Children's Cycling for Transport in Selected Australian Urban Environments: Modal Shares and Determinants of Significance

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Abstract: The past decade has seen a considerable decline in children's use of bicycles for transport in most non-European Western countries. In Australia children's cycling constitutes only four percent of the school mode share. Low levels of children's utilitarian cycling is influenced by relevant built, socio-economic and policy environment factors of which social factors such as parental perceptions of safety and 'stranger danger' have been identified as two key determinants within comfortable cycling distances. Children's cycling can enhance their presence in the urban environment and provide unstructured opportunities for social interaction. Parent and child social networks and views towards neighbourhood social connectedness play a significant role in their perceptions of safety. This paper using CATCH/iMATCH project data to explore parental and child perceptions towards their social and built environment reports on its relationship with cycling take-up and usage. The CATCH/iMATCH data was collected during 2011 – 2012 from primary school students in nine urban schools in Brisbane, Melbourne, Rockhampton and Perth, and involved parental and child questionnaires. Bicycle ownership was found to be substantially high across the study areas, however, comparatively few child respondents used bicycles to travel to specified destinations though there was a considerable latent demand for cycling. Significant associations were found between children's cycling for transport and a child's gender, the urban environment type, vehicle ownership and parental and child perceptions of safety. This paper highlights and informs urban policy on the underlying significance of parent and child perceptions of the built and social environment determinants associated with children's cycling patterns.

1.   Introduction

Children form an integral component of an urban space. However, due to a combination of influences such as increased motorisation, discriminatory societal attitudes and policies towards children's presence in the public space, they are progressively relegated away from the public realm. Travel modes advocated for and chosen by children for trips to schools and to other neighbourhood destinations is perhaps one of the most salient influences of children's presence in and their use of urban space. Increased motorised travel in addition to removing children from urban streets, deprives them of the ability to move around and explore their neighbourhood independently, leads to the development of car-dependent social values (Tranter and Pawson, 2001) and further influences the levels of social interactions amongst residents (Appleyard and Lintell, 1972). Children's cycling as one of the active modes of travel has numerous benefits compared to being driven to destinations. Regular cycling leads to higher energy expenditure per unit of time compared to walking and contributes to the reduction in childhood obesity (Andersen et al., 2011). It also assists in the development of social, cognitive and mental skills of children facilitating social interaction which can help enhance their support network, access to information and reduce their susceptibility to mental problems and being bullied (Bere et al., 2011; Cooper et al., 2008). Despite being an environmentally friendly, healthy and sustainable mode of transport, very few Australian children cycle for utilitarian purposes and a number of built form, social and demographic factors may explain these low levels of cycling (Timperio et al., 2004; Trapp et al., 2011).

Residential distances from schools is a key urban built form determinant of children's cycling whilst the social environment is of greatest significance for children living within comfortable cycling distances of less than 3km (D'Haese et al., 2011; McMillan, 2007). Perception of distance is strongly correlated with the level of social connections that a child has; the more the social interactions, the shorter the perception of distance is and the opportunity for casual social interaction further enhances the sense of safety that a child feels within an urban space (Depeau, 2001). 'Stranger' and traffic danger have been identified as two salient determinants of children's cycling to school. Parental and children's social connections and their "sense of community" play an important role in perceptions of social danger (Prezza et al., 2005). This paper provides an overview of Australian children's cycling mode shares for travel to specified destinations and explores the associations between parental and child perceptions towards particular built and social environment influences and child cycling.

2.   Children's Cycling for Transport

Children's use of bicycles as a mode of transport is low in non-European Western countries and this is most aptly indicated in the low cycling mode share for school travel. Cycling constitutes

approximately one percent of all school trips in the US (National Center for Safe Routes to School, 2011); two percent in the UK (Department for Transport, 2011) and four percent in Australia (Australian Bureau of Statistics, 2011). The exceptions to low levels of children's utilitarian cycling are found in European countries with strong cycling cultures such as Denmark and the Netherlands where cycling constitutes approximately 40 percent of the school modal split (D'Haese et al., 2011; de Vries et al., 2010). Australian children's cycling to school has experienced 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 recreational cycling with two thirds of 5-9 year olds cycling during a typical week compared to only nine percent of forty year olds (Australian Bicycle Council (ABC) and Austroads, 2011).

Two decades ago, the percentage of children granted permissions to cycle by their parents in Canberra was much higher than German and English students and 11% of the children surveyed cycled to schools (Tranter and Whitelegg, 1994). Though there are differences in sampling and methods across studies, cycling rates had reduced 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 and Whitelegg, 1994). The Northern Territory has the highest percentage of children cycling to school (6.7 percent) whilst New South Wales and Tasmania have relatively low rates of less than 2% children cycling to school at an aggregate level (Australian Bureau of Statistics, 2011). More recently, Meron et al. (2011) however discovered that 3.7% of students cycled to school in NSW. The varying levels of children's cycling for transport across States and urban locations are the result of a combination of determinants which influence children's cycling take-up and usage.

3. Determinants of Children's Cycling for Transport

The socio-ecological model (Bronfenbrenner, 1979) suggests that a variety of environments such as social, physical, economic and individual characteristics influence children's behaviour including utilitarian cycling (Alparone and Pacilli, 2012; Børrestad et al., 2011; Trapp et al., 2011). Demographic factors and personal characteristics that influence children's cycling include a child's age, gender, household structure, children's cycling skills and cognitive spatial awareness (Babey et al., 2009; Emond and Handy, 2012). Age is positively associated with child cycling; children are issued with gradual 'licences' to travel independently with increasing age and coupled with advanced cycling skills, older children undertake cycling in larger numbers compared to younger children (Fyhri and Hjorthol, 2009). Gender is the most noteworthy demographic determinant of a child's utilitarian cycling; two to three times more male students cycle to school compared to females (Emond and Handy, 2012; Timperio et al., 2004). Household characteristics which either deter or facilitate children's utilitarian cycling include income and vehicle ownership; parental marital status; presence of siblings; preference for and confidence in child cycling and traffic navigation abilities (Ahlport et al., 2008; McDonald, 2008).

Urban form determinants associated with children's cycling include travel distances, land use mix, residential density and the urban transport system (Larsen et al., 2009; McMillan, 2007; Ridgewell et al., 2009). Distance to school is a key built form determinant; most cyclist students have been found to reside at distances of less than 3kms from their schools (Babey et al., 2009; D'Haese et al., 2011; McMillan, 2007). Higher residential densities bring land uses closer together, implying reduced trip distances from homes to schools and hence has a positive impact on children's cycling participation (Larsen et al., 2011). Transport factors that influence children's utilitarian cycling include the availability of cycling infrastructure, frequency of provisions for safe road crossing and traffic volumes with its related perceptions of safety (de Vries et al., 2010; Larsen et al., 2009).

The existence of safe and quite streets impact children's cycling take-up and usage, the levels of neighbourhood social connectedness and subsequent presence of children in a neighbourhood (Appleyard and Lintell, 1972; Appleyard et al., 1981; Mullan, 2003). Appleyard and Lintell (1972) discovered that residents who lived along streets with low traffic volumes had better quality of life in general with more children playing along streets, greater social interaction amongst residents and children generally depicting enhanced cognitive spatial awareness of the street features compared to residents along streets with moderate and high traffic volumes. The implementation of the Dutch woonerfs and home zones in the UK were based on targeted urban and transport policy initiatives to slow down vehicular traffic in residential areas in order to create a more conducive environment for children's active travel. The use of such built form policies to the exclusion of targeting social influences of children's cycling though quite successful in Netherlands which already had a strong cycling culture has had limited success in UK (Webster et al., 2006).

Amongst social factors, parental perceptions of stranger and traffic danger and 'social traps' of feeling obligated to chauffer their kids to school has consistently been found to negatively impact children's cycling to school (Hume et al., 2009; Timperio et al., 2004). Concerns of stranger danger can be allayed to some extent in situations where parents feel that their neighbours will watch out for their kids based on the accepted norms of behaviour within their social networks and where parents know, socially interact with and trust people in their neighbourhood (McDonald et al., 2010; Prezza et al., 2001). In addition to 'stranger' and traffic danger, other social factors of significance to a child's cycling include their socio-economic status (SES), cultural or ethnic background, attitudes towards the use of bicycles as a mode of transport, maternal education and parental mode of travel (Bere et al., 2008; Emond and Handy, 2012).

3. Methodology

We used data from the CATCH & iMATCH projects to analyse the factors associated with children's cycling patterns. The CATCH/iMATCH research projects are two multidisciplinary and multi-site studies investigating the built and social environment influences of children's independent mobility, active travel and health. Children aged 10 -13 years were selected as this age category is often granted 'licences' to travel independently and have a greater probability of using non-motorised modes of travel. The respondents for the surveys were recruited through nine schools in Brisbane, Melbourne, Perth and Rockhampton and represented neighbourhoods from the four urban environment types where most Australian children reside being regional centres, inner, middle and outer suburbs. Data collection was undertaken in 2011- 2012. The multidisciplinary nature of the projects demanded the incorporation of a number of research methods inclusive of child and parent surveys; travel diaries, GPS and actihearts. This paper reports only on some of the cycling related aspects of the data collected using the child and parent surveys.

Child surveys were designed to collate children's demographic characteristics; current and preferred travel patterns; activity participation and perceptions towards the built and social environment influences of travel. Parent surveys added further dimensions to household and parental characteristics, 'licences' issued to children for independent travel and parental perceptions of the built and social environment. Parents additionally provided information on household components noted of significance in prior research such as maternal and paternal education, parental mode of travel, vehicle ownership and home attributes including ownership and location categorised by road type. Parental and children's perception of traffic, stranger and social dangers have been identified as vital determinants of children's mode choices, active travel and independent presence in urban spaces and similar to other studies (Alparone and Pacilli, 2012; Prezza et al., 2005), Likert scale based responses to perceptions were solicited from parents and children.

Data relating to children's cycling and the social and built environment influences were extracted from the two survey sources and analysed using SPSS (v21) and MS Excel (2010). Cycling patterns were extracted from children's reported data on their current and preferred travel times, modes and accompaniment status of their journeys to schools, places outside the neighbourhood and local destinations of shops, friends and parks. Child surveys further provided data for variables such as bicycle ownership and 'licences' granted to cycle on main roads. Parental and child perceptions which were reported using a five category Likert scale were recoded into three collapsing the strongly agree and agree into a singular category of agree and strongly disagree and disagree into one category of disagree. The relatively small dataset placed considerable limitations on the identification and subsequent analysis of the strength of associations between the variables reported on and current cycling to schools and specific destinations. Therefore a multinomial logistic regression analysis was undertaken to explore the association between selected variables and cycling to any one of the stipulated destinations. The variables of influence were identified using a combination of principal component analysis, correlation and iterative building of the model where those variables that did not contribute to the child opting to cycle to any one of the destinations were discarded.

4. Findings
4.1 Demographic Characteristics of Student

A total of 305 children and 304 parents responded to the questionnaire based surveys, the distribution of these respondents across the four distinct urban types is depicted in Table 1. More female students (63%) took part in the study and this pattern of gender participation was almost unanimous across the four different urban environments with relatively smaller differences in gendered

participation in the inner and middle suburbs.   The aggregate spatial distribution of student respondents was comparable in the regional centre, inner, middle and outer suburbs.

Table 1: Student Respondents from the Four Urban Environments

Respondent Details	Inner Suburbs						Middle Suburbs						Outer Suburbs		Regional		Total	
	Melbourne		Perth		Total		Melbourne		Brisbane		Total		Brisbane*		Rockhampton**			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Gender:																		
Males	16	5	19	6	35	11	20	7	7	2	27	9	28	9	23	8	113	37
Females	14	5	32	10	46	15	24	8	13	4	37	12	61	20	48	16	192	63
Child cycles to at least one destination:																		
Males	7	44	7	37	14	40	8	40	3	43	11	41	6	21	7	30	38	34
Females	9	64	5	16	14	30	2	8	2	15	4	11	6	10	3	6	27	14
Total	16	53	12	24	28	35	10	23	5	25	15	23	12	13	10	14	65	21
Corresponding parent and child cyclist respondents	11	37	12	24	23	28	4	9	5	25	9	14	10	11	8	11	50	16

* = 2 Schools ** = 3 Schools

65 students amounting to 21% of the total student respondents had stated cycling as their mode of travel to at least one of the specified destinations.   This paper focuses on the responses from these 65 students for the cycling patterns to the specified destinations.

4.2   Children's Cycling for Transport to Stipulated Destinations
Bicycle ownership was found to be high across all urban environments with 91% of all child respondents having stated that they had access to a bicycle. This high level of bicycle ownership however was not reflected in the utilitarian use of bicycles. Bicycle usage amongst the child respondents fluctuated in relation to the varied urban environment types, gender and stipulated destinations; refer to Table 2.

Table 2: Comparative Current Cycling Trends across the Different Urban Environments, Gender and Stipulated Destinations

Destination	Accompaniment Status	Inner Suburbs	Middle Suburbs	Outer Suburbs	Regional	All schools		
						Males	Females	Total
School	Bicycle alone	5	0	0	1	4	2	6
	Bicycle with other children	4	1	0	0	2	3	5
	Bicycle with an adult or adults	5	0	0	0	3	2	5
	Total	14 (17 %)	1 (2 %)	0 (0 %)	1 (1 %)	9 (8%)	7 (4%)	16 (5.6%)
Local Shops	Bicycle alone	5	4	3	3	10	5	15
	Bicycle with other children	0	1	0	1	1	1	2
	Bicycle with an adult or adults	2	2	0	0	3	1	4
	Total	7 (9%)	7 (13%)	3 (4%)	4 (6%)	14 (13%)	7 (4%)	21 (7.3%)
Local Friends	Bicycle alone	3	5	1	2	8	3	11
	Bicycle with other children	1	1	0	0	2	0	2
	Bicycle with an adult or adults	3	2	1	1	3	4	7
	Total	7 (9%)	8 (13%)	2 (2%)	3 (4%)	13 (12%)	7 (4%)	20 (6.8%)
Local Parks	Bicycle alone	2	3	1	0	4	2	6
	Bicycle with other children	7	0	0	2	5	4	9
	Bicycle with an adult or adults	6	4	6	0	7	9	16
	Total	15 (19%)	7 (12%)	7 (8%)	2 (3%)	16 (16%)	15 (9%)	31 (11.4%)
Local Organised Activities	Bicycle alone	1	0	0	0	0	1	1
	Bicycle with other children	0	0	0	0	0	0	0
	Bicycle with an adult or adults	2	3	0	0	4	1	5
	Total	3 (4%)	3 (5%)	0 (0%)	0 (0%)	4 (5%)	2 (1%)	6 (2.1%)
Places Outside Neighbourhood	Bicycle alone	2	2	2	0	3	3	6
	Bicycle with other children	1	1	0	0	1	1	2
	Bicycle with an adult or adults	2	0	1	1	4	0	4
	Total	5 (6%)	3 (5%)	3 (3%)	1 (1%)	8 (7%)	4 (2%)	12 (4.0%)

Compared to the other three urban environments, more children from the inner suburbs reported cycling as their mode of travel to at least one destination, with the greatest proportion of stated cyclist students being from the inner Melbourne urban school. There were marked differences across the two gender groups in their use of bicycles for travel to selected destinations with more male students having stated cycling as their mode of travel to all destinations. Cycling mode share was highest for recreational cycling reflected in the proportion of children who cycled to local parks compared to other destinations. School cycling modal split at 5.6% was slightly higher than the national average of 4%, however the greatest contribution to this figure was from the inner urban schools where 17% of the child respondents had stated that they cycled to schools. Cycling mode share to schools and local parks were highest in the inner suburbs while a relatively higher proportion of children from the middle suburbs cycled to local shops and local friends. Accompanied cycling by either other children or more commonly adults was prevalent for travel to all destinations excluding local shops and local friends. The highest proportion of accompaniment by adults had been stated for travel to local parks.

There is a comparatively high latent demand for cycling to all destinations and in particular to local destinations of schools, parks, friends and shops, refer to Table 3. A total of 96 (32%) students preferred to cycle to school and 145 (48%) stated a preference to cycle to at least one of the other stipulated destinations. Social interactions appeared to play a salient role in the preference for cycling as a mode choice; most children who preferred to cycle desired to do so in the company of other children. Gender played an equally important determining factor in current cycling usage and the unmet latent demand for cycling; more male students currently cycled to all destinations and a greater proportion would have preferred to cycle to all destinations if offered a mode-choice.

Table 3: Comparative Preference for Cycling in the Different Urban Environments

Destination	Accompaniment Status	Inner Suburbs	Middle Suburbs	Outer Suburbs	Regional	All schools		
						Males	Females	Total
School	Bicycle alone	12	6	3	6	16	11	27
	Bicycle with other children	18	14	16	16	30	34	64
	Bicycle with an adult or adults	2	0	0	3	2	3	5
	Total	32 (40%)	20 (33%)	19 (21%)	25 (36%)	48 (44%)	48 (25%)	96 (32%)
Local Shops	Bicycle alone	10	4	3	4	15	6	21
	Bicycle with other children	9	15	10	6	18	22	40
	Bicycle with an adult or adults	1	2	1	4	4	4	8
	Total	20 (27%)	21 (37%)	14 (18%)	14 (22%)	37 (37%)	32 (18%)	69 (25%)
Local Friends	Bicycle alone	17	7	4	4	19	13	32
	Bicycle with other children	7	12	7	1	16	11	27
	Bicycle with an adult or adults	1	0	2	2	1	4	5
	Total	25 (34%)	19 (32%)	13 (17%)	7 (12%)	36 (37%)	28 (16%)	64 (24%)
Local Parks	Bicycle alone	3	6	5	5	13	6	19
	Bicycle with other children	17	13	13	7	24	26	50
	Bicycle with an adult or adults	3	5	4	3	6	9	15
	Total	23 (32%)	24 (44%)	22 (29%)	15 (25%)	43 (45%)	41 (24%)	84 (32%)
Local Organised Activities	Bicycle alone	0	1	0	1	2	0	2
	Bicycle with other children	4	5	4	2	8	7	15
	Bicycle with an adult or adults	3	2	0	1	3	3	6
	Total	7 (10%)	8 (15%)	4 (5%)	4 (7%)	13 (14%)	10 (6%)	23 (9%)
Places Outside Neighbourhood	Bicycle alone	2	0	2	0	2	2	4
	Bicycle with other children	7	6	8	5	11	15	26
	Bicycle with an adult or adults	3	2	3	2	5	5	10
	Total	12 (17%)	8 (14%)	13 (16%)	7 (12%)	18 (19%)	22 (13%)	40 (15%)

4.3   Associations Between Child and Parental Perceptions Towards the Built and Social Environment and Children's Utilitarian Cycling

This section of the paper focuses on the findings from the corresponding child and parent surveys of the children who cycled to at least one of the stipulated destinations. The results of the multinomial logistic regression in the form of main variables associated with a child cycling to at least one destination are presented in Table 4.

Factors which are strongly associated with a child cycling to any one of specified destinations are a child's gender, a child seeing people out for walks in the neighbourhood, the type of urban environment, parental involvement in neighbourhood based organisations and parental and child perceptions of safety. The iterative process had identified that parental education levels (both paternal and maternal), a child being issued with licences to cycle on the main roads without an adult, parental marital status, ownership of dogs and shared custody of a child were not strongly associated with a child's cycling and did not provide any additional variance to the regression analysis.

Table 4: Associations Between Selected Variables and a Child Cycling to at least one of the Stipulated Destinations

Variables	X^2	b	(SE)	p	OR	95% Confidence Interval for OR Lower	Upper
Intercept		-11.85	(3.86)	.002			
Urban Type	17.19			.001			
Inner City		3.54	(1.13)	.002	34.47	3.76	315.74
Middle Suburban		1.35	(1.13)	.231	3.87	0.42	35.31
Outer Suburban		0.91	(1.04)	.383	2.47	0.32	18.92
Regional		Reference category					
Child's Gender	26.74			.000			
Male		3.72	(0.93)	.000	41.29	6.66	256.07
Female		Reference category					
Number of registered vehicles in the household	6.99			.030			
0 Vehicles		4.79	(1.92)	.013	120.5	2.77	5239.31
1 Vehicle		0.06	(1.11)	.959	1.06	0.12	9.42
2 or more than 2 vehicles		Reference category					
Parental Social Perceptions							
I am actively involved in neighbourhood – based organizations	12.35			.002			
Agree		0.92	(0.93)	.322	2.51	0.40	15.60
Neither Agree nor Disagree		3.01	(1.04)	.004	20.39	2.64	157.17
Disagree		Reference Category					
Assaults by strangers is a concern in my neighbourhood	10.99			.004			
Disagree		3.06	(1.06)	.004	21.33	2.66	171.37
Neither Agree nor Disagree		2.14	(1.12)	.055	8.49	0.95	75.62
Agree		Reference Category					
This is a close-knit neighbourhood	6.83			.033			
Agree		1.32	(1.29)	.306	3.75	0.30	47.09
Neither Agree nor Disagree		-0.81	(0.95)	.393	0.44	0.07	2.86
Disagree		Reference Category					
Child Built Environment Related Perceptions							
There are lots of great shops that I like to visit in my neighbourhood	8.93			.011			
Agree		2.32	(1.01)	.021	10.18	1.42	73.12
Neither Agree nor Disagree		2.69	(1.09)	.013	14.79	1.75	125.12
Disagree		Reference Category					
Car traffic makes it hard for me to get around my neighbourhood	6.80			.033			
Agree		1.38	(0.83)	.098	3.97	0.77	20.40
Neither Agree nor Disagree		2.18	(0.97)	.025	8.86	1.32	59.54
Disagree		Reference Category					
Child Social Environment Related Perceptions							
You often see people out for walks in my neighbourhood	26.77			.000			
Agree		2.69	(1.65)	.104	14.72	0.58	375.95
Neither Agree nor Disagree		-3.91	(2.01)	.052	0.02	0.00	1.03
Disagree		Reference Category					
It is safe for me to play at the park closest to my house without an adult present	10.56			.005			
Agree		-0.65	(0.87)	0.455	0.52	0.10	2.86
Neither Agree nor Disagree		-3.79	(1.43)	.008	0.02	0.00	0.38
Disagree		Reference Category					
I play outdoors with lots of friends in my neighbourhood	8.11			.017			
Agree		2.33	(0.94)	.013	10.32	1.65	64.61
Neither Agree nor Disagree		0.96	(0.98)	.329	2.61	0.38	17.92
Disagree		Reference Category					

R^2 = .424 (Cox and Snell), .654 (Nagelkerke). Model X^2 (44) = 112.41

Gender was a highly significant predictor of a child's cycling participation (X^2 = 26.74, p < 0.001). Compared to female children, each additional male child had 41 times higher odds ratio of that child cycling to one of the stipulated destinations. Children seeing people out for walks was another variable depicting strong associations with child cycling (X^2 = 26.77, p < 0.001). A child who had agreed with the perception of seeing people out for walks had 14.72 times higher odds of having stated that they currently cycled to any one of the destinations compared to a child who had disagreed with this social environment perception. The urban environment played an important role in a child's cycling take-up and usage. Children from the inner, middle and outer suburbs had higher odds of cycling compared to children from the regional centre; the odds being 34.47, 3.87, and 2.47 for the inner urban, middle and outer suburbs respectively. Parental concern of neighbourhood safety was negatively associated with their child cycling. Parents who disagreed with the perception that assaults by strangers was a concern in their neighbourhood had 21.33 times higher odds of their child having stated that they currently cycled to at least one of the specified destinations. Parent's and children's positive perception of and their active participation in the neighbourhood social environment was positively associated with the child cycling. Children whose parents did not own a vehicle had a 120.5 odds ratio of having stated cycling as their mode of travel compared to those children whose parents owned two or more vehicles.

5. Discussion

Participation in utilitarian cycling has the potential to increase children's visual urban presence, enhance their social interactions and provide unstructured opportunities for regular exercise. The findings from this paper revealed that children's cycling participation varied considerably in relation to travel destinations, urban environments and gender. Bicycle ownership was high for both male and female children across the different urban environments; however this was not reflected in its use for transport purposes. Although 91% of the students had stated that they owned a bicycle, only 21% had stated that they used it as mode of travel to any one of the stipulated destinations. These findings are similar to other international studies, for example Christie et al. (2011) despite their focus on disadvantaged areas in UK, had comparably discovered, that though there were no economic barriers for bike ownership with 76% of the children having access to bikes, only 1% had used it for transport purposes.

Current cycling to school aggregated across all sites at 5.6% and in particular for the inner urban schools was slightly higher than the national average of 4%. A high latent demand for the use of bicycles was observed for travel to all destinations stressing children's preference for cycling as a legitimate mode of travel. One third of all children preferred to cycle to school and close to half of the children preferred to cycle to at least one other destination. These figures though higher than most other studies, reiterate prior findings of high unmet latent demand for children's cycling (Christie et al., 2011; Ridgewell et al., 2009). Social connectedness and en route social interactions seemed to play an important role in children's cycling decisions, most children who preferred to cycle to the specified destinations preferred to do so in the company of other children. Children who had stated that they currently cycled to schools, travelled equivalently with adults and children; however more children cycled to parks with adults and independently to local shops and local friends. Though a large number of children had been accorded 'licences' to cycle along main roads, accompanied cycling trends were reflected in the low multinomial logistic regression model variation explained by the variable issuances of 'licences' and both cyclist and non-cyclist students had equivalently been accorded licences to cycle independently.

Multinomial logistics regression analysis had identified gender as the principal demographic characteristic associated with a child's cycling. More male children currently cycled to all destinations and would have preferred to do so in larger numbers if given a travel mode choice. Though a number of studies have explored the association between gender and child cycling (Bere et al., 2008; Timperio et al., 2004), there are limited findings on the life cycle travel patterns of female student cyclists into adulthood. Lower current cycling participation by female students is envisaged to have significant long-term implications on their cycling abilities and cycling mode choices as adults. Targeted interventions and policies to encourage greater female student's school cycling participation therefore may have substantial short and long term benefits. It can advance not only female children's cycling modal shares to schools and other childhood travel destinations but additionally in the longer term impact adult female cycling culture for travel to destinations such as work.

Urban environment type is another variable which had salient associations with child cycling. An inner city child had the highest odds of cycling to any one of the destinations. This potentially could

have resulted from a number of factors such as better provision of cycling infrastructure, the stimulus impacts of more people cycling in general, better land use mix and more compact development leading to shorter travel distances to selected destinations in the inner city neighbourhoods. These findings are contrary to those of Johansson and Drott (2001) who in their study had found that bicycles were used mainly for play in the inner city and where it was used for transport the use was restricted to visiting friends whilst in the suburbs bicycles was mostly used for transport purposes.

Lack of household car ownership restricts mobility of children and households to public and non-motorised modes of transport. Those children whose households had no access to a vehicle had 120 times the odds of having stated cycling as their mode of travel to any one of the stipulated destinations compared to households with two or more vehicles. Whilst the aim of transport and urban policy should be to augment cycling participation, children who are captives to non-motorised modes of transport should have travel mode options for their daily travel in the long run. The social norms associated with cycling and walking in certain societies have unfortunately deemed them as modes of transport for those segments of the population who are low in social network capital (Urry, 2012). However for cycling amongst children to increase substantially the value accorded to cycling as a mode of travel would need to change so that it is no longer viewed as a mode exclusive to those segments of the population who are captives of non-motorised modes of transport.

Perceptions of 'stranger' and traffic danger are two of the more common social factors associated with low levels of children's cycling (Ridgewell et al., 2009; Trapp et al., 2011). Parents with neighbourhood assault concerns were less likely to allow their children to cycle to any one of the specified destinations. The perceptions of safety to some extent can be moderated by neighbourhood social connections, participation in neighbourhood activities and related feelings of neighbourhood trust. Parents who took part in neighbourhood organizations and who perceived their neighbourhood to be close knit had significant associations with and higher odds of their children cycling. Children who cycled had strong associations with the perception of seeing people out for walks in their neighbourhood and socially interacted in the neighbourhood by playing with their friends outdoors. These children's presence in the neighbourhood public space would have accorded them with a greater propensity to observe the presence of and relate with other people in their neighbourhood urban space enhancing their perceptions of neighbourhood safety. These findings related to fear of strangers and social networks reiterates findings of Ross (2007) who noted that though safety was a major concern for many parents, the existence of 'weak ties' provided for informal surveillance of children during their journeys, allaying safety fears to some extent. Cycling accorded children with an opportunity to establish and maintain social connections whilst spatially and cognitively negotiating their urban environments.

The deviance of the multinomial logistic regression model depicted in the R^2 which is equal to 0 .424 (Cox and Snell[i]) and 0.654 (Nagelkerke[ii]) showed that the variables incorporated in this model are crucial and to a large extent explained the variations in child cycling in these selected Australian contexts. These deviance figures also stressed that there may be other factors such as distance from facilities and the land use mix; incorporation of which could have led to a better model with R^2 values closer to one depicting a perfect or near perfect model. The socio-ecological framework emphasises that a variety of factors influence behaviour and these results further reiterate that child cycling is influenced by relevant built form, socio-economic, environmental and demographic factors and all of these factors need to be addressed holistically in order to enhance child cycling participation.

Travel behaviour interventions targeting cycling to work, school and for shopping has been suggested as a practical means of achieving long term increases in cycling (McClintock, 2002) and many such initiatives are in use in Australia. Cycling to school is strongly associated with children's use of bicycles for travel to other destinations and targeting the journey to school in such interventions could have long term, broader impacts in changing attitudes and travel patterns.

6. Conclusion

Australian children's cycling modal split has declined over the years and is at present substantially low compared to cycling friendly countries of Denmark and Netherlands. Children's cycling participation has the potential to enhance their presence in the urban environment, augment their social

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[i] Is the variance explained by the log likelihood of a new model compared to a baseline model and is theoretically computed to have a value of less than 1, with greater values signifying that a larger variance is explained by the model

[ii] Is an adjusted Cox and Snell model to cover the full range from 0 to a theoretical maximum of 1

interactions and boost their physical and mental health. Within the selected urban contexts, this study found that children's utilitarian cycling aggregated across case study areas was slightly higher than the national average however there were differential participations in child cycling across the distinct urban environment types, the two genders and to the varied destinations. The socio-ecological theoretical framework stipulates that a variety of factors influence behaviour and this paper highlights a segment of child cycling influences. Gender had consistently been found to be significantly associated with children's cycling with fewer female students cycling to all destinations and therefore policies targeting greater female cycling participation to schools are envisaged to have long-term impacts on life-long female cycling participation.

More children cycled for transport purposes in the inner urban areas compared to the other urban environment types and this amongst other factors could potentially result from better accessibility to urban facilities and better provision of cycling infrastructure. Local destinations with less stringent time budgets associated with travel and activity participation such as visiting parks and friends saw greater cycling modal splits compared to participation in organised activities. Stranger danger in the form of parental perceptions of assault concerns was strongly associated with children's cycling. This safety concern to some extent was however moderated by parental and child social connections and participation in neighbourhood activities. The presence of children in urban environments helps foster feelings of peopled places and favourable perceptions of social connectedness and children's cycling to schools and neighbourhood destinations can contribute to increased frequency and presence of children in urban spaces. A combination of holistic policies aimed at enhancing neighbourhood social environment, female cycling participation and cycling accessibility to urban facilities of interest to children can in the long term influence children's cycling mode shares.

This exploratory paper has added to the knowledge on Australian children's cycling for transport by providing cycling modal splits of their travel to selected destinations in a variety of urban environments. It has further identified influential demographic and social influences of children's cycling take-up and utilitarian use. The social environment and related perceptions are as significant as built environment factors and need to be addressed in addition to the provision of safe and conducive cycling infrastructure if children's cycling to school and other destinations are to be encouraged. The findings presented in this paper given the small sample size focused on the logistic regression for children's cycling to any one destination. Based on the socio-ecological model, further work in this research will include comparative holistic analysis of the relevant determinants inclusive of social and built form perceptions and factors such as accessibility to and land use mix and their association with gendered cycling and cycling modal splits for singular destinations.

7. Acknowledgements

8. References

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