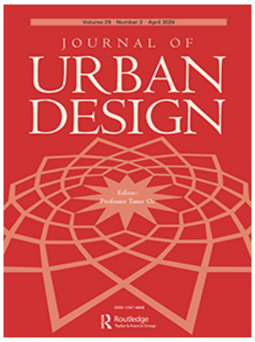

Journal of Urban Design

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/cjud20

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JOURNAL OF URBAN DESIGN
2024, VOL. 29, NO. 2, 208–230
https://doi.org/10.1080/13574809.2023.2223517

Children's and parents' perceptions on safe routes to schools: a mixed-methods study investigating factors influencing active school travel

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ABSTRACT
The proportion of children walking or riding to school is dwindling in Australia, while pedestrian injuries are among children's leading causes of death. A mixed-methods survey was conducted on children and parents of two schools in Australia to understand travel behaviours and attitudes towards active transport to school (ATS). Results showed that road safety perceptions predicted ATS, unlike distance to school and stranger danger. The design of the routes to school was found to be crucial in facilitating ATS, to address the fear of road danger. Practical implications include the need for more controlled pedestrian crossings and protected bike paths.

ARTICLE HISTORY
Received 21 December 2022
Accepted 7 June 2023

KEYWORDS
Crosswalks; pedestrian; sidewalk; cycling; bike tracks; active travel

Introduction

Children are becoming increasingly dependent on parents to chauffeur them to their destinations. As much as 62–82% of all trips made by Australian children are by car as a passenger and this proportion has been increasing over time (Garrard 2009; Morris, Wang, and Lilja 2001; Schoeppe et al. 2016). In 1970 in Melbourne, 55.3% of young people walked to school or higher education, compared to just 22.2% in 1994 (Garrard 2009), despite 60% of Australian parents reporting that the distance between home and school is 3 km or less (Tomkinson et al. 2015). High car dependency among children has been shown to increase childhood obesity rates (Trapp 2012), worsen children's independent mobility (Malone and Rudner 2011; Marzi, Demetriou, and Kerstin Reimers 2018), increase road trauma (Truong and Currie 2019) and have negative impacts on the environment (Toner et al. 2021). Reduced children's independent mobility can lead to reduced social competencies due to isolation, as well as feelings of loneliness (Pacilli et al. 2013).

Barriers to active travel

Countless factors can influence the uptake of active transport. For example, the urban design attributes such as density and whether it is a mixed-use development can

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/13574809.2023.2223517

influence how walkable a place is (Fernando et al. 2022), as well as the distance and travel time between the destination and the origin (Millward, Spinney, and Scott 2013). However, the available pedestrian networks and the design of footpaths and the streetscape also play an important role in walkability (Fernando et al. 2022; Stafford, Adkins, and Franz 2020). Carver et al. (2019) found that in Melbourne, Australia, parental accompaniment to school was negatively associated with children's AT, suggesting that infrastructure interventions to improve the safety of walking and riding, alongside campaigns to promote children's independent mobility are required to increase ATS.

While previous research has investigated children's transport practices and perceived barriers while commuting to school in Australia (Yeung, Wearing, and Hills 2008), there has been a lack of research investigating children's and parents' preferences in active transport infrastructure treatment decisions, such as the type and location of crossings.

Why ask children?

The general public is rarely asked what types of pedestrian and cycling infrastructure they prefer or desire in their area. Even scarcer is research on children's perceptions and preferences regarding infrastructure interventions. However, infrastructure can influence whether a child walks or rides to school as it can affect the perceived safety of the journey (de Lavalette et al. 2009). A few studies have investigated pedestrians' preferences for overpasses versus underpasses in low- and middle-income countries (Javid et al. 2021; Mfinanga 2014; Saha et al. 2013), while other research has investigated driver behaviour while approaching various designs of zebra crossings (Bella and Silvestri 2015; Iragavarapu, Fitzpatrick, and Chrysler 2011; Turner et al. 2006).

Preferences in crossing type

To determine which infrastructure treatments would be effective in encouraging ATS in the area around schools, it can be suggested that consultation with both parents and children would be beneficial. Prior research has made it amply clear that consultation is necessary for successful interventions that promote ATS (Aranda-Balboa et al. 2020; Chillón et al. 2011). Therefore, this study asked respondents about their preferences and perceptions of various crossing and intersection types, from the perspective of the active transport user. It should be noted that in Queensland, people are allowed to cycle on footpaths and have right of way over cars on zebra crossings, which is unlike some other jurisdictions. Consequently, the installation of a zebra crossing can be beneficial to pedestrians as well as people riding bicycles in Queensland and highlights the need for Queensland-based research on ATS.

Current research

Given the numerous advantages of children's active travel to school (ATS), the aim of this research was to survey school children's and parents' views on their current travel modal choices, their current perceptions of safety and their preferences and attitudes towards different types of active transport infrastructure treatments. Three research questions were investigated:

RQ1: What factors predict children's choices to use active transport to get to school?

RQ2: How do parents and children perceive the different pedestrian crossing types in terms of perceived risk?

RQ3: What are the challenges that parents and children perceive in the commute to school and what do they feel is required to encourage children to use active transport to go to school?

Method

Survey design

A cross-sectional, online survey was conducted with both quantitative (RQ1 and RQ2) and qualitative questions (RQ3). The survey was developed using Web Survey Creator and the school principals were consulted on the content of the survey. Ethics Approval was granted by the university ethics committee (A221807). The survey was designed to be able to be completed in less than 10 minutes.

At the start of the survey, participants were asked which school they, or their children attended; the distance that they lived from school; and whether they were a secondary school student, or a parent of a primary and/or secondary school student.

Participants who responded saying they were a school student were asked six items relating to their current perceptions and travel choices to go to school, with answer options being on a five-point Likert Scale from 'Strongly Agree' to 'Strongly Disagree'. These items were customized as no prior literature was found that asked the children about their perceptions relating to ATS.

A two-item scale on how children perceived the safety of their route to school – 'General Safety' (Cronbach's alpha, α = .672). was asked:

(1) *'I can get to school safely using existing paths and crossings'*
(2) *'I feel safe when I'm walking or riding to school'*

A two-item scale on the perception that a risk was posed to children by dangerous strangers – 'Stranger Danger' (Cronbach's alpha, α = .786):

(3) *'I'm worried about strangers when I'm walking or riding to school'*
(4) *'My parents don't allow me to walk or ride to school because they're worried about strangers.'*

Two items relating to perceptions of how road safety issues specifically contribute to risk perceptions – 'Road Safety' (Cronbach's Alpha, α = .827):

(5) *'My parents don't allow me to walk or ride to school because they're concerned I'll get hit by a car'*
(6) *'Road safety is the main reason that I don't walk or ride to school'*

A second part investigated risk perception of crossing types. Both parents and children were presented with seven different types of pedestrian crossings and were asked to rate them in terms of their perceived risk level, in order to understand which types of crossings children and parents feel are safer. Perceived Risk was measured on a five-point Likert Scale ranging from Very Risky to Very Safe. Parents were asked: *'How risky do you feel it is for children you care for to use the following types of crossing?'* where children were asked: *'How risky are the following types of crossings in your experience?'*. The crossing types were as follows: unprotected crossing, untreated crossing side road (a side road where no crossing facility is provided), a refuge, standard zebra crossing, raised zebra crossing, mid-block signalized pedestrian crossing and signalized crossing at intersection (see Figure 1).

Figure 1. Compilation of seven photos of crossing types used in the survey. The photos were used for illustrative purposes so that participants understood the different types of crossings.

Next, participants were asked a multiple-choice question on how often they walked or rode to school which offered answer options including 'All of the way often', 'Some of the way at least sometimes' and 'Never. I catch a bus. It's too far for me to walk or ride'. 'Often' would be considered as more frequent than 'sometimes', which in turn, would be considered as more frequent than 'never'. These descriptors of frequency were adapted from pre-existing Likert scales for measuring behavioural frequency (e.g., Sullivan and Artino 2013). A further two questions asked participants for their gender, and their year group at school.

Finally, two open-ended, qualitative questions were posed to participants on what they would like to change about the way they travel to school and suggestions for improvements to aid active travel (see Appendix in the online supplemental data). These questions were used to assist with sense-making beyond pre-determined response options and to capture knowledge based on the terms of the participant as in Braun et al. (2021).

Survey administration

Parents of students at Chancellor College Primary School and students and parents at Chancellor College Secondary School were invited to participate in this research. The schools advertised the online survey through their Facebook sites, via the Parents and Citizens Associations, and sent to secondary school students' email addresses. School children were also given the opportunity to respond to the survey in their classroom if they wanted to, while they were being supervised by their teacher. These schools are located in Sunshine Coast, Queensland, Australia. Figure 2 shows a map of the site area.

School children were incentivized to fill out the survey by offering a pizza party to the two classes with the highest participation rates. No incentives were offered to parents. The survey was open for 2 weeks from the 25 May to the 7 June 2022.

Data analysis

A binomial logistic regression (BLR) was conducted to test which variables predicted children using active transport to school. Active transport to school included those who did walk or ride to school 'all of the way often' or 'all of the way at least sometimes'. Predictor variables were the Distance from school (categorized), General Safety, Stranger Danger and Road Safety. Gender was also included as a control predictor variable.

Differences in perceived risk levels of the crossings by children and parents were investigated using a Generalized Linear Mixed Model (GLMM) with a Gaussian response, as the study design used repeated measures The risk level scores (1–5) were considered as a continuous variable. They were not normally distributed, and the Markov chain Monte Carlo algorithms (MCMC) was used to fit the GLMM (burnin: 100,000, thinning interval: 100, iterations: 10,000,000). The crossing, participant types and their interactions were used as dependent variables, while the participant code was used for the mixed effects. An uninformative prior was used (inverse-gamma prior with shape and scale equal to 0.001) with a small degree of belief parameter (0.002). The selection of variables for the final model followed a backward stepwise approach, and the Deviance Information Criterion (DIC) was used to balance model fit and model complexity. Residuals were checked and were normally distributed.

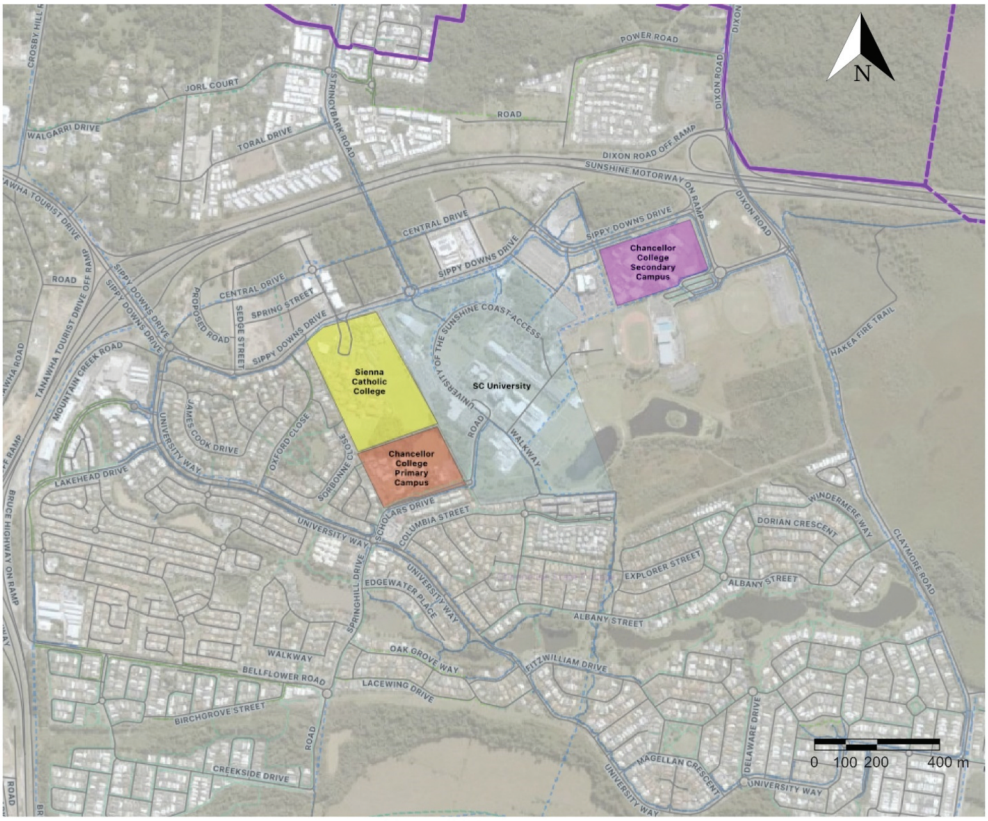

Figure 2. Map showing the area surrounding the schools surveyed in the current study. The schools are in proximity and separated only by a university campus.

IBM SPSS 27 was used to calculate the descriptive statistics and to conduct the binomial logistic regression. R version 4.2.1 and the MCMCglmm package were used to conduct a Generalized Linear Mixed Model analysis of the perceived risk ratings of the pedestrian crossings. A thematic analysis was conducted on the responses to the open-ended questions using Microsoft Excel. Themes were identified inductively (Boyatzis 1998) and responses were placed manually into columns denoting distinct themes. The themes were reviewed for consistency, and consensus was found on the most prominent themes.

Results

Descriptive statistics

The survey received 441 responses. Thirteen respondents did not identify as a parent or child and so were removed. In total, 91 Parents (21.2%; 77 females, 7 males, 7 undisclosed) and 337 (78.7%; 192 females, 114 males, 14 non-binary, 17 undisclosed) school pupils were included in the analysis. The school pupils were in year levels 7–12 (normally aged 12–18), with 128 (38%) being in year 7–8; 90 in year 9–10 (26.7%), 115 in year 10–12 (34.1%), while 4 (1.2%) did not disclose.

Table 1. Distance from school their residence is as reported by parents and children.

Approximately how far do you live from the school you or your children attend?	Parents	%	Children	%
Less than 1 km (up to 15-minute walk or 5-minute ride)	26	29	98	29
1–2 km (12–30-minute walk or 5–10-minute ride)	31	34	92	27
2–4 km (30–60-minute walk or 10–20-minute ride)	20	22	101	30
Greater than 4 km	14	15	46	14
Total	91		337	

Given that the secondary school had approximately 2000 students, a response of 337 students represents a reasonably high response rate of the total school population. Representativeness cannot be guaranteed as participation was voluntary and not a randomized sample.

The distances that the survey respondents lived from their school are presented in Table 1, showing that the vast majority of children (86%) and parents (85%) live within 4 km from their school.

Predictors of active transport use

The frequencies of active travel to school are presented in Table 2.

Assumptions of BLR were checked and no violations were found. Eleven cases were removed as outliers because they had standardized residuals greater than 2.5. Table 3 shows the results of the logistic regression. Distance from school was not found to be a significant predictor, and neither was perception of stranger danger. However, Perceptions of Road Safety, General Safety and Gender did have significant effects, such that children were more likely to report always using active travel to get to school by a factor of 3.18 for every unit increase on the perceptions of road safety scale; by a factor

Table 2. Frequencies of children who either always or never walk or ride to school.

What phrase best describes how often you walk or ride to school? (Dichotomized)	*N*	%
Never walk or ride to school	119	35.3
Always walk or ride to school	146	43.3
Neither	72	21.4
Total	337	

Table 3. Logistic regression on children's current decision to use active transport to school (always or never).

								95% CI for OR	
Variable		B	SE	Wald	df	Sig.	OR	Lower	Upper
Distance from school	Less than 1 km			47.526	3	.000			
	1–2 km	−19.543	6200.606	.000	1	.997	.000	.000	.
	2–4 km	−22.023	6200.606	.000	1	.997	.000	.000	.
	Greater than 4 km	−23.740	6200.606	.000	1	.997	.000	.000	.
Children's perceptions of risk	Stranger Danger (2 item scale)	.178	.249	.509	1	.475	1.195	.733	1.948
	Road Safety	1.156	.308	14.069	1	.000	3.176	1.736	5.810
	General Safety (2-item scale)	.578	.236	6.011	1	.014	1.783	1.123	2.830
Gender	Female			5.259	3	.154			
	Male	.878	.431	4.154	1	.042	2.405	1.034	5.595
	Non-binary	.247	.960	.066	1	.797	1.280	.195	8.406
	Prefer not to answer	1.341	.953	1.980	1	.159	3.822	.591	24.730
Constant	Constant	14.389	6200.607	.000	1	.998			

of 1.78 for every unit increase on the general perceptions of safety scale. Boys were 2.41 times more likely to always walk or ride to school than girls in this data set.

The model was found to be statistically significant, $\chi^2(9, N = 252) = 168.37$, $p < .001$ and explained 48.7% (Cox and Snell R Square) and 65.3% (Nagelkerke R Square) of variance in whether the participant used active transport to school or not, and correctly classified 82.1% of cases.

Analysis of crossing risk ratings

Signalized pedestrian crossings were used as a reference and had an average risk score of 1.91. The GLMM analysis (see Table 4) showed that there was no constant difference between children and parents ($p = 0.26$) but rather varying differences between them for all types of crossings except for signalized intersections (both at intersections and mid-block, $p = 0.98$). Parents rated crossings as riskier than children, the difference increasing (from 0.52 to 1.14 on the scale) as levels of protection at the crossings reduced (see Figure 3).

Children and parents rated signalized crossings at mid-blocks as the least risky type of crossing, with a risk score reduced by 0.20 ($p < 0.001$). Raised zebra crossings were found

Table 4. Generalized Linear Mixed Model (GLMM). Effects of crossing and participant types on risk scores.

Crossing type	Estimate	95% Confidence Interval Low	95% Confidence Interval High	*p*-Value
Intercept (Signalized pedestrian crossing at intersection)	1.91	1.82	2.00	<1e-05
Signalized pedestrian crossing	−0.20	−0.31	−0.09	0.0005
Raised zebra crossing	0.31	0.11	0.51	0.0023
Zebra crossing	0.82	0.61	1.01	<1e-05
Refuge	1.82	1.61	2.01	<1e-05
Unprotected crossing at side road	2.38	2.18	2.58	<1e-05
Unprotected crossing	2.60	2.40	2.80	<1e-05
Raised zebra crossing: Children	−0.52	−0.73	−0.30	<1e-05
Zebra crossing: Children	−0.81	−1.02	−0.60	<1e-05
Refuge: Children	−0.88	−1.09	−0.67	<1e-05
Unprotected crossing at side road: Children	−1.30	−1.51	−1.09	<1e-05
Unprotected crossing: Children	−1.14	−1.35	−0.93	<1e-05

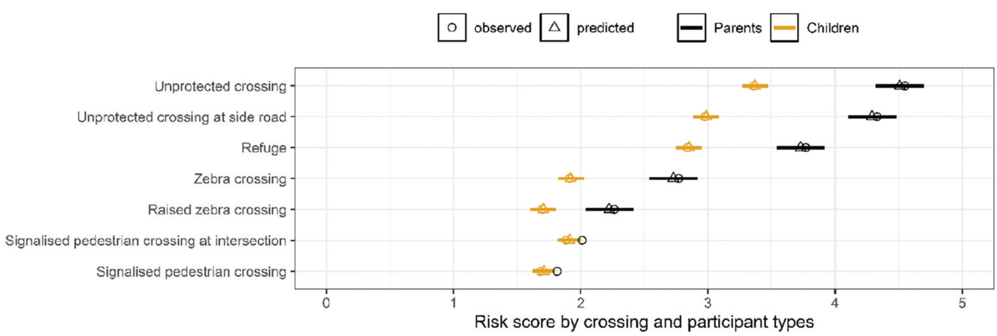

Figure 3. Crossing risk score (circles) as assessed by parents (black) and children (orange), with estimates (triangle) and 95% confidence intervals from the GLMM.

to be riskier by parents by 0.31 (p = 0.002), but not by children (–0.21, p < 0.001), who rated them as similar to signalized pedestrian crossings.

Zebra crossings were rated as similar to signalized intersections at crossings by children but perceived as 0.82 points riskier by parents (p < 0.001).

The riskiest types of crossings as rated by children and parents were refuge crossings, unprotected crossings at side road and unprotected crossings. Children and parents rated refuge crossing as .94 (p < 0.001) and 1.82 (p < 0.001) points higher on the risk scale, respectively. Children rated unprotected crossing at side road as similar to refuge crossing, but parents found them risker by another 0.56 points (p < 0.001).

Unprotected crossings were rated as the riskiest by both children and parents, although parents rated them at the same level as unprotected crossings at side roads. Children rated such crossings as 1.46 points higher than signalized intersections (p < 0.001).

Overall, parents rated the untreated crossings, and refuge crossings much riskier than how children perceived them. This suggests that the parents and children generally agreed on the perceived risk levels of signalized crossings, but there was a discrepancy when it came to crossing types that offered no prioritization for pedestrians).

Qualitative data: open-ended questions

The thematic analysis resulted in eight broad themes being identified from the children's and parents' responses to the open-ended questions. Table 5 provides an overview of these themes.

Seventy-one of the children responded to the open-ended questions suggesting that they did not have any suggested improvements or were satisfied with the current state of affairs. These were comments such as *'None' or 'No I wouldn't change much.'* In comparison, only one of the parents responded with a 'no' type of response. Parents' responses were typically longer and more descriptive than children's responses.

Improved public transport

One of the most common comments from both children and parents was the request for improved public transport. Some of the comments from children were as follows: *'I would like to change to a bus but there aren't any stops close enough to my house'* and *I wish there were buses that went from straight from Chancellor to* [Suburb Name Redacted], *because it's hard for me and my family to get to school. I get home at 4:30 every day and it's so annoying:*

Table 5. Overview of the themes identified from the responses to the open-ended questions by children and parents.

Theme	Children	Parents
Improved Public Transport	Yes	Yes
Desire for Car Travel	Yes	No comments
More or Improved Car-Oriented Infrastructure	Yes	Few comments aimed at drop-off zone
Desire to Walk and/or Cycle	Yes	Yes
Longer Crossing Time on Signalized Crossings	Yes	No comments
More Active Transport Infrastructure	Yes	Yes
Speed Limit Reduction	No comments	Yes
Stranger Danger	1 Comment	2 Comments

(Comments from parents included *'More buses to eliminate cars at school. Buses are too full and kids are standing which is unsafe'* and *'More buses. Less traffic around school'*.

It is evident from the comments that both parents and children felt that the current bus service was insufficient. Research in Australia has shown that buses are effective in reducing traffic congestion, even if they need to stop and start at bus stops (Nguyen-Phuoc et al. 2018). Further Australian research has found that bus prioritization strategies such as bus lanes have road safety benefits in terms of reduced crashes and trauma (Goh et al. 2013). Therefore, the desire from the school community for improved bus services is clear and prior research suggests that there could be considerable benefits in terms of reduced congestion and improved safety if more bus services are provided.

Desire for car Travel

There were some comments from the children that suggested that they would like to travel by car. For example: *'I will be driving soon alone as I am a year 11 student so that is how I will get to school when I get my Ps'* and *'I wish my mum could drive me to school because I get very sweaty in the morning'*. As children approach adulthood, it is understandable that they are excited to attain a driving licence and start driving a car. Another benefit is the comfort of car travel. Interestingly, none of the parents mentioned the desire for car travel. Presumably, the parents are in a position to travel by car if they so wish, unlike children. Furthermore, there were far more comments from both children and parents that called for improved active transport infrastructure and public transport services suggesting that there was greater desire for public and active transport improvements.

More or improved car-oriented infrastructure

There were some comments from children that had a focus on expanding the infrastructure to facilitate more cars:

> I would love to be able to park in the staff parking at school, the parking distance from my school is so far, I drop other siblings in the morning and by the time I get to *[name of road redacted]*, I may as well not come because I'm late and will get a detention anyway' *and*: 'more roads or wider roads so there is less traffic on the way to school and so it doesn't take as long in the mornings.

Parents, on the other hand, mentioned improving better drop-off system and spaces: *'Better drop off and pick up system to ease congestion'* and *'The school needs a dedicated drop and go area. This would allow traffic to flow and easy access into the school for the students'*.

It has been established for over 70 years that increasing the capacity of roads leads to increased volumes of traffic, and not improving journey time (Goodwin 1996; Næss, Skou Nicolaisen, and Strand 2012). Therefore, other traffic interventions which encourage active travel, such as drop-off spots, whereby parents can drop of their children by car at locations situated 500–800 metres from the school can be an effective way of introducing increased levels of physical activity among children, as well as a way of better managing school-affected traffic (Bejarano et al. 2021; Vanwolleghem et al. 2014). Similarly, a school in Merri-bek City Council in Victoria, Australia, has been trialling an 'Open Streets' programme (Bicycle Network 2022), comparable to the City of London, UK's

'School Streets' programme which has launched at 500 schools since 2017. These programmes restrict access to cars entirely on streets in front of schools during pick-up and drop-off times. This has led to significant increases in ATS, reduced travel by car to schools and significant reductions in tail pipe emissions (Bicycle Network 2022; MoL 2022).

Desire to walk and/or cycle

The children expressed a desire to either walk or cycle to school with comments such as *'I would love to ride or walk to school but I live 15 km away, and I have to cross the highway'* and *'YES I wanna walk to school'.*

Parents also expressed enthusiasm for more walking and riding with comment such as *'Would love for them to be able to walk or ride/scooter safely to school by themselves in the near future'*. There was a clear emphasis on safety issues as being a hurdle to walking and riding more: *'We'd love to walk or ride more often however with 4 kids and the lack of visibility crossing University Way is an issue plus the speed at which cars are buzzing down. People that reside from Fitzwilliam & Albany Streets have to cross University Way to get access to the service road in able* [sic] *to get to school. This is extremely dangerous for kids!'*

The comments from the participants of this study align with the findings by Zaragoza et al. (2020) who found in their survey that children's need for autonomy, relatedness and competence in relation to ATS, as well as perceived behavioural control, and perceived environmental barriers predicted children's intentions to ATS. From the comments in the current study, it is apparent that the perceived environmental barriers play a big role in discouraging ATS, despite much interest and desire. The distance between school and home also acted as a barrier for some students.

Longer crossing time on signalized crossings

Many of the children commented that they would like the time allocated at signalized crossings for pedestrians to cross to be longer than what it is currently: *'Make crossing intervals longer'* and *'Longer crossing time 15–20 seconds'*. Interestingly, none of the parents commented on this.

This discrepancy between parents and children highlights that the design of the streets insufficiently considers the user experience of children. In Australia, the walking speed used for determining the walk time on intersections is 1.2 m/s (Truong et al. 2018), although Schwartz, Rozumalski, and Trost (2008) found the walking speed of developing children ranged between 0.11 and 2.56 m/s. The choice of using a 1.2 m/s standard is possibly not an inclusive choice, as many people, for example, younger children, the elderly and people with mobility impairments, may need more time. Longer crossing times at signalized intersections would allow for children who walk slower to cross safely, as well as for ensuring that larger groups of people crossing have enough time to cross.

More active transport infrastructure

There were many comments from both parents and children requesting improvements to the active transport infrastructure. One of the most commonly occurring suggestion for improvement was the request for better and more footpaths and cycleways: *'Proper paths that are of a width that can fit pedestrians and bikes. I am required to walk through a part of the Uni where there is no actual path'*. And: *'Create separated bike pathways as most of the* *near misses I've had to either hurting people or being hurt are when walking pedestrians or bike riders are not looking or it is too crowded due to the number of people.'*

Children also identified the need for safer crossings: *'more zebra crossings or safer pathways'* and: *'More signalised crosses, Around corners there should be traffic lights because when I'm riding I can't see the upcoming traffic.'*

Similarly, parents also expressed the need for safer paths and crossings: '*Safer paths and crossings. University way is like a highway these days with the speed and amount of traffic in the area. There are only footpaths on one side and the road is too narrow'*. In particular, parents highlighted the need for separated bike paths: *'Bike ways on the road do not work for young children due to the risk that they will fall or swerve accidentally onto the road. Bike ways for primary aged children need to be a separate path off the road. Currently University way path is on the same side as all the houses and other streets'*. Another complaint from the parents was the lack of a connected active travel network: *'Better pathways that link up. Some paths stop and the kids have to cross a road to get to another path'*.

The feedback from both parents and children clearly point to the need for a well-connected footpath network, as well as a separated bike path network. The importance of building cycle paths such that they are physically separated from motor vehicle traffic, has been well documented in the literature as being important predictors of higher modal share of cycling and cycling comfort (Buehler and Pucher 2012, 2009; Zhibin et al. 2012). A systematic review and meta-analysis by Pan et al. (2021) found that bike lane access increased children's physical activity, and that degree of separation of the cycle path, as well as evenness of the path were positively related to adolescents' intentions to cycle. Investing in cycling infrastructure in Queensland has been estimated to have an investment-to-return ratio of 1:5, with benefits being in the form of health, reduced traffic congestion, among others (TMR, Department of Transport and Main Roads 2022). Therefore, there is strong evidence from this study and existing literature to support increased investment in cycling infrastructure for a wide variety of benefits, including economic, health, congestion, and children's independent mobility.

Hull and O'Holleran (2014) conducted a literature review on how the design of cycle paths can encourage riding. Some of the main recommendations were to ensure the paths are wide, provide separation wherever possible; avoid discontinuities of cycle lanes at hazardous locations; and refer to the Dutch design manual for active transport when building active transport infrastructure since the Netherlands is widely regarded as setting world-leading standards in cycling infrastructure (CROW n.d.; van den Berg 2015). These recommendations are in line with the comments from parents and children in the current study.

Speed limit reduction

Parents, but not children, often requested measures to reduce car traffic speed:

> Lower the speed limit on University Way. More school crossings and footpaths' *and* '40 km school zones from Albany Street on University Way to Oxford Street cars travel way to fast.

There is clear evidence of an exponential link between the speed of motor vehicles and crash rates (Aarts and Van Schagen 2006). A meta-analysis by Hussain et al. (2019) found that an increase of 1 km/h increases the odds of a pedestrian fatality by 11%, and so speed limits of no more than 30–40 km/h are recommended in areas with high pedestrian traffic. A qualitative study by Cleland et al. (2021) has found that speed limit reductions to 20mph (32 km/h) in Belfast, Northern Ireland led to increased perceptions of cyclist and pedestrian safety. The roads around the study-site area are typically 60 km/h, with small sections in front of schools being school zones which reduce the limit to 40 km/h during pick-up and drop-off times. However, to reduce the number of child deaths and injuries, it is recommended to lower speed limits to no more than 30–40 km/h in all urbanized and residential areas (Pilkington 2000).

Stranger danger

There were just two comments from children regarding stranger danger and one from a parent. For example, one child wrote, *'Probably more open areas to reduce the chances of kidnapping'*.

The comment from the parent was

> Walking/ cycling through USC *[University of the Sunshine Coast]* is fine at peak times but if kids have activities before or after school it can feel unsafe- USC can be quite quiet- need more activation to make it feel safe, also at the transit station - this is not a safe location for a transit station there are at times very poor natural surveillance - both at the station and down the bus lane connecting to primary school drive (this comment relates more to weekend/ holidays/ after hours than school peak hours)

The low number of comments suggests that stranger danger is not a primary perceived barrier to ATS, supporting the quantitative analysis results in the current study that stranger danger was not a significant predictor of ATS. However, as the comments, allude, it is important to consider *crime prevention through environmental design*, by considering the presence of *natural surveillance* (Subbaiyan and Tadepalli 2012). This means making public places more visible to other people, to increase the perception of increased personal safety. While stranger danger does not appear to be a main concern for participants in the current study, future interventions such as new bike paths could consider the natural surveillance features to enhance the feeling of safety.

Discussion

The current study was conducted to investigate which factors predict children's choices to use active transport to get to school; what parents and children desire in terms of commuting to school and how they perceive the different pedestrian crossing types in terms of perceived risk; and what the challenges are that parents and children perceive in the commute to school and what they feel is required to encourage children to use active transport to go to school.

In response to the first research question, the data showed that distance and perceptions of danger from strangers did not predict the choice to use active travel to get to school. On the other hand, perceptions of general safety, road safety and gender were significant predictors of active travel use. In response to the second research question, the analysis of the risk ratings found that controlled crossings (such as raised zebra crossings and signalized crossings) were perceived as much safer than crossings where no priority is given to pedestrians, such as refuge islands and untreated crossings. Raised zebra crossings were also found to be perceived as significantly safer than unraised zebra crossings.

In response to the third research question, the responses to the open-ended questions suggest a strong demand for safer active transport infrastructure, such as more footpaths and separated bike paths that are well connected and sufficiently wide, longer crossing times on signalized crossings, as well as speed limit reductions. Interestingly, children often mentioned the need for more time at signalized crossings to be able to cross which was not mentioned by parents. Conversely, parents frequently requested speed limit reductions which children did not.

While parental anxiety relating to stranger danger and road safety has long been cited as motives to restrict children's use of active transport (Carver et al. 2010; Hillman 1990; Johansson 2006), the results from the current study show that children's own perceptions of road safety predicted their choices in using active transport to school. While perceptions of road safety have also been cited before as a barrier to ATS, this is one of the first studies that has identified that children themselves – and not just the parents – are avoiding ATS due to perceptions of road danger. As the international review by Pucher, Dill, and Handy (2010) has found that a collection of interventions, in particular, active transport infrastructure is required to increase levels of active transport use, these findings build the case for urban design to be adapted to enable safer active travel, not only so that parents feel safer but so that children can feel safer to engage in ATS. The current study also identifies preferences in crossing types, as a point of focus for improving urban design to enhance the user experience of active transport users.

Risk perceptions of crossing types

The current study found both parents and children want safer active transport infrastructure, including safer crossings. MacGregor, Smiley, and Dunk (1999) write that parents often overestimate the cognitive abilities of children to cross safely, as many children do not conduct adequate visual searches before crossing such as looking behind for turning traffic. Furthermore, prior research on uncontrolled refuge island crossings has shown that the intervention has clear flaws, as pedestrians accept smaller gaps when crossing from the island to the kerb leg, in comparison to crossing from the kerb to the island (Saleh, Grigorova, and Elattar 2020). Wann, Poulter, and Purcell (2011) conducted perceptual tests showing that children may not be able to detect vehicles approaching at speeds more than 20 mph (32 km/h) due to the visual looming effect, and adults have similar challenges (Onelcin and Alver 2015). Consequently, urban designers should ensure that pedestrians are only expected to cross where speed limits are no higher than 32 km/h, or a controlled pedestrian crossing is provided.

Both children and parents perceived raised zebra crossings as safer than unraised zebra crossings. Interestingly, children rated raised zebra crossings as safer than signalized crossings, whereas parents rated signalized crossings as safer than raised zebra crossings. This could be because children use this type of crossing more frequently than parents and so have different perspectives. Furthermore, children frequently complained about not having enough time to cross at signalized intersections, suggesting another reason why children may prefer raised zebra crossings. Makwasha and Turner (2017) found that crashes reduced by 63% at raised zebra crossings in Australia, thus the effectiveness of raised pedestrian crossings in improving road safety and reducing car traffic speeds has not only been demonstrated internationally (Cafiso et al. 2011; Gitelman et al. 2017; Pratelli, Pratali, and Rossi 2011) but also in the Australian context (Candappa et al. 2014; Makwasha and Turner 2017) and so are a preferred choice as a crossing type.

Distance to school and active travel

The finding that distance did not predict active travel to school, is comparable to the findings by Zaccari and Dirkis (2003) who found that at a school in Sydney, 80% of children lived within 1 km of school but over 62% travelled to school either by car or bus. In contrast, Kathrin, Grasser, and van Poppel (2022) found that Austrian children who lived closer to the bus stop or the school, in either duration or distance, were more likely to use active travel. The results from this study and the findings of previous literature suggest that, unlike some other countries, the decision to not walk or ride to school is not due to the physical distance, but due to other factors, such as perceptions of dangerous traffic environment.

Gender and active transport

The analysis in this survey found that boys were more likely to use active transport to school than girls. Marzi, Demetriou, and Reimers (2018) found in their systematic review on gender, the environment and children's independent mobility, that lower levels of girls' independent mobility in comparison to boys were mainly attributed to the design of the neighbourhood, including the walkability of the neighbourhood. Improving walkability has been found to not only increase the overall number of people walking but also the proportion of women walking, compared to men (Jensen et al. 2017).

The proportion of females cycling in Australia is much lower than males, at approximately 20–22% (Debnath, Haworth, and Heesch 2021; Garrard, Rose, and Sing Kai 2008). However, in high cycling countries where cycling infrastructure is more present, women cycle in equal proportion to men, and in the case of the Netherlands and Japan, at higher rates than men (Goel et al. 2022). Garrard, Rose, and Sing Kai (2008) refer to the gender differences in average averseness to risk and find that participation in cycling by women increases dramatically when cycling infrastructure provides high level of separation from motor traffic.

Urban design and active transport

Prior research and the results from the current study provide ample evidence that there is much demand for improvements to active transport infrastructure to enable higher rates of ATS. Rothman et al. (2014) conducted a systematic review of urban design and correlates of safe walking, particularly relating to child pedestrian injuries and found that built environment features that calmed traffic, such as roundabouts and features that separated children from the road, such as parks and playgrounds both encouraged rates of walking and reduced injuries. Pont et al. (2009) also found in a systematic review that urban design attributes such as short travel distances, presence of recreation facilities (such as parks) and the presence of walking and cycling paths were linked to increased

Figure 4. Pictures of roads with poor pedestrian infrastructure around Sippy Downs, Queensland. The top picture shows an intersection with a road with multiple lanes of traffic, speed limit of 60 km/h. No controlled pedestrian crossing is provided. The middle picture shows an intersection with absent facilities for pedestrian crossings. The bottom picture is in front of a school and is an untreated crossing that connects to the bus stop on the other side of the school. The crossing is obscured, at the speed limit is 60 km/h, with two lanes of traffic in each direction.

active travel by children. Footpaths in the Sunshine Coast are currently poorly considered add-ons to car-centric infrastructure, rather than designed spaces that create a sense of place and safety (see Figure 4) (Council, Sunshine Coast Regional 2011; Stevens and Salmon 2014).

As Stevens and Salmon (2014) highlight, roads in Queensland are still focused on the technical functions of motor vehicle traffic flow, rather than being designed as socio-spatial systems. The consequence is the unwelcoming urban design for people walking and cycling.

Implications and recommendations for future research

Practical implications to increase ATS include speed limit reductions, longer crossing times at crossings, better and more connected separated bike paths and footpaths, as well as safer crossings which would all improve the urban design in terms of walkability and cycle-friendliness. Crossings that control traffic, such as signalized crossings or raised zebra crossings, are perceived as much safer, particularly given the evidence that people, particularly children have trouble judging what is a safe gap to cross (Onelcin and Alver 2015; Wann, Poulter, and Purcell 2011).

The responses from the current study, and prior research suggest providing controlled crossings for pedestrians as frequently as possible, such as signalized and raised zebra crossings, and avoiding uncontrolled crossings such as untreated crossings (side roads and mid-block) and refuge islands, particularly where speed limits are higher than 32 km/h. This recommendation is in contrast to current practices in Queensland, wherein refuge islands are frequently used as crossing facilities on roads with posted speed limits of 60 km/h because zebra crossings are not recommended on roads with speed limits higher than 50 km/h (Austroads 2021; TMR 2021), and signalized crossings are much more expensive to instal then refuges or zebra crossings. Refuge islands could be considered discriminatory against people with visual impairments (Disability Discrimination Act 1992) as they are not able to safely negotiate uncontrolled crossings (Parkin and Smithies 2012). Furthermore, the findings that children are unable to safely negotiate uncontrolled crossings (Onelcin and Alver 2015; Wann, Poulter, and Purcell 2011) could indicate that current practices of providing uncontrolled crossings where traffic speeds exceed 32 km/h is discriminatory as per the Age Discrimination Act 2004). This is the current state of affairs in the current study site, many of the roads near the schools are posted at 60 km/h, and only the section directly in front of the school is reduced to 40 km/h during the beginning and end of school days. Thus, it is recommended to either provide controlled crossings at all intersections and/or reduce speed limits to lower than 32 km/h in order to reduce road trauma (Bornioli et al. 2020; Mako 2015). An alternative intervention is School Streets, which make the streets in front of schools car-free zones during pick-up and drop-off hours (MoL 2022).

Further research in active transport in Australia needs to be increasingly linked to public health, environmental health and the economy (Beck et al. 2022). The before, after and long-term levels of ATS after the installation of active transport infrastructure upgrades in the bikeable radius around a school would also be beneficial to evaluate future implemenations.

Strengths

The use of online surveys meant that a large sample size was included in the data set, and made it possible for participants to express their views anonymously, encouraging candid responses (Braun et al. 2021). The large sample sizes suggest high representativeness of the school community. This study also successfully employed a mixed-methods approach, allowing for a richer understanding of the research topic, based in part on local knowledge and experiences of parents and children. Furthermore, this study is novel in seeking the perspective of children themselves in what they find the barriers and opportunities are for increased active travel to school.

Limitations and suggestions for future research

This study did not investigate many details of how to make crossings, intersections and roads safer for vulnerable road users. For example, the use of curb extensions or parking restrictions near zebra crossings has been shown to be effective in improving the safety of zebra crossings (Bella and Silvestri 2015). Furthermore, many of the intersections in the study site have slip lanes which are known to be dangerous for pedestrians (Jiang et al. 2020). Thus, guidelines on the details of designing active transport infrastructure can be found elsewhere (CROW n.d.). This study also only surveyed one school area in Queensland, Australia, and so further research may be required to understand what the barriers to ATS are in other parts of the world.

Among the parent respondents, there was a much higher proportion of females than males, which suggests that fathers' perceptions may have been underrepresented in this study. On the other hand, Australian mothers are much more involved in childcare duties than fathers and so this gender imbalance is not necessarily a surprise and mothers may be more involved in decisions on how the child commutes to school (Craig and Mullan 2011).

The current study did not ask participants about their preferences and risk perceptions of cycling-specific infrastructure such as bike racks and segregated and painted bike lanes. Unfortunately, this topic was out of scope of this study, but it is recommended that future research include preferences and risk perceptions of various types of cycling-oriented infrastructure.

Conclusion

This study found considerable desire among the school community to walk or ride to school, yet perceptions of road safety were the key barrier, rather than fear of strangers or distance from the school. Both children and parents were similar in their perceptions that controlled crossings, such as signalized crossings and zebra crossings (particularly raised zebra crossings) were much less risky than uncontrolled treatments such as refuge islands and untreated crossings on side roads and mid-block. The thematic analysis of the responses to the open-ended questions highlighted that both parents and children desire improvements in active transport infrastructure, both in terms of connectedness of routes as well as the provision of safe crossings, wide footpaths and separated bike paths. The findings suggest that improvements to the urban design of the schools and surrounding cyclable area, particularly in terms of active transport infrastructure would address concerns of poor road safety, which in turn could increase participation in active transport to school.

Author contribution

RS, survey design, identified themes inductively; quantitative analysis, write-up; PO, survey design, coordination of survey distribution, funding, write-up; VT, survey design, reviewed themes for consistency, write-up; GL, survey design, quantitative analysis, write-up.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Motor Accident Insurance Commission (MAIC) and the Sunshine Coast Council (SCC).

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