Children's Cycling in Australia: A Review of Determinants, The Role of Social Connectedness and Implications for Policy and Practice

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Abstract

Children's physical health, their emotional health and social wellbeing is reliant on their ability to travel independently and collectively with other children. Children's bicycle riding, particularly riding to school, is increasingly recognized as important, yet in Australia very few children cycle to school. As part of a broader project on children's independent mobility, this research seeks to identify the determinants of child bicycle riding and to explore associations between cycling and social connectedness. The intent is to identify if and how social environment influence children's cycling behaviors and how, in turn, cycling may help shape children's social connections, within particular neighborhood types. Theoretical insights into the roles of lead users and opinion leaders, derived from Kratzer and Lettl (2009), are fused with early experiences in the CATCH (Children's Active Travel, Connectedness and Health) project, to explore dimensions of cycling take-up and usage amongst children. These help frame a research agenda around child cycling and social connectedness that focuses on the phase of child development (aged 7-11 years) when children first develop key social perspectives and are given 'licenses' by parents for independent mobility. The scope and parameters for this research agenda are explored in detail. The questions raised, if answered, have the potential to significantly improve bicycle promotion activities and other policies targeting children's travel behavior.

1. Introduction

Cycling is a healthy, safe, space and energy efficient mode of transport, which is generally affordable to a large majority of households (Gatersleben et al. 2007; Lumsdon et al. 2001; Moudon et al. 2005). If carried out on a regular basis, cycling as a form of moderate exercise has significant physical and mental health benefits (Armstrong 1993; Bringolf-Isler et al. 2008; Cooper et al. 2008; Ogilvie et al. 2011; Telfer et al. 2006; Unwin 1995). Regular exercise especially amongst children increases attention spans, improves moods and reduces anxiety and if undertaken independently and collectively with other children can enhance a child's social skills and social networks (Bixler et al. 2002; Brown et al. 2008; Marketta 2004). A key opportunity for children to cycle regularly is their travel to school.

Children have recently been brought to the forefront of transport and health research due to the significance of active school travel in mitigating the prevalence of obesity and being overweight (Boarnet et al. 2005; Bringolf-Isler et al. 2008; Buliung et al. 2009; Cooper et al. 2005; Mackett et al. 2005). The past few decades, have seen a declining trend in the use of walking and cycling to school (active modes) in favour of the private car and at the same time there have been increases in the obesity levels of children; a phenomenon more prevalent in the Western countries. The journey to school, therefore provides a significant opportunity for children to increase their daily levels of physical activity by walking and cycling (Larsen et al. 2009). In addition to the health and social benefits arising from active travel to school,

understanding children's travel behaviour has numerous and significant implications for transport planning.

Motorised school travel increases traffic flow and congestion along streets in the vicinity of and leading to schools (McMillan 2007), creating unsafe travel environments for those children who walk and cycle. Parents who chaperone their children to school, endure significant time and money in terms of escort time, congestion, resource and pollution costs (Tranter et al. 1994). The schedule of time and travel management for parents and in particular mothers, hinges on commitments relating to children's travel which often renders traffic management initiatives targeting adults such as carpooling programs unsuccessful (McDonald 2005). Furthermore parents who drive their children to school may forge unhealthy travel patterns for their adult life by "reinforcing unsustainable transport habits in children, which are likely to lead to car-dependent social values in adulthood (Tranter et al. 2001). "The implications and outcomes of school-related travel, however, are under-researched despite their centrality to the lives of children, parents and teachers"(Kearns et al. 2003, pg 290).

In addition to health benefits and broader implications of increased active travel on the wider energy use and greenhouse emissions, children cycling to school has significant benefits in strengthening the community through increased social interactions on streets and within neighbourhoods. As the number of children cycling increases, so does the notion of community safety, as 'peopled' places are safer places (Garrard 2009). Though the benefits of cycling are numerous, the low levels of cycling in many Western countries highlights that there are factors which impact cycling decisions and which have not been addressed to successfully increase children's cycling to school. This paper provides a systematic review of barriers and enablers for cycling, and the interrelationships between cycling and social connectedness. The preliminary findings from the CATCH/iMATCH data collection in Melbourne provide further insight into children's cycling to school in the Australian context.

2. Methods

Relevant literature for this review was sourced from key word searches in the databases: Web of Science; Science Direct; PubMed and Google Scholar. Search terms included various combinations and synonyms of children, cycling, active travel, social connectedness, transport, school, non-motorized transport, spatial travel and independent mobility. Abstracts were perused and any article which did not meet the following inclusion criteria was excluded from the review:
- Age group: Children and young people aged 5 – 18 years
- Subject: Determinants of cycling as an exclusive mode of transport for children or as a combined modal split of children's active travel
- Type: Cross sectional studies providing empirical evidence of cycling status within the children's active travel realm,
- Full paper articles excluding abstracts only
- Spatial context: studies undertaken in urban settings, rural focused studies have been excluded

The only exceptions to the above criteria were studies relating to children's social connectedness. No single study has explicitly delved into children's cycling and its relationship with social connectedness. Any study which explored an aspect of children's

active travel and its implications for children's social connectedness was included in the review.

3.   Cycling as a Mode of Transport for Children

Children's use of bicycles as a transport mode is low in most Western countries. Cycling constitutes approximately 1 percent of all school trips in the US (National Center for Safe Routes to School 2011); 2 percent in the UK (Department for Transport 2011) and 4 percent in Australia (Australian Bureau of Statistics 2011).   The exceptions to these low levels of cycling to school in Western countries are found in Europe. For example, in Denmark and the Netherlands, cycling constitutes approximately 40 percent of the mode split for school travel (D'Haese et al. 2011; de Vries et al. 2010). Not only have these countries managed to maintain their cycling culture over the past few decades, they have also effectively addressed children cyclists' concerns about vehicular traffic flow, provision of adequate cycling infrastructure and social concerns of parents relating to children's safety (Andersen et al. 2009). In countries with very low levels of cycling but that have more conducive physical, social and policy environments for cycling have fared much better. Table 1 provides a summary of known child cycling behaviours at population level for key Western countries.

*Table1: Cycling as a Mode of Travel for School Children in Selected Countries*

Country	City/ Region	Type of study	Sample Size	Percent Cycling Trips	Source / Year
Australia	Nationwide	National Cross sectional survey	25,307	4%	(Australian Bureau of Statistics 2011)
	Brisbane, Australia	Cross sectional survey of primary school children and their parents	248 student and 128 parent surveys	4.7% to and 4.3% from school	(Ridgewell et al. 2005)
	Perth, Western Australia	Cross sectional survey	1197 students attending 25 primary schools	31.2% of boys and 14.6% of girls cycled $\geq$ 1 trip per week	(Trapp et al. 2011)
United Kingdom	Nationwide	National cross sectional survey	18,791 students	1.9% overall. 1% students aged 5-10yrs and 2% aged 11-16 years	(Department for Transport 2011)
	15% of the 15 NRSI disadvantaged areas)	Stratified cross sectional sample of disadvantaged areas	4286 children aged 9-14 from 37 schools	2%	(Christie et al. 2011)
	Norfolk	Cross-sectional study of 9-10 year old students.	2012 participants	9%	(Panter et al. 2010)
United States	Nationwide	2009 National Household Travel Survey (NHTS)		1%	National Center for Safe Routes to School, 2011
	National Household Travel Survey	National cross sectional survey	8231 youth	0.8%	(McDonald 2008)
	North Carolina, 2001	Cross sectional survey of 2151 6th - 8th grade and 2297	4448 students.	3.4%	(Evenson et al. 2003)

Country	City/ Region	Type of study	Sample Size	Percent Cycling Trips	Source / Year
		9th-12th grade students			
	San Francisco Bay Area, 2007	Cross-sectional survey of parents of 10- to 14-year-olds	357 parents of 10–14-year-olds	5%	(McDonald et al. 2010)
Netherlands	Netherlands	Cross sectional survey of 10 disadvantaged neighbourhoods	216 boys and 232 girls with a mean age of 8.5 yrs	40%	(de Vries et al. 2010)
	Rotterdam	Cross-sectional study using ENDORSE survey data	1361 adolescents aged 12–15 years from 16 schools in Rotterdam	35% total. 54% native Dutch, 40% Western ethnicity and 18% non-western ethnicity adolescents, travel to school by bike at least 3 days/week	(Bere et al. 2008)
Belgium	East- and West-Flanders	Cross sectional parental survey	696 parents	38.1%	(D'Haese et al. 2011)
Israel	National Survey	Cross sectional questionnaire based survey of students and parents	1800 Jewish and Arab students aged 9-15	1% Arab and 2% Jewish students	(Elias et al. 2011)
Canada	City of London, Ontario	Cross sectional, survey of grade 7 and 8 students	614	2.8%	(Larsen et al. 2011)
Taiwan	Hsin-Chu technopolis	Cross sectional study - 13 to 15 years old students	1,610	15%	(Chang et al. 2008)
Spain	Cities of Madrid, Murcia, Granada, Santander and Zaragoza	Cross sectional survey- adolescents aged 13 – 18.5 years	2183	0.5%	(Chillon et al. 2009)

Children's cycling to school in Australia has experienced a substantial decline in recent decades though children's recreational cycling rates remain relatively high. At a national level, children comprise the highest participant group in cycling with two thirds of 5-9 year olds cycling during a typical week compared to only 9 percent of forty year olds (Munro et al. 2011). The percentage of children given permission to cycle by their parents in Canberra was much higher than German and English students, possibly due to the success of network planning in Canberra and greater distances of schools from residences (Tranter et al. 1994). The Australian Capital Territory (ACT) despite having a reasonable natural environment for cycling and strongly planned urban development has over the years shown marked decrease in cycling rates. Though there are differences in sampling and methods across studies, cycling rates from around 11 percent in selected schools in the early 1990s to only 4.7 percent across the ACT in 2011, albeit the latter is still higher than in many other Australian cities (Australian Bureau of Statistics 2011; Tranter et al. 1994).

The levels of children's cycling vary spatially amongst the various states and specific school/ neighbourhoods. However, though the figures are substantially different for adult and child cycling as modes of transport, the distribution is similar across the States, as shown in Figure 1. Northern Territory has the highest percentage of both children cycling to school (6.70 percent) and adults cycling to work (3.73 percent) whilst New South Wales (NSW) and Tasmania have low rates of both children's and adult cycling. These figures suggest that across these locations similar factors may be at play in determining children's cycling to school as for adult cycling to work.

Figure 1: State and Territory Cycling Mode Shares for Children's Journeys to Schools and Adult Journeys to Work[1]
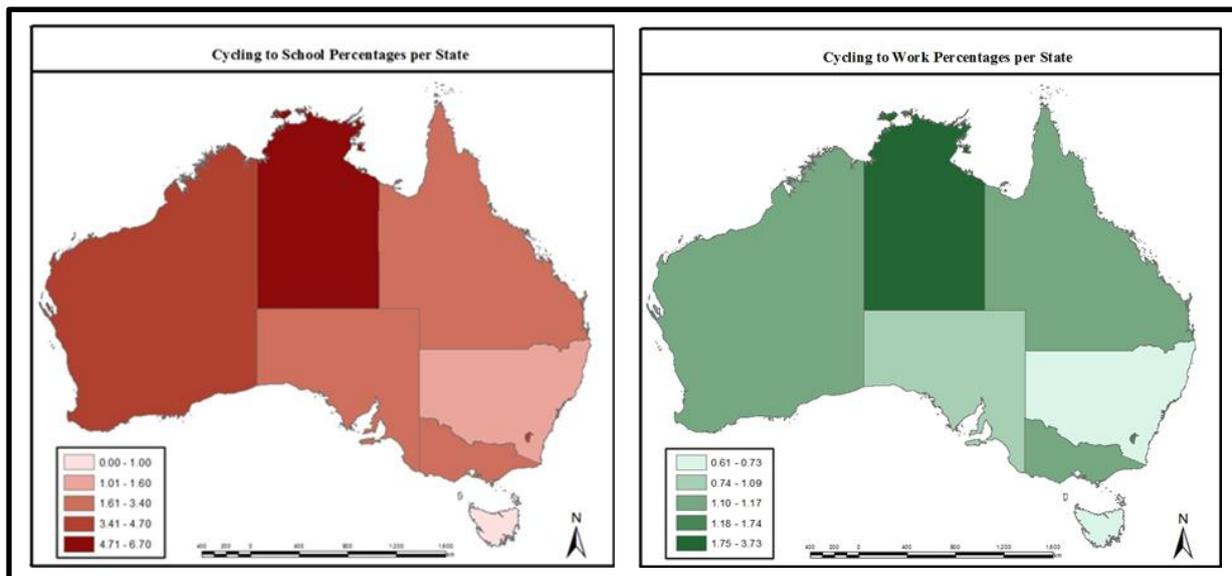
(Data sources: Australian Bureau of Statistics: Travel to School (2011) and Journey to work Census (2006).

4.   Determinants of Children's Cycling

The recent evolution of research on children's transport and in particular the correlates of active travel and its implications on their physical and mental health has seen a number of models and research frameworks being proposed for studying these interrelationships. The oldest and most used model to explain the multifaceted and interrelated factors that influence children's active travel decision is based on the social ecological model which was formulated by Bronfenbrenner (1979) and stipulates that a variety of environments influence behavior. Based on the social ecological model, children's active travel including cycling has been found to be correlated with a number of factors categorised using various classifications and titles such as personal, interpersonal, physical environment, policy, urban form, built environment, social, cultural and individual (Ahlport et al. 2008; D'Haese et al. 2011; de Vries et al. 2010; Forman et al. 2008; Panter et al. 2010; Timperio et al. 2004).

McMillan's (2005) framework varies from this approach, based on the premise that parents are the ultimate decision makers for their children's travel and that parental decision-making

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[1] These two cycling maps should be read with caution as different classification of cycling percentages have been used to show the spatial spread across States for the school and work categories

is based on a set of mediating and moderating factors. The main mediating factors arise from urban form and consist of elements such as real and/or perceived neighbourhood and traffic safety, whilst the moderating factors consist of parental attitudes and demographic features of the child (McMillan 2005). This framework has been adopted by some researchers whilst noting its limitations in explaining the travel behaviour of adolescents and older children whose travel behaviour may not be a parental decision in entirety.

With such models, it is important to understand the factors that act as barriers and enablers of children's cycling. In this review, these factors have been grouped into demographic, transport, environmental, economic, policy and social factors.

4.1 Demographic Factors

Demographic factors known to influence children's cycling include age, gender, cycling skills and cognitive awareness. Age has been found to be positively related to cycling amongst children (Fyhri et al. 2009). As children get older, they are given permission or 'licences' by their parents to travel independently. Generally, it has been found that children who are older, tend to cycle to school in larger numbers compared to younger children (Hume et al. 2009). However in Sweden, parental licences and restrictions have been found to have no significant impact on children's independent travel to school (Johansson et al. 2010).

Gender is perhaps an even stronger factor in cycling participation, with female students cycling to school in much lower numbers compared to male students (Babey et al. 2009; Evenson et al. 2003; Evenson et al. 2007). In Norfolk in the UK, only 6.2 percent of female students cycled to school compared to 13 percent of males (Panter et al. 2010). In similar research in Ontario, Canada, only 0.6 percent of females in the sample population cycled to school, as opposed to 5.6 percent of males (Larsen et al. 2011). In Davis, California, 30 percent of the female students were cyclists compared to 43.4 percent of the males (Emond et al. 2012). Based on the US national survey, males have been found to be two to three times more likely to bicycle to and from school than females (McDonald 2012). Gender differences were found to be more profound in 10-12 year old Melbourne children than 5-6 year old children with the possible explanation that parents could be accompanying 5-6 year olds irrespective of their gender whilst 10-12 year old boys have more freedom to travel by themselves (Timperio et al. 2004). This may relate in part to a female student's own preference for cycling to school and their cycling skills, but a likely issue is that parental 'licences' for independent mobility are often given later to female students than to male students, such that girls tend to have more restricted independent mobility and activity participation compared to boys (Fyhri et al. 2009). There have been very limited findings on the life cycle travel patterns of female student cyclists into adulthood, however lower cycling levels in female students would have significant implications on their cycling abilities and decisions as adults. Given the low participation of females in cycling to school, targeted interventions and policies to encourage female cycling may have substantial benefits in raising the levels of cycling to schools and in the longer term, impact female cycling culture to other destinations such as work.

Another significant correlate of children's cycling to school is the household structure. Children from single parent families bicycle to school less frequently than children whose parents are either married or living together (Martin et al. 2007). This may arise due to parents having greater time and personal resources to walk and cycle their children to school or to be at home to receive kids cycling home from school, and not have to wait to be picked

up from after-school care. Having siblings can be both a barrier and facilitator of children's cycling (Ahlport et al. 2008). In a US study households which had a larger number of children and therefore had a potential for older children to care for the younger siblings on their school trips were more likely to cycle and walk to schools (McMillan 2007).

Children liking to cycle and their confidence in cycling skills and abilities also influences their propensity to cycle to school (Emond et al. 2012). Parental perception of children's cycling skills and their ability to manoeuvre in traffic has strong significance in children being allowed to cycle to school (Christie et al. 2011). In Taiwan, it has been established that while 79 percent of the students owned bicycles and only 16 percent of the parents had objections to their children cycling, cycling abilities of students were generally poor with males having better cycling skills and greater participation in cycling to school than females (Chang et al. 2008). The low proportion of children cycling to school and for many other transport purposes in countries such as Australia and the US may mean these child populations have less developed skillsets than their peers in nations such as Denmark and the Netherlands.

Though a very small number of children currently cycle to school in most countries, when and where asked a much higher percentage of children would prefer to cycle (Larsen et al. 2011). This signals a latent demand for cycling and suggests a range of other socio-economic, physical and transport factors are limiting children's choices.

4.2 Transport Factors

One of the key factors in providing a conducive environment for children to cycle to school is the provision of adequate cycling facilities. The availability of on- and off-road cycling infrastructure and frequency of pedestrian crossings and traffic lights is strongly correlated with the high levels of cycling to school in the Netherlands (de Vries et al. 2010). The existence of safe and quite streets have been found to be of the greatest significance to children's cycling (Panter et al. 2010). Parental use of cars has been found to negatively correlate with Norwegian children's active travel including cycling (Fyhri et al. 2009). Available travel alternatives also play a significant role in children's cycling status and decisions (Bergström et al. 2003). In Western countries where cycling is not a significant mode, the choice to cycle is nestled amidst the decision on whether a student will travel by a car or other modes. Cycling is just one of the choices, in addition to walking and travelling by public transport, if one does not decide to travel by car (Inouye et al. 2008). The greater the number of vehicles per driver in a household, the lower is the correlate of children actively traveling to school (McMillan 2007).

Children have problems coping with vehicular traffic and are more vulnerable to traffic related injury and death. In Australia, traffic accidents were one of the key causes of death amongst children, in 2006 accounting for 15 percent of total mortality for children aged 1-14 years (Australian Bureau of Statistics 2007). Heavy and fast vehicular traffic flow has negative impacts on children's cycling through parental fears of traffic (Ahlport et al. 2008). Of the network factors, safe cycling infrastructure appears to be a particularly effective enabler. In a study of children's travel in Boston, Cincinnati and San Diego, cycling to school was strongly correlated with safety barriers (Forman et al. 2008). The length of local roads and the presence of traffic lights have not always been found to have significant associations with children's travel, whilst it played a greater role for older youth active travel and cycling in Melbourne (Carver et al. 2008). This may be a result of parents accompanying young

children in their cycling trips to school; however children who are old enough to travel by themselves are more able to use complex road environments on their own, such that traffic conditions, road safety and travel distances are of more significance to them.

4.3 Physical and Natural Environment Factors

Physical and natural environment factors are key correlates of children's cycling to school. Urban form, the layout and form of the urban environment at the neighbourhood scale, has long been recognised as a key determinant of travel patterns and mode choices of households and of adults (Badland et al. 2008; Frank 1996; Kwan et al. 2008; Lawrence D 2004; Matthew E 2002; Schwanen et al. 2001; Susan 1996; van de Coevering et al. 2006). A number of models have been developed to explain the interrelationship between urban form and transport with factors such as residential density, street connectivity, and land use mix identified as key urban form factors influencing adult travel. A smaller number of studies have applied these approaches to children's travel, and have reached similar conclusions in that urban form appears a key determinant of children's active travel (Boarnet et al. 2005; Gallimore et al. 2011; Lin et al. 2011; McMillan 2007; Ridgewell et al. 2009). The key urban form and built environment factors which influence children's travel include: distance from school; the presence of sidewalks; residential density; and street connectivity (Larsen et al. 2009; McMillan 2007).

Distance to school has been identified as one of the most significant factors influencing the decision to cycle to schools. Children are more likely to walk or cycle to school if they live less than two miles from school (Babey et al. 2009). In California, children who lived within a mile of school are three times more likely to travel by active modes to school than being driven (McMillan 2007). In Belgium, children are more likely to cycle to school, if they are residing at distances between 1.5 and 3 km from schools, with 86.8 percent of all children who cycled to school, living at distances of less than 3.0 kms from school (D'Haese et al. 2011). Sometimes it is the perception of distance rather than actual distance which influences active travel including cycling. Parents and children living within a 1.5 mile radius from a school in North Carolina identified distance as negatively impacting the children's decision to walk and cycle to school, despite living within reasonable walking and cycling proximity of their school (Ahlport et al. 2008). Perceived distances also significantly contributed to children's cycling in Davis, California (Emond et al. 2012).

Public schools have higher percentages of children actively travelling and cycling to schools compared to private schools, which likely results from the larger catchments and hence longer mean travel distances for students to private schools (Babey et al. 2009). For schools with large catchments it may be more important to provide cycling infrastructure given fewer students may be able to walk to school.

Higher residential densities bring land uses closer together, implying reduced trip distances from homes to schools, and residential density has been found to have positive impact on children's cycling to school (Larsen et al. 2011).

Investment in a cycling-friendly urban form, including on- and off-road facilities, and the encouragement of a cycling culture in the Netherlands has meant there has been little or no decline in cycling over recent decades. Approximately 50 percent of inner city school children cycle to school for distances as far as 10 kms (Bere et al. 2008). Even so, children's cycling to school in the Netherlands is strongly correlated with the built environment,

including provision of cycling infrastructure and the provision of greenspace (de Vries et al. 2010). Flanders, in Belgium, also has very high rates of children cycling to school and in addition to the children residing relatively close to the schools reducing cycling distances, other factors such as the mild climate, the relatively flat terrain and the dense network of cycle paths could be attributed to the higher levels of cycling to school (D'Haese et al. 2011). Many of the world's cities with the highest mode shares for cycling, including Amsterdam, Copenhagen and Shanghai, are all essentially flat.

Land use mix allows additional recreational, social and retailing opportunities, including open spaces, that a child has access to enroute to schools. Land use mix and the presence and use of recreational and green spaces has positive correlations with cycling to school.

The design of streets, beyond the availability of cycling infrastructure, traffic speeds or volumes, is also thought to influence behaviour. It is difficult to detach factors such as street surveillance from street volume. However, McMillan (2007) noted that proportions of streets with more than 50 percent of houses containing windows facing the street was positively correlated with active travel. Secluded areas along school routes imply that there is a lack of observation of children cycling independently raising parental concerns.

Natural environment influences include topography, as discussed earlier, weather extremes and tree cover in form of the presence of street trees. Weather and climatic conditions and associated perceived comfort in cycling are correlates of cycling to school. In the European winter, cycling to school tends to decline and results in mode shifts to walking (Fyhri et al. 2009). The presence of street trees provides a more temperate cycling environment in countries with high temperatures.

4.4 Economic Factors

The socio-economic status of a child's parents influences the number of private vehicles that a child has access to, which has implications on their travel to school mode choice. Maternal professional status and parental education have been found to be negatively correlated with cycling to school implying that the higher a mother's professional status and the higher the parent's education, the less likely it is for the child to cycle to school (Evenson et al. 2007). Higher household incomes have been found to be negatively correlated with children's cycling to school (Chillon et al. 2009; Larsen et al. 2011; Martin et al. 2007; McDonald 2008; McMillan 2007). However, within disadvantaged areas in England socio-economic status was not found to be correlated with children's cycling to school, perhaps as most households were of relatively similar socio-economic standing (Christie et al. 2011). However on the contrary in Melbourne, students from higher SES neighbourhoods undertook more cycling and walking trips compared to students from lower SES, with both parents and children aged 10-12 in the lower SES areas having a negative perception of their built environment (Timperio et al. 2004).

4.5 Policy Factors

Individual schools have their own policies which can either encourage or discourage cycling to school. Cycling support in schools and the provision of cycling infrastructure such as storage facilities for bicycles and helmets can encourage the use of bicycles. Other school policies which have negative connotations for cycling include prohibitions on children cycling to schools, age-limits on children cycling to school, and cyclists and walkers being

the last to be dismissed from schools after other students have been picked up in cars (Ahlport et al. 2008).

4.6   Social Factors

Children's perceptions of cycling differ across societies based on socio-cultural norms. This is a key influence on children's cycling take-up generally and their school travel. In a survey undertaken in eight primary schools in Yorkshire, England, children's perceived the bicycle as being a 'toy' rather than a mode of transport to destinations, with children conceiving of cycling for recreation, not transportation (Baslington 2009). Where children perceive that it is not cool to cycle to school, there are lower percentages of children cycling to school (Forman et al. 2008).

Parental perceptions of stranger and traffic danger and 'social traps' of feeling obligated to chauffer their kids to school have a negative impact on children's cycling to school. 'Stranger danger' has been found to be one of the key concerns of parents (Ridgewell et al. 2009). In Melbourne 88 percent parents of 5-6 year old children and 81 percent parents of 10-12 year raised concerns about stranger danger though this was not correlated with children's own perceptions of danger or parental decisions relating to children's cycling (Timperio et al. 2004). However, parental perceptions of the neighbourhood, rather than children's own perceptions, have more influence on cycling trends of younger children when compared to older children (Timperio et al. 2004). In addition to stranger danger, parental perceptions of child safety arising from personal safety barriers such as bullying have been found to be a significant deterrent of children's cycling (Ahlport et al. 2008). Concerns of stranger danger can be allayed to some extent in situations where parents feel that their neighbours will watch out for their kids which rests on the premise of child-centred social control (McDonald et al. 2010).

Parental fears around traffic danger are also significant. Traffic safety for child cyclists arises from having adequate provisions for cycling network infrastructure, lower volumes and speed of vehicular traffic. Whilst objective traffic safety may be of concern in many countries with inadequate infrastructure provision for children cycling to schools, parental perceptions of safety have been found to be of significance in whether parents allow their children to cycle to school. In Melbourne, a longitudinal study established that a large proportion of parents had concerns relating to traffic safety (Hume et al. 2009). Parental and student fear of accidents is imbedded in the notion that being a cyclist increases the probability of being involved in an accident (Ahlport et al. 2008). Perception of safety can be improved by provision of increased off-road facilities as well as reduced vehicular traffic volumes (Inouye et al. 2008).

A student's cultural/ethnic orientation has been found to have significant implications on the mode choice for travel. In the Netherlands, which has a strong cycling culture, being from a non-Western or non-Dutch cultural background has a negative correlation with cycling to school, presumably due to the cultural perception towards cycling and cycling skills of children of foreign born parents (Bere et al. 2008). By contrast, in the US where there is a dominant car culture, students of mixed race and Latinos are more likely to actively travel to school compared with white and African-American students (Babey et al. 2009). In Israel a higher percentage of Jewish students cycle to school compared to Arab students, however this could result from the economic background differences of the two cultures in as much as the

cultural differences (Elias et al. 2011). There is a research gap in terms of understanding how Australia's diverse ethnic and cultural mix influences child cycling behaviours.

In addition to parental perceptions of safety, parental attitudes towards use of bicycles and motivations for physical activity can have a profound impact on children's cycling. Parents have been found to have much greater influences on children's cycling than peer influences (Emond et al. 2012). Children whose mothers cycled to work were more likely to cycle to schools (Panter et al. 2010). As noted by Garrard (2009, pg. 17) 'social and cultural norms of travel behaviour are a powerful influence, but a neglected area in active transport research and interventions'. Parents, teachers, fellow students and friends' encouragement and perception towards cycling influences positively a child's decision to cycle to school and can have significant influences on portraying the norms of travel and cycling behaviour (Evenson et al. 2007). Social interaction amongst neighbours and caregivers within the neighbourhood has positive implications for active travel and cycling to school with social factors being more at play for children's travel at a younger age. Children whose parents in Melbourne, Australia knew many people in their neighbourhood and who reported that the child had many friends in their area were more than twice as likely to increase their active commuting compared with other children (Hume et al. 2009). Caregivers who valued interactions, not only for themselves, but more so for their children as they travelled to school were more likely to encourage active traveling such as cycling (McMillan 2007). Social concerns of parents are strongly tied with their and their children's social connections, with both parental and children's cycling decisions greatly influenced by the accepted norms of behaviour within these social networks.

5. Implications of Children's Cycling on Social Capital and Connectedness

Children's development, their wellbeing and social connectedness is influenced by opportunities to participate in those physical activities that provide opportunities for interaction with others (Prezza et al. 2005). Children's unstructured outdoor play and activities, including cycling, can lead to higher energy expenditure, reducing child obesity and assisting in the development of social, cognitive and mental skills. This can also facilitate social interaction, which can help in the reduction of children's susceptibility to mental problems and being bullied (Bundy et al. 2011). A high dependency on motorised modes deprives children of their ability to move independently whilst independent active travel allows children to explore the neighbourhood (Tranter et al. 2001). Children learn essential life skills when travelling by bicycle, including the ability to make decisions, to socialise with others and solve problems whilst gaining a sense of ownership from the public space. Removal of children from the streets and neighbourhoods into cars removes them from many of the experiences such environments have to offer, including exercise, exploration and social interaction (Kearns et al. 2003; Walsh 2006).

Whilst not assuming a causal relationship that cycling and walking determine the social capital and connectedness of a child, or that the social capital of a neighbourhood determines whether a child will cycle or walk to school, social capital and children's independent travel are interlinked. Children who have perceived their neighbourhoods to be close knit and with a high social capital were more inclined to want to walk to school and be physically active (Hume et al. 2009). Children who make use of public spaces have been found to relate better with adults and other children, enhancing the social capital of neighbourhoods, and 'the

presence of children is an effective way of breaking down the natural reserve between adults' (Tranter et al. 2001, pg. 30). Safety and stranger danger are two of the key parental perceptions that reduce active travel, however cycling to schools can provide unstructured opportunities for social interaction and can raise the perceptions of neighbourhood safety by increasing the presence of children in public space.

Perceptions of distance have been shown to be important factors in children's propensity to cycle. However, perceptions of distance are strongly correlated with the level of social connection that a child feels with the urban environment. The more the social interactions, the shorter the perception of distance is and the opportunity for casual social interaction with both adults and children increases (Depeau 2001). In Southern California, social interaction amongst parents and children and households in close spatial proximity had significant impacts on active mode choices of walking and cycling, with households where children travel actively being clustered together spatially (Sidharthan et al. 2011). In European countries, a larger percentage of children still travel by cycling or walking to school even though they have access to cars. This is, in part, attributed to higher levels of social connection amongst children and between the children and other neighbourhood residents, where though children travel independently, they are under constant casual surveillance, have a sense of belonging and garner higher levels of social capital through active travel (Ross 2007). In Auckland, New Zealand, increased social interaction is the second most important consideration after an eagerness for exploring the environment for more than half the students who wished to change their current mode of transport from motorised to active modes of walking, cycling and roller skating (Mitchell et al. 2007)

Children's social connectivity and their perception of the built and social environment have been elicited using a number of child-friendly research methods that can effectively incorporate their views. Aerial photographs, photo elicitation, mental mapping and geographic information systems (GIS) have been used by researchers to create mapped information on children's social interaction and their use of urban spaces in their neighbourhoods (Freeman et al. 2010; Wridt 2010). With the understanding that the built environment has significant implications on the active and non-active travel of children and the opportunities for and types of social interaction, Photovoice has been used as methodology for children to express their views regarding their environment in Toronto, by taking pictures, conversing and writing descriptive stories about them (Fusco et al. 2012). Children who actively travelled to school took more pictures on the way to school and through their photos and narratives gave greater significance to social interactions than children who were driven and whose interaction on the way to school was limited to caregivers or parents driving the car (Fusco et al. 2012).

In combination with other participatory and qualitative methods, Wridt (2010) had children mark places and areas of interest for various themes including access and transportation to community spaces and social networks on laminated aerial photographs, using concepts of community mapping. She discovered that gender has significant implications on active travel and social connections. Global positioning systems (GPS) and rolling mobile phone surveys revealed that in chosen schools in Denmark, approximately 50 percent of the sample students cycled to school and most of these students did so in the company of friends by making arrangements to meet them at fixed locations to cycle together to schools in groups of two or three students and returned home in larger groups. However gender again was a significant factor with females preferring to travel with other female students with the exception of male family members (Mikkelsen et al. 2009). Overall children who actively travelled to school

have been found to have more social connections than those who not only travelled to school by car and also did not walk to friends' houses or in the neighbourhoods outside of school hours (Freeman 2010).

6. Preliminary Research Findings from the Children's Active Travel, Connectedness, and Health (CATCH) Project

The CATCH project explores the social and built environment influences on children's independent and active travel and health. Currently underway, the study is seeking data from around 600 students aged between 10-13 years in six study areas across urban and regional Australia, which are reflective of the locations where most Australian children reside. Participants are surveyed using a variety of methods including travel diaries, parent and student questionnaire based surveys, GPS recorded data, photo mapping and independent audits of the built environment. The initial phases of the project have included data collection in schools in Melbourne, Rockhampton and Brisbane. Reported here are only preliminary results from a small section of the findings from two schools in the inner- and middle-suburbs of Melbourne, focusing on children's travel patterns and their perceptions as reported by the children and their parents in separate surveys. Seventy-four child and 35 parent questionnaire-based surveys with response rates of 34 percent and 16 percent respectively, were filled by children and their parents in the two Melbourne schools in October and November 2011. We recognise the small sample size here, and that this is only a small sub-set of the full future dataset, however it is instructive to see some of the emergent results. Parents provided details of their residential addresses which were geocoded in ArcGIS and a basic network service area analysis was undertaken for the two schools. The very initial analyses on the survey data has been undertaken in SPSS version 20 and Microsoft Excel.

6.1 Survey Findings

Of the 74 student respondents aged between 10-13 years, 46 percent were males, 51 percent females and two percent did not state their gender. Approximately 92 percent of all children owned bicycles, though only 16 percent of students cycled to school. A child's gender played a relatively small role in children's cycling with 18 percent of the male and 16 percent of the female students cycling to school. Similar to previous studies on children's cycling (Larsen et al. 2011), there was a high latent demand for cycling to school with slightly less than half (40.6 percent) of the children surveyed stating they would prefer to cycle to school. The majority of the cyclist students (83 percent) self-reported that they cycled less than 15 minutes to school.

Distances from home-to-school and the presence of major roads did not appear to have a significant impact on the parental licences issued for children's cycling, as the majority of the parents reported allowing their children to cycle along the main roads without an adult being present. Sixty percent of the children were currently allowed to bicycle alone in the streets of the neighbourhood, 66 percent without adult supervision and with other children, and 91 percent were allowed in total including those who are allowed to cycle but only with adult supervision. The rates of cycling to school are significantly higher in these two schools than the Australian average, albeit there appeared potential for more cycling given children's stated preferences.

Interestingly, the perceptions of stranger danger were much higher in children who travelled via non-active modes of transport than students who walked and cycled to school. Only a

quarter of cyclists and walkers stated having a fear of strangers in the neighbourhood as opposed to nearly half of the students travelling to school by motorised modes. Significant percentages of both active travellers including walkers (52 percent), cyclists (67 percent) and non-active travellers (48 percent) considered it safe to play in the neighbourhood parks without any adult supervision. This perception of safety from strangers to travel independently to school via cycling and to play in the neighbourhood parks could have partly been attributed to the familiarity with the neighbours, however there were no marked differences in the attitudes towards neighbours across the different modes, with approximately half the respondents by each modes agreeing that they knew their neighbours well and that the neighbours could be trusted.

Instead of stranger danger, cyclists were more concerned about traffic safety around their schools. Cyclists and walkers had a more negative perception towards traffic around the school compared to non-active travellers with one third of the cyclists strongly agreeing that there was a lot of traffic around the school. Though more than 50 percent of the student cyclists had to cross a busy road when they cycled to school, 80 percent felt safe crossing roads near their schools (see Figure 2). Clearly cyclists are well versed with road rules and traffic movements and hence the feeling of safety despite their concerns of traffic numbers around the school. Most students, irrespective of their current mode of travel, were aware of school provisions for cyclists with large numbers agreeing that there were safe places to leave their bicycles at school.

Figure 2: Children's Perception in Percentages of by the total mode share towards Selected Aspects of the local and school environment
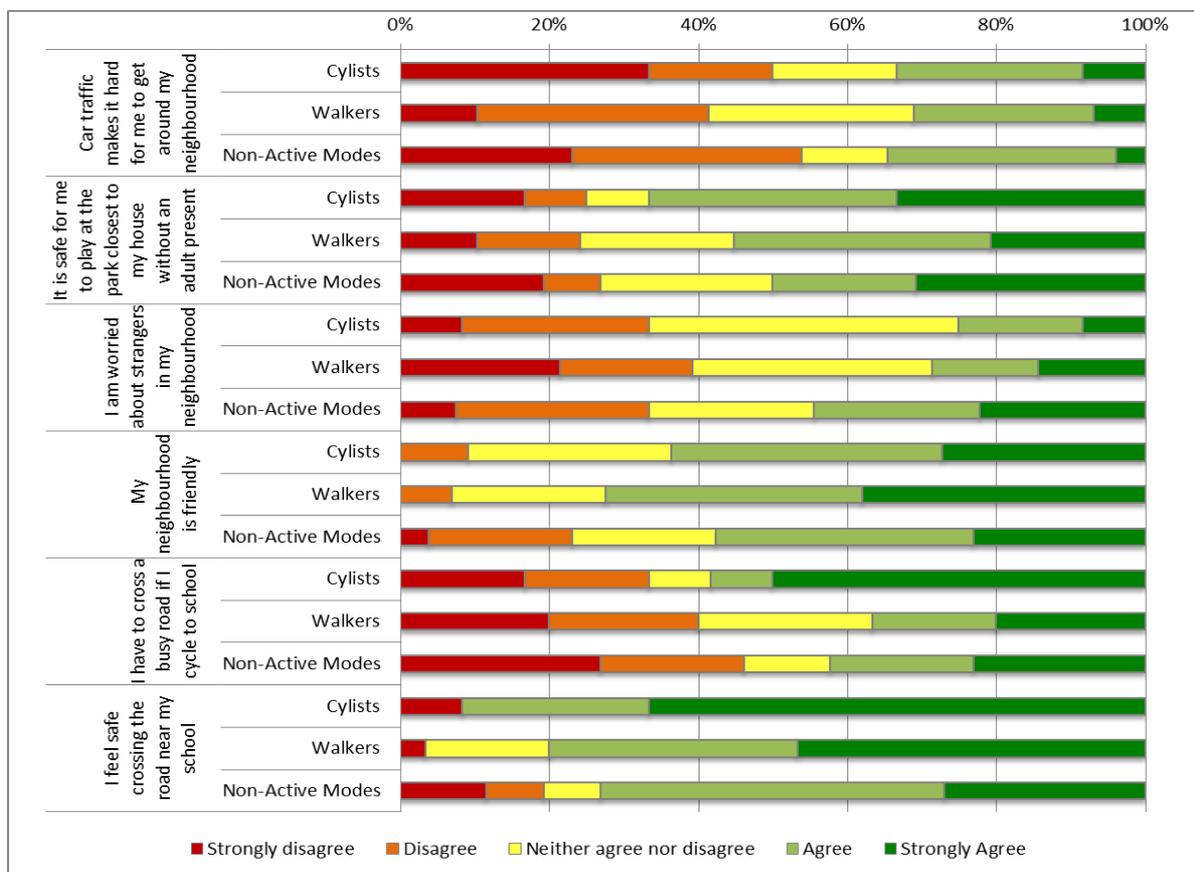
Regarding social networks, cyclists knew more children who cycled to school (compared to those who walked or were driven to school) and this may have implications for their social connectedness and interaction amongst the student population. Social interaction seems to play an important role in the way children would prefer to travel to school, with more than half of the children preferring to cycle to school and 24.3 percent stating they would rather ride their bicycles with other children than travel alone. The most common reasons for students preferring to cycle to school with other children were cited as being "it is fun" (12.2 percent) and "I can talk to my friends on the way" (10.8 percent, see Table 2). Children who preferred to cycle with other children also saw this as an opportunity to undertake exploration and stop at places along the way, something which was not a motivation for either cycling alone or with adults.

Table 2: Reason for Preferred Mode of Choice for Travel to School

Preferred Mode of Travel to School in absolute numbers	Reason for preferred mode choice in percentages (%)										
	I live a long way from school	I live close to school	I can stop at places on the way	I can talk with friends on the way	I have a lot to carry	I can avoid bullies	It's quicker	I feel more grown up	It's fun	It's safer	Other
Bicycle Alone (11)	0	1	0	1	0	1	4	3	7	0	1
Bicycle with other children (18)	5	5	7	11	0	0	5	8	12	1	0
Bicycle with an adult or adults (1)	0	0	0	0	0	0	0	0	1	0	0

7. Where to next?

The review conducted and these first preliminary results from the CATCH dataset suggests children's cycling to school, amidst other relevant factors, may be strongly influenced by not only children's own, but also their parent's social connections and social capital. But how might one explore children's social connectedness, the nature of their networks, the ways in which it influences cycling, and potentially harness that for use in improving school-based travel demand management activities?

7.1 Lead users and Opinion leaders

Children's social contacts and their social circles help to establish their accepted travel behaviour norms, including for their travel to school. Of help here are the lead user and opinion leader concepts that have been widely used in marketing and business fields to help understand new product development and innovation (Kratzer et al. 2009). Lead users are identified as those individuals who are ahead of a market trend, are the first to design and use products and who serve as role models to other users. Opinion leaders are more involved and familiar with products and have greater experience and expertise on the products than average users. Though the two roles seem similar, they have very distinctive roles in their social networks and in particular for children who rely greatly on word of mouth. The roles and networks of the lead users and opinion leaders are of significance in the diffusion of products and innovations (Kratzer et al. 2009). Lead users network bridges across diverse local groups, whereas opinion leaders act as a hub within local groups.

These concepts of lead users and opinion leaders and their effectiveness in the initiation of and the encouragement of the use of bicycles has not as yet been explored, but could be accomplished using network theory. The first working hypothesis would be that there are certain adults and children in each parental and child social network who are influential enough to have impacts on children's travel decisions. Children's social networks span their various interests and school and family connections. If there are role models within these social networks who can be identified as lead users and opinion leaders for cycling as opposed to other modes of transport, this may be influential in changing travel patterns of the children in these networks. Where these opinion leaders are absent, one would expect less cycling. Opinion leaders by virtue of their designated nature would have better cycling skills than other children within the same network and might be instrumental in teaching and raising the cycling skill levels of these children. Similar concepts can be applicable to the social networks of children. A lead bicycle user amongst a particular social group may eventually help change the travel behaviours of non-cycling students. However the significance of lead users and opinion leaders in children's cycling can only be gleaned from studying existing child cyclists and their roles in social networks. This would explore how, where and when they acquired their cycling skills, which persons were influential in their cycling to school decisions and what impact did they have on and how they were influenced by their various social networks.

The authors are currently working to contribute to this research agenda. Within the CATCH study, significant correlates for children's cycling and the interrelationship with the children's social connectedness will need to be determined in further research and analysis. This will be possible using combinations of GPS data, child and parental survey data, and travel diary information. Following this, a further set of in-depth studies in schools will explore these issues with a smaller sub-set of children. A key focus of the extension studies will be on the marketing concepts of lead users and opinion leaders to analyse the role of social connections and social networks on the acquisition of cycling skills and cycling to school within the Australian context. It is hoped that this will elicit new understandings for cycle promotion of use to those shaping policy and running school-based travel behavior change programs.

Acknowledgements

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