

Children's Cycling Trends, Accessibility to and Utilisation of Urban Facilities in Selected Australian Urban Environments

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Abstract

Children's travel is an integral component of overall transport demand in Australian cities. The mode choices of children and their parents impact not only traffic flows around schools, but also children's mental, physical and social health. Despite cycling being a healthy, safe, affordable and space/energy efficient mode of transport, current bicycle mode shares for the journey-to-school are low in Australia. Previous research has identified that amongst other socio-economic and built form factors, distance is an important determinant of the use of cycling for transport. This paper uses a sample of the broader CATCH/iMATCH survey data to explore the stated and revealed preferences for the use of bicycles. During 2011-2012, approximately 350 children in nine selected primary schools across Rockhampton, Brisbane, Melbourne and Perth, completed attitudinal surveys and wore global positioning systems (GPS) units and completed travel diaries for four days. A segment of these data are used to explore the role of travel distance in terms of accessibility to selected destinations and its association with children's travel preferences, and especially cycling. The results include cycling mode shares, travel distances by bicycle, accessibility mapping for selected school neighbourhood populations by bicycle using GIS, and reported attitudes towards cycling. The findings show a disconnect between children's stated preferences for cycling and revealed behaviour, despite considerable potential for bicycle travel in most school neighbourhoods. Tentative explanations are provided as to why these differences exist, which have implications for Australian policy and programs.

1. Introduction

The focus on sustainable transport and accessibility represents a shift away from the conventional emphasis on the performance of transport infrastructure to the holistic evaluation of the land use and transport interaction with an increased recognition of the significance of non-motorised transport modes, streets as liveable active spaces and the social dimensions of travel (*Banister, 2008; Bertolini et al., 2005; Boschmann and Kwan, 2008; Curtis and Scheurer, 2010; Vega, 2012*). Of particular significance to long-term transport sustainability is the travel patterns and mode choices of children who develop attitudes towards and preferences for the different modes of transport from childhood. The last decade has seen a significant decline in children's cycling and walking school trips, a reduction in their independent mobility and a resultant decline in their active use of and presence on the streets particularly in the non-European Western countries (*Alparone and Pacilli, 2012; Babey et al., 2009; Badland et al., 2011; Kyttä, 2004*). At the same time there has been an observed increase in the number of children who are overweight and who do not meet their daily physical activity requirements (*McDonald, 2008a; Timperio et al., 2004*). These trends have had a number of impacts on children's mental, social and physical health; the transport system and the direction of transport and health research related to children's travel.

The decline in active school travel in favour of private motorised modes of travel has been instrumental in the increased traffic flow and congestion along the streets in the vicinity of and leading to schools (McMillan, 2007), creating unsafe travel environments for those few children who use active modes of transport. Children who are driven to school develop unhealthy travel patterns for their adult life due to parental chauffeuring which is influential in “reinforcing unsustainable transport habits in children, which are then likely to lead to car-dependent social values in adulthood” (Tranter and Pawson, 2001, pg. 45). In addition to the transport impacts, children’s travel patterns have recently been brought to the forefront of transport and health research due to the significance of active school travel in mitigating the soaring prevalence of obesity and being overweight amongst children (Boarnet et al., 2005; Bringolf-Isler et al., 2008; Buliung et al., 2009a; b; Cooper et al., 2005; Mackett et al., 2005).

The journey to and from school constitutes a considerable share of a child’s weekly travel and provides an opportunity for them to increase their daily levels of physical activity by walking and cycling (Larsen et al., 2009). Further to health benefits, children’s active travel to school provides an opportunity for them to travel by modes which they are in control of and which allows them to dynamically interact with the built and natural environment as well as socially with other children and adults (Carr and Lynch, 1968). Walking and cycling are both important active modes of travel; however cycling has greater impact on cardiovascular and respiratory fitness and obesity than walking (Andersen et al., 2011; Bere et al., 2011; Cooper et al., 2008). Cycling enables the expenditure of twice as much energy per unit of time when compared to walking and is therefore a more energy intensive mode of active travel (Bere et al., 2011). 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). However very few children cycle for transport purposes in Australia and other comparable Western Countries and a number of built form, social, environmental and individual determinants are instrumental for these low levels of cycling take-up and usage.

Several studies on the relationship between urban form and children’s travel have emphasised that urban form and the resultant accessibility to and travel distances from school is an important determinant of children’s active travel including cycling (Boarnet et al., 2005; Gallimore et al., 2011; Lin and Yu, 2011; McMillan, 2007; Ridgewell et al., 2009). This paper using a sample of children’s survey data from the CATCH/iMATCH project explores children’s cycling patterns across selected urban environments in Australia and examines the associations between a child’s gender, the urban typology, travel distances and cycling mode choice for travel to stipulated destinations as an attempt to provide an insight into children’s cycling for transport within an Australian context.

2. Children’s Cycling for Transport: Status and Determinants

Despite, cycling being a healthy, safe, space and energy efficient mode of transport which is generally affordable to a large majority of households (Gatersleben and Appleton, 2007; Lumsdon and Tolley, 2001; Moudon et al., 2005), the use of bicycles constitutes a very small percentage of children’s travel mode share in most of the non-European Western countries. 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). Comparatively, in European countries of Denmark and Netherlands, the cycling mode share is as high as forty percent for school trips (D’Haese et al., 2011; de Vries et al., 2010). Australian children’s cycling mode share though comparatively low at present has seen a substantial decline over the years.

Tranter and Whitelegg (1994) had observed that around 11% of the children in selected Canberra schools used to cycle to school close to two decades ago, with the percentage of children being given permission to cycle by their parents back then, being much higher than

that accorded to German and English students. The Australian Capital Territory (ACT), despite having a reasonable natural environment and adequately planned and conducive urban development for cycling, has over the years shown marked decrease in cycling rates. Though there are differences in sampling and methods across studies, cycling rates in the Australian Capital Territory was only 4.7% in 2011, albeit this mode share being higher than in many other Australian cities (*Australian Bureau of Statistics*, 2011; *Tranter and Whitelegg*, 1994). At a State level, the Northern Territory has the highest percentage of cycling mode share for school travel (6.7 percent) whilst cycling constitutes less than 1% of the school modal split in New South Wales and Tasmania (*Australian Bureau of Statistics*, 2011).

In addition to spatial disparity, Australian children's use of bicycles amongst other variables is differentiated by the purpose of trips. Whilst children's cycling for transport and in particular as a mode share for school travel has experienced substantial decline in recent decades, 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 9 percent of forty year olds (*Australian Bicycle Council (ABC) and Austroads*, 2011). A number of determinants are influential in children's cycling take-up and usage for transport purposes across countries and for the intra-urban and intra-regional differences.

The decline in children's active travel including cycling as an important component and its resultant and potential impacts on the health, cognitive, social and psychological development of children has driven the flurry of research on the trends and determinants of children's travel in the last decade. Bulk of the research on travel determinants has combined children's cycling with walking (*Evenson et al.*, 2003; *McDonald et al.*, 2010; *McMillan*, 2007; *Panter et al.*, 2010; *Timperio et al.*, 2004) with very few studies focusing exclusively on children's cycling determinants (*Christie et al.*, 2011; *Trapp et al.*, 2011). The existing research on children's travel determinants is based on three of the more eminent models being the social ecological framework, the McMillan model and the Ecological and Cognitive Active Commuting (ECAC) framework.

The social ecological model formulated by Bronfenbrenner (1979) is the oldest and most used model which stipulates that a variety of environments such as social, physical, economic and individual characteristics influence children's behaviour (*Alparone and Pacilli*, 2012; *Børrestad et al.*, 2011; *Giles-Corti and Donovan*, 2002; *Robertson-Wilson et al.*, 2008; *Timperio et al.*, 2006; *Trapp et al.*, 2011). The McMillan framework is based on the premise that parents are the ultimate decision makers for their children's travel and that parental decision making is based on the interplay between the urban form, mediating and moderating factors (*McMillan*, 2005). Sirard and Slater (2008) have used the combined McMillan, social ecology framework and social cognitive theory for their Ecological and Cognitive Active Commuting (ECAC) framework in which both the physical and social environment perceptions combine with other factors such as psychosocial mediators and resources to influence the frequency of active travel which in turn shapes perceptions. All these models emphasise that children's cycling as well as other travel modes are reliant not on any single determinant but a combination of factors, some of these determinants are stipulated below.

Children's cycling determinants explored in literature can be categorised as demographic, socio-economic, physical and policy environment factors. Demographic factors found to influence children's cycling include age, gender, perceptions of and observed cycling skills, household structure and cognitive awareness, with gender being a more compelling determinant as more male students have been found to cycle to school (*Ahlport et al.*, 2008; *Babey et al.*, 2009; *Chang and Chang*, 2008; *Christie et al.*, 2011; *Emond and Handy*, 2012; *Evenson et al.*, 2007; *Evenson et al.*, 2003; *Fyhri and Hjorthol*, 2009; *Hume et al.*, 2009b; *Larsen et al.*, 2011; *Martin et al.*, 2007; *McDonald*, 2012; *McMillan*, 2007; *Panter et al.*, 2010). The socio-economic determinants found to influence children's cycling include

elements such as household income; attitudes towards use of bicycles; parental perception of 'stranger' and traffic danger; maternal professional status; parental education; cultural background; household social disadvantage; social networks and neighbourhood social capital (Ahlport et al., 2008; Chillon et al., 2009; Christie et al., 2011; Elias and Katoshevski-Cavari, 2011; Emond and Handy, 2012; Evenson et al., 2007; Hume et al., 2009a; Hume et al., 2009c; Larsen et al., 2011; Martin et al., 2007; McDonald, 2007; 2008b; McMillan, 2007; Panter et al., 2010; Prezza et al., 2001; Ridgewell et al., 2009; Timperio et al., 2004).

The built physical environment determinants found to be influential in children's cycling are traffic volume and flow along streets with related perception of safety; the availability of on- and off- road cycling infrastructure; frequency of pedestrian crossings; presence of traffic lights; distance, residential density and landuse mix (Babey et al., 2009; Bere et al., 2008; D'Haese et al., 2011; de Vries et al., 2010; Larsen et al., 2009; McMillan, 2007). These built environment factors can be broadly classified as the 5D's being density, diversity, design, distance and destination accessibility (Boarnet, 2011; Cervero and Kockelman, 1997; Cervero et al., 2009; Ewing and Cervero, 2010). Of these, distance and related destination accessibility to school have been identified as the more significant built environment determinants with most cyclist students residing within 3km from schools (Babey et al., 2009; D'Haese et al., 2011; McMillan, 2007). Natural physical environment determinants include elements such as topography, weather extremes and tree cover in form of the presence of street trees (Fyhri and Hjorthol, 2009; Prezza et al., 2005). Influential policy factors include school and relevant authority strategies to promote or restrict cycling such as the provision of cycling infrastructure including at school facilities, minimum ages at which students are allowed to cycle, cycling competency training together with design and policy instruments which create an inductive cycling environment (Ahlport et al., 2008; Pucher et al., 2011; Webster et al., 2006).

Children's cycling is a function of a combination of a number of relevant determinants with distance from and accessibility to schools and urban facilities of interest to children being identified as one of the more significant objectively and subjectively measurable determinants which is further explored in this paper.

3. Cycling Accessibility and Travel Distances

Accessibility as a measure of the potential ease with which people can reach goods, services and opportunities has become widely used within the urban and transport planning sphere as an effective and inclusive outcome indicator of the integration between the prevalent transport system incorporating the different transport modes and urban land use (Bertolini et al., 2005; Curtis and Scheurer, 2010; Straatemeier, 2008). Depending on the context it is applied in, there are variations in the definitions and approaches used with one of the earlier authors, Hansen (1959, pg. 73) defining accessibility as the 'potential of opportunities for interaction'. Miller (2004) defines accessibility as a person's physical reach in space and time through movement within the field of time and activity space research. Accessibility is a resultant indicator of the interaction between a number of components which according to Geurs and van Wee (2004) are the land use system, transport, temporal and the individual component. These components are comparable to the transport, temporal, spatial, economic, social, cultural and coupling accessibility constraints categorised by Odoki et al (2001). Stemming broadly in similar categorisation as these components and constraints are accessibility measures and indicators, which have been classified as infrastructure, person/people and place based indicators (Bocarejo S and Oviedo H, 2012; Delafontaine et al., 2012). Further, Curtis and Scheurer (2010) list seven categories of accessibility measures being spatial separation, contour, gravity, competition, time-space, utility and network measures.

Infrastructure based measures with the noted limitation that it does not take into consideration land use aspect of accessibility but focuses on the performance of transport

infrastructure in entirety, refers to the performance of transport infrastructure calculated in terms of travel times, speed, delay along the network and congestion levels (*Geurs and van Eck, 2001; Geurs and van Wee, 2004; Vandenbulcke et al., 2009*). Space time activity measure and utility indicators are individual person and people based accessibility measures. Disaggregate space time activity measure takes into consideration spatial and temporal restrictions that an individual faces in reaching certain destinations and comprises of the routes of travel to and the locations of activities for individuals (*Bocarejo S and Oviedo H, 2012; Geurs and van Wee, 2004; Schönfelder and Axhausen, 2003*). Utility indicators are based on econometric models and measure economic and social equity benefits that people gain from accessing activities within a given context (*Bocarejo S and Oviedo H, 2012; Curtis and Scheurer, 2010*).

Place or location-based accessibility measures include distance and contour measures and are the more commonly used spatial planning macro accessibility indicators (*Geurs and van Wee, 2004*). Distance measure also known as spatial separation measure is used to compute relative accessibility between any two locations and is built around the assumption that locations which are far apart are deemed to be less accessible than those that are closer together without taking into consideration the attraction variables (*Aultman-Hall et al., 1997; Bhat et al., 2000; Curtis and Scheurer, 2010; Pirie, 1979*). Contour or the cumulative opportunities measures depict isochrones of the relationship between the number of opportunities and transport costs in the form of the number of opportunities which can be reached within a given generalised cost or vice versa (*Handy and Niemeier, 1997*). Distance and contour measures are widely used due to the ease with which they can be interpreted and their limited data requirements, however, they do not take into consideration individual preferences for urban opportunities under scrutiny, the capacity restrictions of the facilities to cater for the purported demand and is based on arbitrary time and distance cut-offs (*Curtis and Scheurer, 2010; Geurs and van Wee, 2004*). Noting these limitations, place based accessibility measure is used to calculate the travel distances in this study.

The potential measure, often of the form of a gravity model, estimates accessibility from one zone to other zones with an understanding that the potential for interaction between two places declines with increasing travel distance and is positively related to the attractiveness of a place (*Hansen, 1959*). A number of distance decay functions have been formulated to measure the potential for interactions between sets of origins and destinations (*Geurs and van Eck, 2001; Krizek et al., 2007*), including the negative power or reciprocal function (*Davidson, 1977; Handy and Niemeier, 1997; Hansen, 1959*), the negative exponential function, the modified normal or Gaussian function (*Guy, 1983*) and the modified (log)logistic function (*Bewley and Fiebig, 1988; Martínez and Viegas, 2013*). Curtis and Scheurer (2010) define network based measure of accessibility with its origins in graph theory as a measure of the distance between nodes and links with indicators of the measure including degree centrality, the betweenness centrality and closeness centrality.

4. Methodology

This paper uses a segment of the data collected for the 'Children, Active Travel, Connectedness and Health' and the 'Independent Mobility, Active Travel and Children's Health' (CATCH/iMATCH) research projects, a combined Australian national study into the built and social environment influences on children's independent mobility, active travel and health. Data for the CATCH/iMATCH project was collected during the school terms in 2011 and 2012 from primary school students and their parents who were recruited through nine schools selected to represent the variety of urban environments where most Australian children reside, being the inner, middle, outer suburbs and regional towns in Brisbane, Melbourne, Perth and Rockhampton. A number of data collection instruments including self-administered child and parent surveys; GPS, actiheart and travel diary recordings together with photo elicitation were employed for the objective and subjective reporting of and perceptions towards child travel and activity patterns. This paper reports only on a fraction

of the data collected from the child surveys with emphasis placed on findings relating to children's cycling for transport.

The child survey was designed to collect basic demographic information of the child, their current travel patterns to selected destinations, their preferred travel modes; perceptions towards the school and neighbourhood environment; their independent mobility; factors which could influence greater active and independent travel participation and their current time utilisation for passive and active activities. The basic demographic information that children self-reported on were their gender, age, school year, bicycle ownership and 'licenses' issued for cycling in the neighbourhood. Travel patterns were reported for selected destinations of schools, local shops, friends, parks, organised activities and activities outside of the neighbourhood with options for travel times and travel modes including being driven or the use of the public transport, walking and cycling alone or in the accompaniment of other children and adults. Though reported this paper does not report on the differences between the independent and accompanied current cycling patterns and preference for bicycle as a mode of travel choice for travel to stipulated destinations. Further, the child responses for similar urban environments such as the two outer suburban schools in Brisbane and the three regional schools in Rockhampton are spatially aggregated based on urban environment type rather than individual reporting for these five schools.

Trip descriptive statistics for child characteristics and travel patterns were calculated using a combination of SPSS (version 20) and Excel (2010) whilst GIS analysis has been undertaken in ArcGIS (version 10.1). Trip distances were calculated for a sample of the data being the two Melbourne schools and the middle suburban school in Brisbane. The residential locations were geocoded using, where available, the addresses provided in the parent survey and as identified using the GPS tracks. The road network dataset used comprised all road types, including trails which could be used by cyclists and pedestrians; however the limitation is noted for the potential understatement of motorised travel distances. Distances of child residences from schools and selected facilities were calculated using the shortest path algorithm with distances between schools, commercial facilities and residences calculated from their respective centroids whilst the open space distances included the edges converted to points in addition to the centroids. School travel distances theoretically represent travel distances for the revealed school choice whilst the local open space and shop distances signify potential accessibility as children have not expressed explicitly which particular facility they travel to and the travel distance is calculated from the nearest facility noting the limitation that attractiveness and the resultant travel could be based on other facility attraction factors rather than just travel distances.

5. Results

5.1 Student Characteristics across the Selected Case Study Schools

A total of 305 students, 113 male and 192 females responded to the student surveys from the nine schools in Melbourne, Brisbane, Perth and Rockhampton. More female students responded to the child surveys in all school sites; however the gender differences in surveys were less notable in the two Melbourne schools. Student respondents were equivalently sourced from the four urban environments types; 27% from the inner suburb schools, 21% from the middle suburb, 29% from the outer suburbs and 23% from the Rockhampton regional schools. The basic characteristics of the student respondents categorised by the schools spatial location and urban typology are depicted in Table 1.

A majority of the students (89%) who participated in this survey were from school years five to seven aged between 10-13 years. Bicycle ownership was high across all the schools, 92% of all students owned bicycles with marginal differences in ownership across the two genders with 94% of all males and 92% of the female students owning a bicycle.

Table 1: Student Characteristics across the Selected Schools

Respondents Characteristics	Melbourne Inner Urban School		Perth Inner Urban School		Brisbane Middle Suburban School		Melbourne Middle Suburban School		Brisbane Outer Suburban Schools (2)		Rockhampton Regional Schools (3)		Total	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Gender														
Males	16	(53)	19	(37)	7	(35)	20	(45)	28	(31)	23	(32)	113	(37)
Females	14	(47)	32	(63)	13	(65)	24	(55)	61	(69)	48	(68)	192	(63)
Total	30	(10)	51	(17)	20	(7)	44	(14)	89	(29)	71	(23)	305	(100)
School Grade Level														
Year 3	0	(0)	0	(0)	0	(0)	7	(16)	0	(0)	0	(0)	7	(2)
Year 4	18	(60)	0	(0)	1	(5)	8	(18)	0	(0)	1	(1)	28	(9)
Year 5	9	(30)	23	(45)	6	(30)	13	(30)	27	(30)	25	(35)	103	(34)
Year 6	3	(10)	19	(37)	7	(35)	15	(34)	48	(54)	28	(39)	120	(39)
Year 7	0	(0)	9	(18)	6	(30)	0	(0)	14	(16)	17	(24)	46	(15)
Bicycle Ownership														
Males	15	(94)	19	(100)	7	(100)	17	(85)	26	(93)	21	(91)	105	(93)
Females	14	(100)	26	(81)	12	(92)	22	(92)	58	(95)	43	(90)	175	(91)
Total	29	(97)	45	(88)	19	(95)	39	(89)	84	(94)	64	(90)	280	(92)

5.2 Children's Stated Cycling Travel Patterns

Cycling as a travel mode choice varied substantially across the different urban environments and the destinations that children were asked to report their travel patterns for. In total 5.6% of all the children reported cycling as their mode of travel to school, this figure being slightly higher than the national average of 4%. Urban environment seems to play an important role in the cycling mode choices for school travel with more children from the inner urban schools in Melbourne (n=10; 36%) and Perth (n=4; 8%) having stated cycling as their mode of travel compared to none of the students in the Brisbane schools, just one student in the middle Melbourne suburb and in regional Rockhampton schools. Across all the schools, children stated using bicycles to travel to selected local destinations such as travel to local parks, local friends and local shops, travel to destinations which potentially could be less stringently demanding on children's travel and activity participation time budgets. Cycling for recreation purposes was found to have the highest participation, with more students using bicycles to travel to parks than any other destination. The cycling mode share for selected destinations across the different school types is depicted in Figure 1.

Figure 1: Current Cycling Trends to Selected Destinations Categorised by School Type

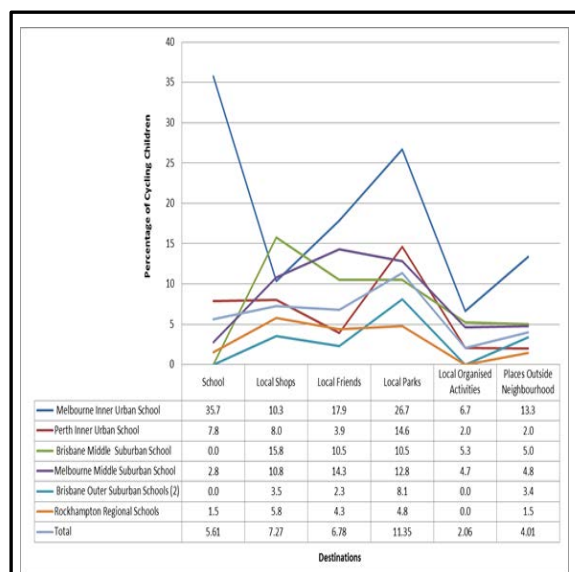
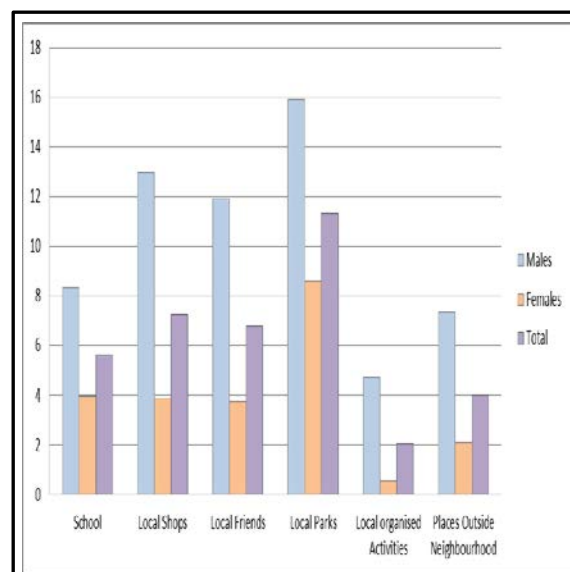


Figure 2: Gender Distribution of Cycling Mode Choice for Travel to Selected Destinations



Gender appears to play an important role in the use of bicycles as a mode choice for travel to all the stipulated destinations, with greater percentages of male student stating that they cycled to selected destinations, refer to Figure 2.

5.3 Latent Demand for Cycling

Amongst other stipulated alternative travel modes significant percentages of children stated that they would prefer to cycle to school and specified destinations. The preference for cycling as a mode choice is highest for travel to school, followed by local parks, shops and friends. There are substantial differences in the latent demand for cycling across the diverse urban types and gender. Greater percentages of male students and those from inner and middle suburbs have stated a preference for cycling as a mode of travel to selected destinations, refer to Table 2.

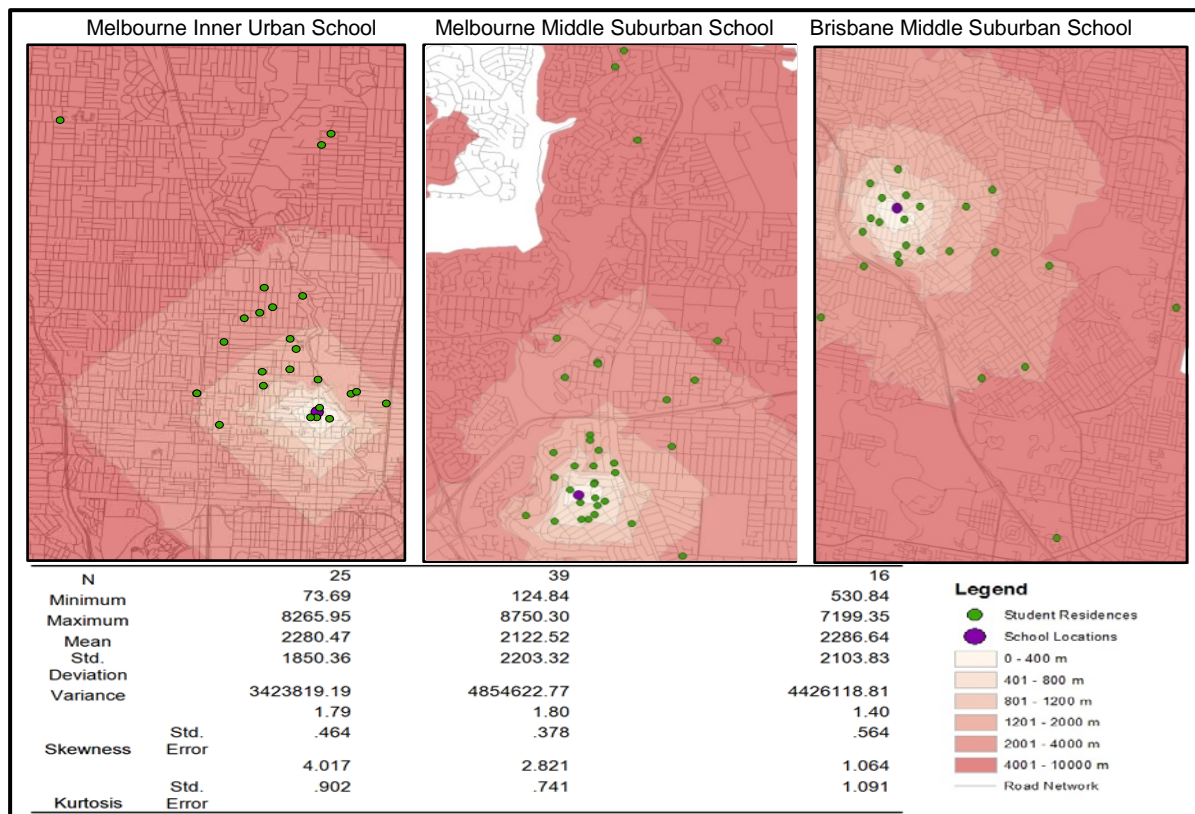
Table 2: Preference for Cycling as a Travel Mode to Selected Destinations across the Schools

Variables	Melbourne Inner Urban School	Perth Inner Urban School	Brisbane Middle Suburban School	Melbourne Middle Suburban School	Brisbane Outer Suburban Schools (2)	Rockhampton Regional Schools (3)	Total
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
<i>Stated Demand for Cycling As a Mode of Travel to Selected Destinations:</i>							
<i>School</i>							
Males	8 (53)	9 (47)	3 (50)	8 (42)	11 (39)	9 (39)	48 (44)
Females	8 (57)	7 (22)	3 (25)	6 (25)	8 (13)	16 (34)	48 (25)
Total	16 (55)	16 (31)	6 (33)	14 (33)	19 (21)	25 (36)	96 (32)
<i>Local Shops</i>							
Males	4 (36)	7 (37)	3 (50)	8 (44)	9 (36)	6 (30)	37 (37)
Females	4 (29)	5 (16)	3 (27)	7 (32)	5 (9)	8 (19)	32 (18)
Total	8 (32)	12 (24)	6 (35)	15 (38)	14 (18)	14 (22)	69 (25)
<i>Local Friends</i>							
Males	5 (42)	11 (61)	2 (29)	9 (50)	6 (24)	3 (17)	36 (37)
Females	5 (42)	4 (13)	4 (31)	4 (18)	7 (13)	4 (10)	28 (16)
Total	10 (42)	15 (31)	6 (30)	13 (33)	13 (17)	7 (12)	64 (24)
<i>Local Parks</i>							
Males	5 (42)	7 (39)	2 (33)	10 (63)	12 (48)	7 (39)	43 (45)
Females	4 (33)	7 (23)	5 (38)	7 (35)	10 (19)	8 (20)	41 (24)
Total	9 (38)	14 (29)	7 (37)	17 (47)	22 (29)	15 (25)	84 (32)
<i>Local Organised Activity</i>							
Males	2 (18)	2 (11)	1 (17)	4 (25)	2 (8)	2 (11)	13 (14)
Females	1 (9)	2 (6)	2 (18)	1 (5)	2 (4)	2 (5)	10 (6)
Total	3 (14)	4 (8)	3 (18)	5 (14)	4 (5)	4 (7)	23 (9)
<i>Outside Activity</i>							
Males	2 (20)	5 (28)	0 (0)	3 (18)	6 (23)	2 (11)	18 (19)
Females	3 (25)	2 (6)	3 (25)	2 (9)	7 (13)	5 (13)	22 (13)
Total	5 (23)	7 (14)	3 (17)	5 (13)	13 (16)	7 (12)	40 (15)

5.4 Accessibility to Schools in terms of Travel Distances and Related Travel Mode Choices

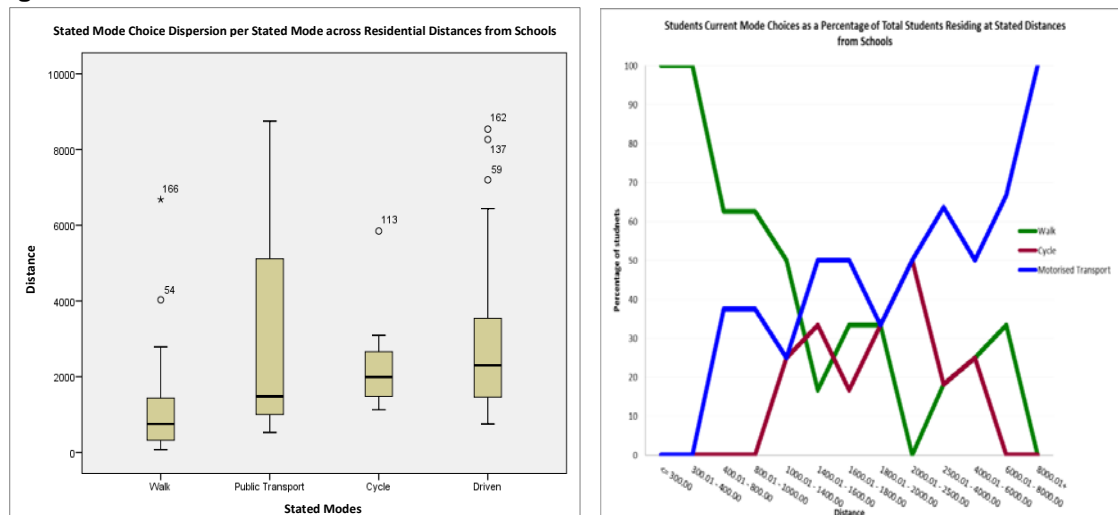
Of the 94 students in the two Melbourne schools and the middle suburban Brisbane school, data on residential addresses were available for 80 students. Most of the student respondents reside at distances of less than 4km in all three schools with a minimum travel distance of approximately 74m in the Melbourne inner urban school and a maximum of 8.7km in the Melbourne middle suburban school; this is depicted in Figure 3.

Figure 3: Travel Distances from Schools (in meters) and the Distribution of Students in the two Melbourne and the Middle Suburban Brisbane Schools



Though the sample size is relatively small for the calculation of meaningful distance decay functions for the stated current and preferred modes, however, excluding the outliers, distinct travel patterns across the residential distances from the school can be observed for the specified modes of travel. Most of the students who stated that they currently cycle to school, reside between the distances of 1 and 3 km from school compared to majority of the walking students who reside at distances of less than 1km. Student's mode choice for school travel gradually shifted from higher percentages of walking to cycling and motorised modes of travel with increments in travel distances. Students chose to cycle beyond 1 km and being driven beyond 400m; refer to Figure 4. Similar trends were observed for stated preference, with 70% of students who prefer to cycle to school, residing at distances of upto 3km from schools.

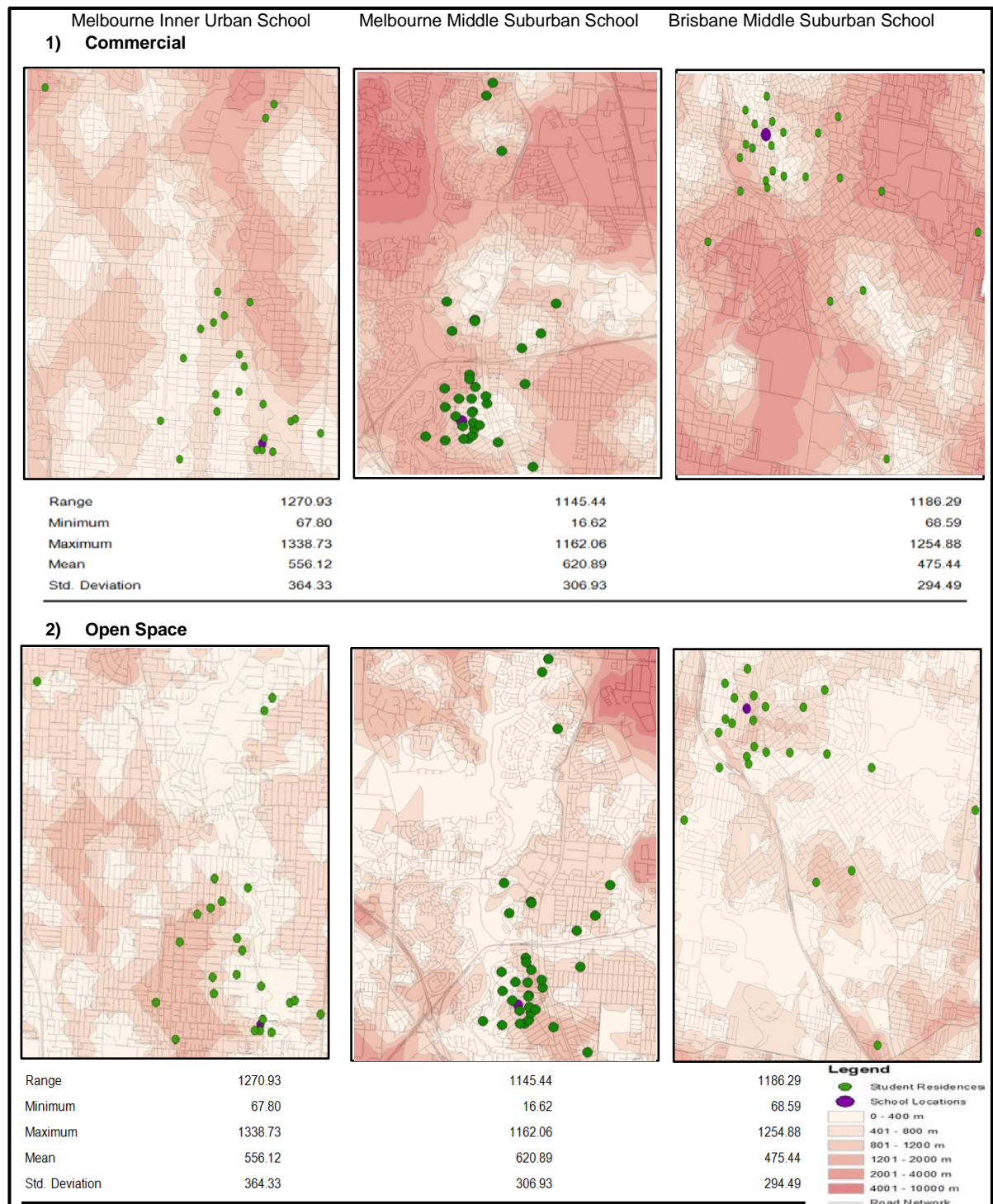
Figure 4: Stated Current Mode Choices across Residential Distances from Schools



5.5 Accessibility to Local Shops and Parks in terms of Travel Distances and Related Travel Mode Choices

Using GIS to calculate distances, children in the Melbourne schools appear to live within more equitably accessible distances of local commercial lots and local parks, as compared to the Brisbane middle suburban school (see Figure 5). The maximum travel distances to parks are less than 1.5km for the children from these three schools whilst the maximum travel distances for local commercial is less than 2km for the two Melbourne school children and 2.8km for the Brisbane school. These figures are considerably lower than the maximum travel distances to schools which varied between 7.2 and 8.8km for the student respondents in the three schools.

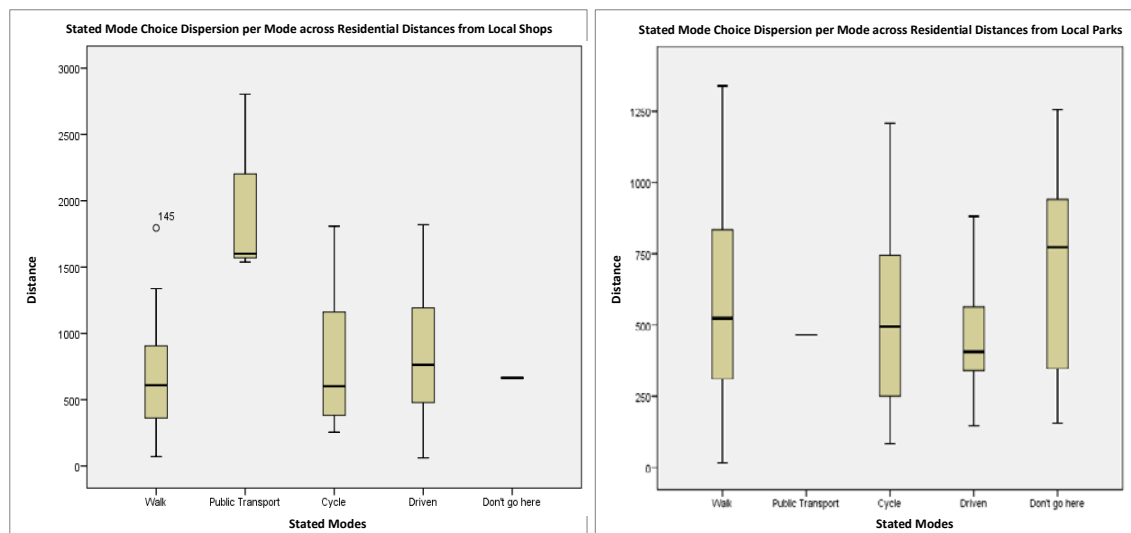
Figure 5: Travel Distances from Closest Local Commercial and Park Land Parcels



Better accessibility could potentially be associated with the higher proportion of student respondents in the Melbourne and Brisbane middle suburban schools respectively cycling to local shops (10.8%, 15.8%) and local parks (12.8%, 10.5%) than to schools (7.8%, 0%). However it is noted that in addition to distance from local shops and parks, other potential factors such as child time budgets, traffic situations and bicycle storage capacity in these two facilities could have played a role in children's cycling decisions.

Given the relatively higher levels of accessibility there are no major differences in the travel distances in particular the mean and median travel distances for the different travel modes, refer to Figure 6. The significant exception in the choice of travel modes related to travel distances is seen in the use of public transport which is utilised only where travel distances to the nearest commercial parcel exceeds 1.5km. Overall more children have used motorised modes of travel for shopping trips compared to local parks where cycling and walking are the predominant travel modes. However the modal share for motorised modes of travel to local shops and parks is relatively lower than school trips.

Figure 6: Stated Current Mode Choices across Residential Distances from Commercial Lots and Local Parks



5.6 Interrelationship between Selected Variables and Children's Travel Modes

Children's travel decisions and mode choices are influenced by a number of applicable determinants. To explore the interrelationship between children's travel modes and some of the factors for which data was available from the child surveys, a correlation analysis was undertaken. In this analysis, current travel modes have been correlated with the expressed preferred modes of travel to analyse the potential importance of children's current mode choices on their travel preferences as it has been previously noted in literature that the use of particular travel modes impacts the perceptions of and hence the long-term utilisation of the different modes of travel. The results of the correlation analysis between current travel modes, preferred travel modes and some of the selected variables are presented in Tables 3 and 4 respectively.

Noting the limitations in correlation analysis that a cause and effect relationship cannot be ascertained, there are however significant correlations amongst a number of factors and children's travel modes indicating associations between these variables. The current travel mode to school has significant correlations with travel distances from school, urban type, and current mode choices for travel to local parks and friends. Amongst all the factors considered in this analysis, distance from schools has the strongest association with travel modes to school which could potentially imply that better distribution of schools could result in shorter travel distances and hence additional utilisation of active modes of cycling and

walking. Children's travel to local destinations including local parks and shops is notably interrelated with the urban environment as well as the school travel modes.

Table 3: Correlation between Selected Variables and Current Travel Modes

Kendall's tau_b for Selected Variables	Urban Environment	Local Shop Mode	Local Park Mode	Organised Activity Mode	Local Friends Mode	Outside Neighbourhood Mode	Distance from school	Distance from local park
School Mode	.158**	.239**	.206**	.125*	.237**	.173**	.427**	-.203*
Local Shop Mode	.156**	1.000	.208**	.102	.207**	.263**	.158	-.128
Local Park Mode	.233**	.208**	1.000	.106*	.110*	.108*	.105	.048
Organised Activity Mode	-.010	.102	.106*	1.000	.217**	.223**	.033	-.012

** . Correlation is significant at the 0.01 level (2-tailed); * . Correlation is significant at the 0.05 level (2-tailed).

Preferred travel modes to school are associated with current travel modes to local destinations, urban typology and preferred travel modes to local destinations. Significant correlations exist between the current and preferred modes of travel to local destinations which potentially signify implications of current travel patterns on future mode preferences.

Table 4: Correlation between Selected Variables and Preferred Travel Modes

Preferred Modes for Travel to:	Urban Env.	Gender	Current Travel Modes to:			Preferred Modes of Travel to:			
			School	Local Friends	Local Parks	Local Shop	Local Friends	Local Parks	Organised Activity
School	.118	-.232**	.176**	.133	.169**	.223**	.232**	.239**	.032
Local Shops	.167**	-.117*	.154**	.113*	.167**	1.000	.183**	.298**	.067
Local Friends	.028	-.030	.140*	.501**	.120*	.183**	1.000	.251**	.225**
Local Parks	.166**	-.149*	.143*	.153**	.549**	.298**	.251**	1.000	.102
Organised Activity	.164**	-.029	.056	.101	.100	.067	.225**	.102	1.000
Outside Neighbourhood Activity	.095	-.073	.064	.120*	.168**	.252**	.361**	.157**	.414**

** . Correlation is significant at the 0.01 level (2-tailed); * . Correlation is significant at the 0.05 level (2-tailed).

6. Discussion

Children's cycling for transport within the selected Australian contexts at an aggregate level, though not as low as the national average, has shown significant variation across the selected urban environments, destinations and amongst the two gender groups. Access to bicycles did not play a significant role in its use with bicycle ownership being high in all the schools; however, this ownership has not translated into the utilitarian use of bicycles for transport. The significance accorded to bicycle as a valid mode of transport has to some extent been depicted in its use for travel to the stipulated destinations. More children use bicycles for travel to parks than to any other destination which reiterates findings of the Australian Bicycle Council (2011) that significant proportion of Australian children do use bicycles, however for recreational travel only. The urban environment, which a child resided in, played an important role in the cycling mode share for travel to all of the selected destinations. A higher proportion of children from the inner urban suburb followed by the middle suburbs and regional centres currently use bicycles for transport to all the destinations. This could potentially be attributed to the better provision of cycling infrastructure, the higher overall use of bicycles for transport by the general population as

well as the land-use distribution with its resultant lower travel distances to selected destinations within the inner suburbs when compared to other urban environments.

Gender was found to be another significant determinant of children's cycling, with male students comprising two thirds of the aggregate cycling modal share. There were marked differences amongst the two gender groups in the use of bicycles for travel to local friends, shops, organised activities and activities outside of the neighbourhood, where twice or more than twice the number of male students cycled compared to female students. These findings echo those of other international (*Larsen et al.*, 2011; *Panter et al.*, 2010) and Australian studies (*Timperio et al.*, 2004) that have reported on the gender differences in children's cycling for transport, even though most of these existing studies have focused exclusively on children's school travel. Children's mode choice for school travel was found to be associated with the mode choices for the other stipulated destinations which could imply that school travel has implications on children's perception of and utilisation of travel modes and that targeted interventions to encourage cycling to school can potentially lead to increased cycling participation for travel to other destinations. In addition to the gender and urban environment influences, distance from school played an important role in children's cycling. A majority (90%) of the students, who currently cycled to school, resided between distances of 1 and 3km from the schools. Taking into consideration the built environment, cycling infrastructure and cycling participation dissimilarities, D'Haese et. al. (2011) had likewise discovered that most cyclist students resided at distances of less than 3km in selected schools in Denmark.

Findings on cycling latent demand echo those of existing research which has revealed that in Western countries, though the current bicycle mode share is quite low for school travel, there is substantial latent demand (*Christie et al.*, 2011; *McDonald*, 2008c; *Ridgewell et al.*, 2009). A considerable number of children in this study across all urban environments expressed a desire to use bicycles as a mode of travel to all local destinations including schools. The highest latent demand for cycling (32%) was expressed for a preference in travel to schools and local parks. In addition to the variation in destinations, gender is a strong determinant of the latent demand for cycling with a higher proportion of male students preferring to cycle to all specified destinations.

Accessibility to schools in terms of travel distances has been found to play the most important role in school mode choice with distinct patterns observed in mode choices across varying travel distances from selected schools. The other important correlates of school travel and cycling mode share are the urban environment and the current utilisation of different modes for the specified destinations. Distance had the strongest correlation with the school travel modes but in itself has not fully explained the variation in the school mode shares. These findings restate that children's travel mode choice is reliant on a combination of factors and though highly significant, no single determinant can adequately explain the differences in children's mode choice. Children's preferred mode choice is most strongly correlated with the current travel modes used by the students stressing the significance of previous opinions of Tranter and Whitelegg (1994) who had stated that the current travel mode choice of children forges attitudes towards and the use of different modes of travel at the later stages in life. This can be explicitly seen in children's preferred travel modes which despite displaying a change in preference for cycling are to a large extent still based on a child's current mode of travel. This signifies that for any long-term changes in the use of cycling for transport, interventions are needed to target child travel patterns and in particular a child's school travel patterns.

7. Conclusion

Children's cycling for transport, in the selected Australian urban environments under scrutiny in this paper, though not as high as that of the cycling figures in cycling friendly countries of Denmark and Netherlands, is however an important contribution to the overall children's transport mode share for travel to stipulated destinations. The current cycling mode shares

for school travel have shown variations across the different urban environments, gender and travel distances from school. The most meaningful association amongst all variables is that between distance and school travel modes. This suggests that a more equitable distribution of schools across urban environments could ensure that schools are more accessible which could increase not only the cycling mode share but also walking. Current education department preferences for larger schools with larger catchments may be counter-productive to active school travel. Children's travel to all other destinations is correlated with school travel which means that interventions aimed at increasing cycling to school could have spill over impacts on travel to other destinations. Across all the schools and for all destinations, children have expressed a significant latent demand for cycling suggesting if other factors can be resolved more of this activity will occur. The preferred travel modes in addition to the urban environment are strongly correlated with the current travel mode choice of the children which signify that current travel patterns can and do influence a child's perception and use of the different transport modes.

Though distance from schools, urban environment and gender are significant determinants of children's utilitarian use of bicycles, they do not fully explain the variations in cycling mode shares across the different schools. Further work for this research on children's cycling for transport will include a holistic look at other determinants of children's cycling take-up and usage and in particular will focus on the influence of the social environment and a child's social connections. The associations between the relevant determinants and children's travel mode choices and in particular cycling will be further analysed through regression modelling as a follow on from the basic correlation results articulated in this paper.

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