ED care. These recruitment methods may have resulted in a selection bias by unintentionally excluding working parents or more severely injured children. This bias could be reflected in Table 2, where we can see that no participants were admitted to the hospital or transported in an ambulance, with only relatively minor injuries in our sample. The exclusion of severely injured children in our study could be another reason we saw so few motor vehicle-bicyclist collision cases, as past research has shown that collision with a motor vehicle increases the severity of injury (Embree et al., 2016; Hagel, Romanow, Enns, Williamson, & Rowe 2015; Romanow et al., 2012). There may also be concern regarding the possibility of recall bias, given that children were self-reporting their injury and some were interviewed up to two months post-injury due to logistical scheduling details. Although this may have affected the accuracy of details, we believe it is still important to record the child's perspective on their injury and that potential errors still contribute to an overall impression of the child's bicycling injury.

Moreover, recommendations in research for pediatric injury recall indicate that one to three months is the optimal recall period for interviews; therefore our interview and recruitment period is supported in the literature (Harel et al., 1994).

Additionally, since this project was not originally designed for qualitative analysis, interviews were not audio recorded and responses were written down by research team members to match the children's stories. This is an issue of measurement validity because it may have compromised the richness of the responses.

Conclusions

Results from this research indicate that child bicyclist perspectives are important in interpreting interactions with the built environment and injury risk. Hill grade, going too fast, and obstructions in the path were highlighted as difficult for young bicyclists to manage. The negligence of pedestrians and motor vehicle drivers was also cited as a hazard. Many children were engaging in risk-taking behavior prior to their injury, even if they knew that it was something "silly" and dangerous to undertake. Further research is required on the association between perceived injury risk and actual injury risk to confirm whether there is a relationship and how proactive safety protocols can be adapted to accommodate for child fear and panic.

Ultimately, this research is a preliminary qualitative case study on child bicyclists and may be used to generate new questions about child-sensitive built environments.

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Author Contributions

M. Whelan, T. HubkaRao, and B.E. Hagel conceived of this study. B.E. Hagel, A. Stang, S. Freedman, A. Macpherson, A. Howard and P. Fuselli contributed to acquisition of funding. M. Whelan contributed to data collection. M. Whelan and B.E. Hagel contributed to the qualitative analysis. M. Whelan finalized the thematic coding and drafted the initial manuscript. All authors contributed to interpretation of the data, critically reviewed the paper and approve the submission.

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