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Is private-schooling problematic for transportation? Evidence from Southeast Queensland, Australia

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Abstract: School travel behaviors are associated with children's health and well-being, traffic congestion, and sustainability. Australia has seen a steady rise in the number of car-passenger trips made by children to school, and a decline in walking-to-school. Australia differs from most nations in that it has one of the highest rates of private schooling in the world at around 34%, supported by high levels of Commonwealth Government funding. Little is known about the effects this has on travel behavior and whether it is a factor in Australia's high rates of chauffeuring. This paper looks at journeys-to-school in South-East Queensland. Two research questions were posed: i) how do students in private and public schools travel to school, including mode shares and median trip-distances by mode?; and ii) is there any relationship between school type and mode choice, when controlling for key demographic and land use variables? Advanced geo-spatial matching allocated all trips made to schools in the 2017-2019 South East Queensland Travel Survey to either public or private schools. The resulting dataset included 2600 public school students' trips to school and 1117 private school students' trips to school. The public and private schools' commuting travel behavior was then examined. Private motor vehicle is the most frequently chosen mode for travelling to school across the two groups (72.3% for public and 74.6% for private). The proportion of students walking/biking to school is 2.3 times greater for public than for private schools (16.8% versus 7.3%) even though those two groups share the same median trip distance value in active travel. For all other travel modes (automobile, public transportation and school bus), median trip distances are greater for private school students than private school students. Multinomial logistic regression modelling suggests that private school students are less likely to walk/cycle to school than public school students when controlling for key demographics and schools' urban form characteristics. Private schools appear to disproportionately contribute to traffic congestion. Australia should consider amending its school policy frameworks to help address these concerns.

Keywords: Journeys-to-school, private school, public school, urban form, travel behavior difference

1   Introduction

There are global debates over private school policies and their effects. The private and government-funded charter school movements in the USA have raised significant concerns about their effectiveness and their impact on the public school system (Gleason, 2019; Imberman, 2011). In the UK, researchers debate the "private school problem" —with a focus on elitism and social mobility (Green & Kynaston, 2019; Kennedy, 2009; Kennedy & Power, 2010; Khan, 2011). Private schooling is an increasingly visible and socially accepted part of life in nations across much of the developing world including countries as diverse as Ghana, Jamaica and Nepal (Heyneman & Stern, 2014; Macpherson et al., 2014). But despite increasing private school enrolments, the influence of private school policies on travel behavior has not been scrutinized in detail. This matters as one in ten number of kilometers traveled in southeast Queensland are for school purposes and school-related travel is often between 30-40% of all travel in the AM peak period (State of Queensland, 2012).

Private schools, their locations in the city, the proportion of children that they educate, and the travel behaviors produced by this specific school type are the focus of this paper. Understanding how changing school geographies are affecting travel behavior is a key research need. Though the planning and distribution of schools within cities has been explored, there has been less attention to the travel behavior effects of such changes. In this paper, analysis of school-related household travel survey records for Southeast Queensland is used to show the scale of the impact of private schooling on travel behavior.

Two research questions were therefore posed: i) how do students in public and private schools travel to school, including their mode shares and median trip-distances by mode, and ii) is there a relationship between school type and mode choice, when controlling for key demographic and land-use variables? The research questions were explored using advanced geospatial matching techniques applied to household travel survey data for the Southeast Queensland region. Travel behavior and urban form differences by school type were analyzed. A multinomial logistic regression model of potential factors affecting children's travel mode then better isolated the effects of private schooling and trip distances.

2   Review

2.1   Why is school travel important?

These issues matter as children's school travel behavior is associated with children's health and safety, parents' time chauffeuring children, traffic congestion and environmental impacts (Mackett, 2013; Rhoulac, 2005; Wilson et al., 2010). Though many motorized school trips may be part of trip-chains (with a parent or guardian traveling on to work or another activity) increasing numbers of children being driven to school adds to at least three impacts: congestion, localized air pollution and global greenhouse gas emissions (Wilson et al., 2007). Increased chauffeuring to school also creates public health concerns (Chillón et al., 2011). Children who frequently cycle or walk to school are more likely to meet their prescribed daily moderate to vigorous physical activity recommendations; they also establish an active lifestyle that can influence physical activity and transport decision-making well into adulthood (Buttazzoni et al., 2018). The percentage of children who use active transport to/from school has declined dramatically over the past 40 years across many nations—with interventions aiming to reverse this trend being implemented by public agencies (Chillón et al., 2011; Sidharthan et al., 2011). *Initiatives such as Safe Routes to School* (SR2S) in the US, Active School Travel schemes in Australia and *School Travel Planning* in the UK intervene via improvements to street design, new physical infrastructure and/or social marketing activities, to encourage active transport (walking, cycling and wheeling) (Moghtaderi et al., 2012; Wilson et al., 2010).

2.2   Previous research on private schools and school travel

Most of the literature on private schools has focused on the so-called "private school problem," pertaining to whether these private schools entrench disadvantage and encourage elitism in society (Green & Kynaston, 2019; Kennedy, 2009; Kennedy & Power, 2010; Khan, 2011). Studies into the impacts of private schools have looked at their economic and political impacts, such as distorted use of national resources and democratic impoverishment (Green & Kynaston, 2019; Khan, 2011), their contribution to increasing society inequality (Green & Kynaston, 2019; Kennedy, 2009; Kennedy & Power, 2010; Khan, 2011) and the differences in student academic performance between private and public school students (Benveniste et al., 2003; Braun et al., 2006; Figlio & Stone, 1997; Lubienski & Lubienski, 2013).

It is now well understood that the near global shift towards private motor vehicle travel to schools has undesirable consequences, including inadequate daily exercise for children, traffic congestion during peak hours and negative environmental impacts (Ermagun et al., 2015, p. 1; van der Ploeg et al., 2008). Past research on children's journeys-to-school has identified a set of factors that appear to influence children's travel behavior. These include socio-economic characteristics, such as children's ethnicity, age and gender, as well as adults' perception about children's travel, parental escort and "licensing" decisions, urban form and road safety factors (Ermagun et al., 2015; Giles-Corti et al., 2011; Mackett, 2013; McMillan et al., 2006; Ridgewell et al., 2009; Schlossberg et al., 2006). If adults in a household drive to work, this significantly increases the probability of children being dropped off at school (Deka 2013, p. 60). Boys are more likely to be allowed to travel "actively" to school than girls (Guliani et al., 2015, p. 509). Ethnicity appears to have an effect, perhaps due to socio-spatial clustering, with white students in Sheffield, in the UK, traveling shorter distances to school than other ethnic groups (Easton & Ferrari, 2015). The weather also plays a role, with students less likely to ride bicycles to school in the Northern European winter (Müller et al., 2008, p. 350). While higher block density is positively correlated with children's walking/cycling, household private motor vehicle ownership is negatively associate with children's active travel (Mitra et al., 2015). Urban-form measures (intersection density, residential density) are positively associated with children's walking, after controlling for social, intra- and inter-personal factors (Moran et al., 2018). Other features such as higher traffic volumes, incomplete sidewalks and major street crossings decrease the odds of walking/cycling (Guliani et al., 2015).

2.3   Changes in education policy and school geography

The spatial distribution of schools has been changing in many nations. Whether it be Charter schools in the USA (independent schools that receive government funding), or "unlocked" school catchments in Ireland or New Zealand (where parents can send their children to a school in a different zone, if there is a spare place), a new geography of schooling is emerging. Before COVID-19, private/independent schooling was increasing its share of the market in many nations. In Australian cities, these shifts have also been paralleled by a rise in larger outer-suburban public schools (so-called "super-schools") with three or more times the enrolments and catchments of inner-city schools (Giles-Corti et al., 2011). The general trends are towards a greater diversity of school types, with more private/independent schools, larger school populations, and, larger school catchment areas.

Australia is a useful nation to explore the transport impacts of such changes in education policy and school geography, as it is at the vanguard of these global trends.

A burgeoning Australian private school sector now teaches almost forty per cent of all secondary school students thanks to generous Commonwealth Government policies and funding programs that

directly support private school education, including for both Catholic and independent schools (Australian Bureau of Statistics, 2018).

As many previous school travel studies indicate, trip distances play an important role in mode choices for school travel, especially for active modes (Mandic et al., 2017; Wilson et al., 2010). Public schools in pre-war Australia tended to have smaller enrolments (less than 500 students) and modest catchment sizes. Schools were found in almost every suburb, and were located on grid street networks that allowed for good pedestrian access. Children enrolled locally were tied to a local school and tended to have a reasonable maximum walking distance or at least an easy cycling distance (for children aged 10 or more) to get from home to school (Burke & Brown, 2007; Mitra et al., 2015), though road conditions were not always conducive to active travel[1]. Australia has long had a sizeable Catholic school sector especially at primary school level, and also has a smaller number of mostly Protestant private schools, across both primary and secondary school levels. Unusually, compared to elsewhere in the world, these schools are supported by state subsidies. Up until the 1980s, nearly 80% of Australian students attended public schools. Increased state subsidies to the non-government school sector from 1983 increased private sector enrolments (Barcan, 2010). By 1999, private school enrolments were 60% higher than in 1974 (Burke & Spaull, 2002) and by 2018 some 34.3% of all Australian school children attended a private school, moreso at secondary school level (Australian Bureau of Statistics, 2018). The urban form of schools also changed in Australia. Where schools were once planned without car parks, newer schools often have large staff and visitor parking areas, and circuitous and tightly managed school drop-off zones. State education departments today seem to prefer "super-schools," larger public schools in new Greenfields developments. Primary schools with well over 1,000 student enrolments are increasingly common. Restrictions forcing children to be enrolled locally have been partially unlocked, with parents now generally free to choose, if there is a spare space at a public school elsewhere. Greater availability of private schooling options was increasingly provided, albeit in locations that may demand parents drive children to school (Jarvis, 2003, p. 600).

The distribution of private schools in Australian cities—their diversity (i.e., religious affiliation), and their often larger size, means they tend to have larger school catchments than public schools. Private schools generally capture enrolments across a sub-region, rather than from a single suburb. Some students attending the new public super-schools in the outer suburbs also face large catchment sizes. But in theory, private school students are more likely to travel further than students attending public schools. Given households have limited travel time budgets, this is likely to encourage the use of faster modes for journey-to-school trips, especially private motor vehicle travel.

There may be many differences between public and private schools that may influence travel. This includes ethnicity, income levels, car ownership, as well as children's and adult's travel attitudes and perceptions. But these are common variables in most studies of children's travel behavior. One particular geographical difference between public and private schools is their catchment sizes.

2.4   Conceptual layout of schools in Australia

Hypothetically, the greater catchment sizes of private schools place many, if not most, of their students in homes well beyond what are observed 85th percentile walking distances to schools in Australian cities (Burke & Brown, 2007)[2]. School locations can substantially influence school travel behavior by increasing travel distance, which in turn influences mode choice (Wilson et al., 2010). Children are less likely to walk or cycle if the trip distance to school is too long, or traffic volumes are high around the school they attend (Giles-Corti et al., 2011). Given their larger catchment sizes, private school students should

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[1] Australia's posted street speeds in local streets and in school zones are 20km/h and 10km/h higher, respectively, than in much of continental Europe and the United Kingdom.
[2] Australia's posted street speeds in local streets and in school zones are 20km/h and 10km/h higher, respectively, than in much of continental Europe and the United Kingdom.

be more likely to be chauffeured and less likely to walk or cycle to school, than their public-school counterparts.

Figure 1 shows a conceptual layout of schools in Australia, their catchments and the resulting trip distances from home-to-school. A set of public primary schools have relatively small and quite fixed catchments, and short median trip distances from homes to schools. The public secondary schools have larger relatively fixed catchments, and medium trip distances. Two private primary schools have overlapping catchments and medium trip distances. The single private secondary school has the largest catchment and the longest median trip distance.
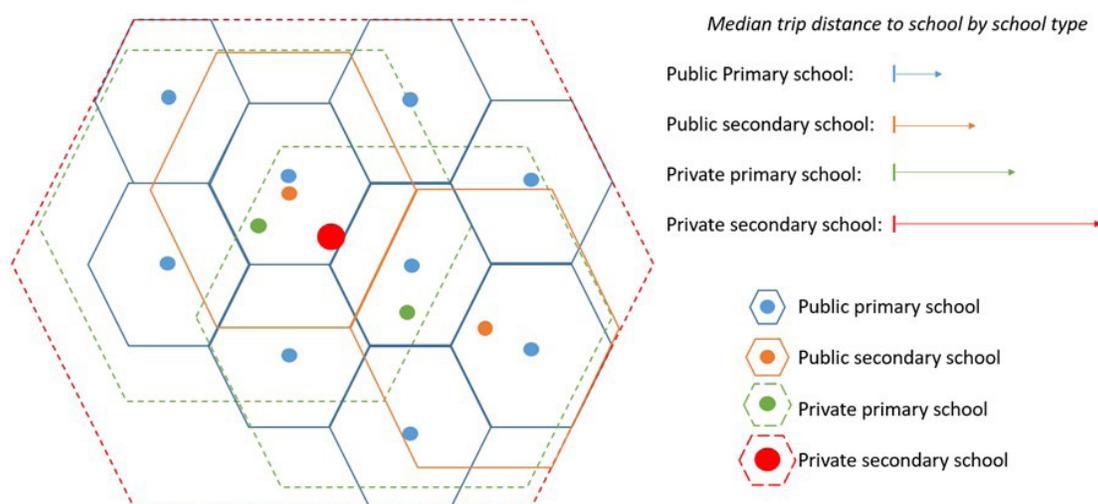

Figure 1. Conceptual arrangement of schools, their catchments, and median trip distances, by school type

There are only a few studies that have noted differences in private school travel versus public school travel. In a South Australian study, Treewanchai (2014) explored school and residential choices when private schooling is available. Enrolment in a public school requires no tuition fees but usually necessitates residence in the school catchment area. There is less co-location between house location and school location for private school students. Deka (2013) applied Heckman probit models to the 2009 US National Household Travel Survey data to explore the relationship between adults' work trip mode and children's school trip mode. Public school students were more likely to walk, bicycle or take a school bus and less likely to be driven to school than private school students (Deka, 2013, p. 58). Mehdizadeh et al. (2017) used logistic regression analysis to isolate the effect of school type (public versus private) for active travel to school in a survey of 7- to 9-year-olds in Rasht, Iran, but found no statistical differences in their reported active travel behavior, once other effects were considered (ibid, pp. 323-324). Spinney and Millward (2011, p. 64) found children at the very small number of private schools in Halifax, Canada, were "almost exclusively driven to school" unlike their counterparts in public schools who were more likely to walk, cycle or use public transport. Jarvis (2003, p. 602) interviewed parents in San Francisco, finding that social constructions of a "good parent" involved sending one's children to "the 'best' (white, middle class, suburban or private) school" but that this in turn often dictated "wasteful journeys" by car. Love's (2015, p. 208) PhD thesis explored travel behavior change initiatives in Catholic schools in Victoria, Australia, suggesting that the larger school catchment sizes of these schools, compared to local public schools, did stymie efforts to shift journey-to-school mode choice away from the car. In summary, these studies tend to show more chauffeuring at private schools. But the studies often feature small niche samples, or focus on one type of private school, or are otherwise difficult to generalise to broader popula-

tions. The only study to use household travel survey (HTS) data to explore differences in public/private schools (Deka 2013) focused only on mode share differences in the USA. This has limitations in that, first, is at a national scale, at which it is very difficult to control for known built environment factors, and secondly, has a school busing system that is somewhat unique to North America. Methodologically, the field needs new methods to identify public/private school information for trip records in HTS datasets, where it was not captured initially. There also remains a sizeable research gap in terms of understanding the empirical differences in travel behavior of public and private school students at the city or region scale, looking at trip distances by mode (not just mode shares), all whilst controlling for demographic and urban form factors. These new methods and understandings are important, especially in nations such as Australia where there is a trend towards increasingly high private school enrolments.

3   Methods

The approach involved conventional travel behavior research on private versus public school travel, using theoretical bases of travel budgets by Metz (2008), Hägerstrand (1985) and others, and a cross-sectional research design. The methods involved: i) advanced geo-spatial matching techniques using Python to allocate all trips made to schools in Brisbane from the *2017-2019 Southeast Queensland Travel Survey* (SEQTS) to either public or private schools as coded in Education Queensland geo-spatial data, using the destination locations of home-to-school trips; ii) two sample tests of proportion using the normal approximation, and Mood's median test, were then applied to analyze the mode choices and trip distances across the two groups (public/private school trips) using R programming language; iii) *Geographic Information Systems (GIS)* were employed to determine urban form characteristics (public transportation level of service, road length of different road types and population density) of public and private school locations; and, iv) a Multinomial Logistic Regression Model (MNL) was used to explain the relationship between multiple categories of independent variables and multiple categories of dependent variables. Following the approach of others using MNL (Deka, 2013; Wilson et al., 2010), we decided to develop a multinomial logistic regression model in *A* that allows us to explore the likelihood of a private/public school student traveling to school via private motor vehicle or school bus or public transportation or active travel (walk, bicycle) while controlling for socio-demographic factors and urban form factors, as a function of continuous and categorical independent variables(school urban form attributes, trip distance and child and household characteristics). The full datasets used in the study are listed in Table 1.

Table 1. Data source, treatment and variables

Dataset	Source/Reference Year	Treatment	Variables obtained
Southeast Queensland Travel Survey (SEQTS)	Department of Transport and Main Roads (TMR), 2017-2019	- Spatially matched each school trip's destination to the corresponding school type	- Mode share - Trip distance
School's location	Education Queensland	- For each school a 400m buffer "catchment" is created as the reference area	- Type of school attended(public/private) - Year(primary/secondary)
General Transit Feed Specification (GTFS)	Queensland Government, 2019	- Used ESRI ArcGIS's *BetterBusBuffers tool* to create overlays of public transport frequency	- Public transport level of service (PTLOS) proportion score in each school catchment
Roads and track data	TMR, 2018	- Road lengths falling within school catchment - Number of intersections was calculated but not used	- Road length in each school catchment - Intersections in each school catchment (not used)
Australian population grid	Australian Bureau of Statistics, 2016 (Census year)	- The values of the nearest raster grids are interpolated to the school locations	- Population density at the school catchment

A "main mode" was allocated by the Department of Transport and Main Roads of Queensland Government (DTMR) to each trip, including home-to-school trips. The "main mode" is the highest mode used on any trip stage in an overall trip, using a hierarchy (from high to low) of public transport modes, then private vehicle travel, then cycling, then walking. If a trip is made by both car and public transport it is categorized as public transport, and so on. The sample included 2,600 public school students and 1,117 private school students, with five cases excluded due to abnormally large trip distances to school. Special school students, mostly being disabled, were excluded due to their particular travel needs. Figure 2 presents all schools that were included in our analysis, with blue dots representing the public schools and red dots representing the private schools in SEQ. This shows that, contrary to local myth, private schooling is not a uniquely inner-city phenomenon, with a distribution of private schools across the inner, middle and outer suburbs, similar to that of public schools.
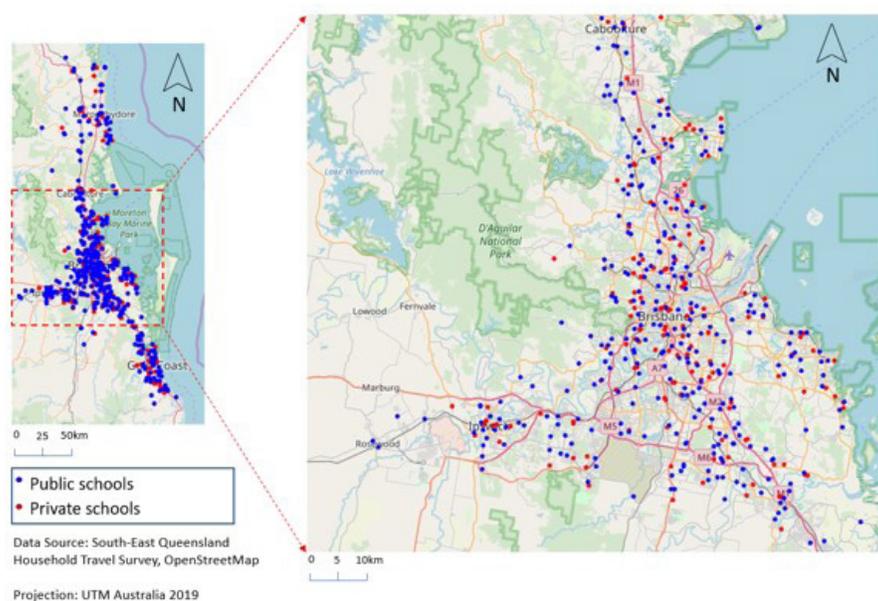

Figure 2. Locations of private and public schools in the Southeast Queensland region

Using Python, every trip made by a child to these schools was identified. These trips were allocated to the nearest known school, whether public or private (Catholic and independent), using the longitude and latitude of the destination reported in the trip record. School locations were matched using Education Queensland's School Locations 2018 dataset. A series of mode share and trip distance analyses were then undertaken in R using the Trip file and using the "main mode allocated to each trip. A two sample test of proportion using the normal approximation and Mood's median test were performed using R to test the hypotheses that:

1) The proportions of private school students who use private motor vehicle, public transportation or school bus modes to school are larger than the proportions of public school students using these modes;
2) The proportion of private school students who use active transport to school is lower than the proportion of public school students; and,
3) Private school students have higher comparable median trip distance values for all modes of travel, than public school students.

A 400m geodetic buffer around each school was used as the reference area for the land-use and public transport variables. While it is possible to use different sizes, we assumed 400m for this study, which is frequently used for pedestrian catchment analysis and describes reasonably well the immediate urban form of the school neighbourhood. 400m is deemed to be the distance most people are willing to walk to a destination (Daniels & Mulley, 2013). Future work may include a comparison of other distance buffers.

A simplified version of public transport level of service (PTLOS) produced for Southeast Queensland (Leung et al., 2015) was adopted as the public transport variable in this study. Public transport data is based on General Transit Feed Specification (GTFS) from 26th July, 2019. The *BetterBusBuffers* tool provided by ESRI was used to calculate the hourly number of public transport departures for each transit stop. A PTLOS score ranging from 1 to 7 was then assigned (see Table 2). This score provides an indication of the amount of public transport service available at a stop and its associated influence area (a 400 network distance buffer along walkable paths and streets based on the road and track dataset, which excludes limited access freeways). While this method does not measure the monetary and time cost of traveling, it is a general estimation of whether a school is serviced by frequent public transport (Walker, 2012).

Table 2. Public transport level of service (PTLOS) scores (Adapted from Leung et al., 2018; Pitot et al., 2006)

Number of services per hour	Frequency(minutes)	PTLOS Score
Over 20	Less than 3	7
12 to 20	Less than 5	6
6 to 12	10	5
4 to 6	15	4
2 to 4	30	3
1 to 2	60	2
Under 1	more than 60	1

To calculate population density for each buffer area, the "Australian Population Grid 2016" from the Australian Bureau of Statistics was adopted and operationalized using the "Extract values to points" tool in ArcGIS.

The approach is similar to most advanced children's travel behavior studies in that it considers both mode choices and trip distances. Mode choice (alone) is a limited metric, being a-spatial; combining it with trip distances helps overcome this problem. There are some other limitations of the approach used. The trip data was collected for one diary day and may not represent that child's regular travel pattern to school. Parents completing the form may not have directly observed their child's travel that morning. Origin locations in the SEQTS are randomly assigned to proximate locations in the immediate area (over 93% of trips are home-origin based), so as to de-identify the dataset. Trip distances are calculated via shortest path algorithms and may be different from the actual routes used. Less than 10 school trips in the dataset were made to a destination (longitude/latitude) with two schools close nearby. These trips were allocated to the nearest school. The methods did not explore travel onwards from schools by parents and guardians, neglecting possible trip chaining effects. Only summary information is provided here, such that no child's individual route or travel patterns are reported. Table 3 presents the summary of variables included in the analysis across private and public school students.

Table 3. Summary statistics for independent variables across private/public school

	Private School					Private School				
	Sample Size	Percent-age	Mean	Median	SD	Sample Size	Percentage	Mean	Median	SD
Full Sample	N=1112	30.06%				N=2587	69.94%			
Gender										
Male	553	49.51%				1306	50.48%			
Female	564	50.49%				1281	49.52%			
(Home-to-school) Trip distance (km)			7.86	6.11	7.11			4.83	3.06	5.14
Urban form Variables										
At home neighborhood										
Public Transport Level of Service (PTLOS) (from 0 to 7 score)			27.11	28.00	16.34			28.93	29.00	15.99
Junction Counts (sum of junctions within the buffer area)			27.11	28.00	16.34			28.93	29.00	15.99
Proportion of Freeways/Motorways/Highways (the ratio of the sum of Freeways/Motorways/Highways length to the sum of all roads length)			1.22	0.00	0.06			1.57	0.00	0.07
Proportion of Bike/walkways (the ratio of the sum of bike/walkways length to the sum of all roads length within the buffer area)			2.57	0.00	0.06			2.62	0.00	0.05
At school neighborhood										
Junction Counts (sum of junctions within the buffer area)			29.58	27.00	17.19			32.75	31.00	15.20
Proportion of Freeways/Motorways/Highways (the ratio of the sum of Freeways/Motorways/Highways length to the sum of all roads length)			1.70	0.00	0.06			2.14	0.00	0.07
Proportion of Bike/walkways (the ratio of the sum of bike/walkways length to the sum of all roads length within the buffer area)			2.69	0.00	0.06			3.13	0.26	0.06
Socio-demographic variables										
Age (5 years old - 19 years old)			11.94	12	3.56			10.87	11	3.38
Household Size (2 persons to 14 persons)			4.40	4.00	1.06			4.49	4	1.37
Number of Vehicles per household (from 0 to 9)			2.15	2.00	0.90			1.94	2	0.87

4   Results

4.1   Comparing mode shares and trip distances between public and private schools

A one-way analysis of variance (ANOVA) was conducted on mode share differences and median trip distance differences to explore if there is any difference between private/public school students' travel behavior. Results are summarized in Table 4. Comparisons between the travel mode choices of children in public and private schools are shown in Figure 3.
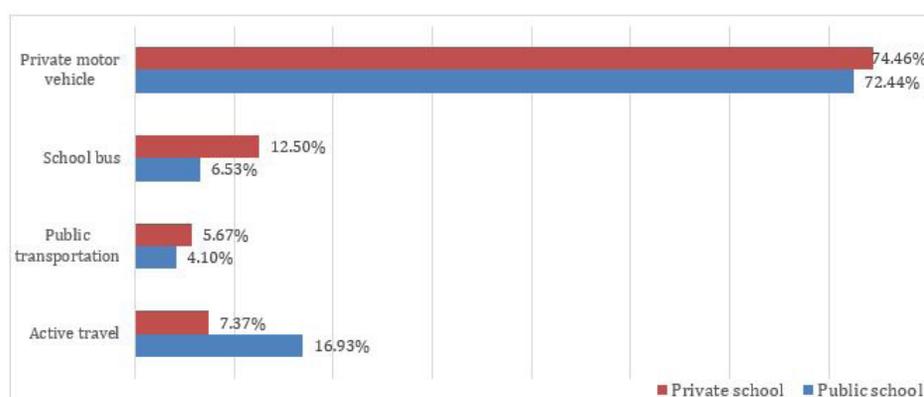

Figure 3. Mode Share Comparison between public/private school students

Table 4. Descriptive analysis and statistical tests on mode share and trip distance

School travel mode choice	School type	N (sample size)	Mode share	Z-test on mode share difference	Median values of trip distance(km)	Mood's median test on difference between median values of trip distance
Private motor vehicle	Public school	1874	72.4%	x2 =1.51	**3.43**	x2 =129.05
	Private school	828	74.5%	(p= 0.11)	**5.88**	(p< 0.001)
Active travel	Public school	438	**16.9%**	x2 = 58.00	1.02	x2 = 9.8517e-30
	Private school	82	**7.4%**	(p< 0.001)	1.03	(p= 1)
School bus	Public school	169	**6.5%**	x2 = 35.50	**6.47**	x2 = 19.333
	Private school	139	**12.5%**	(p< 0.001)	**10.00**	(p< 0.001)
Public Transportation	Public school	106	**4.1%**	x2 = 4.03	**6.38**	x2 = 6.7842
	Private school	63	**5.7%**	(p< 0.05)	**11.04**	(p< 0.01)

In comparing **mode shares**, some 16.9% of the public-school students actively travel to school, compared to only 7.4% of the private school students. School bus use is much more important for private school students compared to public school students (12.5% versus 6.5%, respectively). A larger proportion of private school students travel by public transport than their public school counterparts. 72.4% of public school students travel to school using private motor vehicles, compared to 74.5% of

private school students. As suggested by Z-test results of private motor vehicle share differences between public and private schools, though sizeable, the difference across the two groups approaches but does not quite reach statistical significance (p =0.11). The greater differences for the active transport, school bus and public transportation mode shares between public and private schools are much less in dispute.

In comparing **trip distances**, the differences by school type are provided in Figure 4 and in Table 4. Median values are offered, as mean averages are often skewed by a few extremely large values in household travel surveys (i.e., occasional longer distance trips, possibly from a distant co-parent's house in the case of children's travel). Overall, the public school students traveled much shorter trip distances for most modes compared to the private school students. Public school students and private school students had almost the same median trip distance of 1.02 km and 1.03 km for active travel trips. For public transportation and school bus modes, private school students traveled almost twice as far as public school students. For private motor vehicle trips, private school students have a median trip distance of 2.45 km more than public school students. *Mood's median test* results suggest that, except for active travel, all the differences observed are statistically significant.

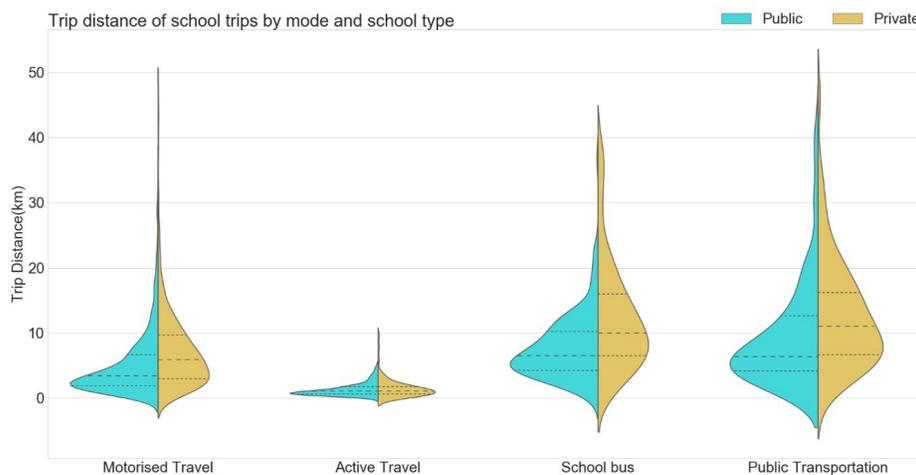When considering these one-way relationships, Hypotheses 1, 2 and 3, all appear to hold up.

Figure 4. Trip distance comparison for different travel modes by school type

4.2   Multinomial logistic regression modelling

Section 4.1 showed strong one-way relationships between school type and students' commuting behavior. The only exceptions were the similar mode shares of private motor vehicle trips and the very similar median trip distances for active travel trips for both public and private school students. But were the observed differences in mode choices to school due to the influence of trip distances, as suggested by our concepts of catchment size? Or are they due to other factors?

As shown in Section 2, children's travel behavior is influenced by a larger set of factors, including individual/household socio-demographics and the built environment around their residential locations and schools. To explore if the mode share differences related to school type (private/public) still hold when controlling for other factors, a multinomial logistic regression model was developed. Initially, a broader set of factors were considered. Variables known to influence behavior, including population density around both home and school neighborhood, and PTLOS at school neighborhood were removed from the final model because of their strong correlation with other variables included (i.e., junc-

tion counts, proportion of bike/walkways within the buffer area).

All variables included in the final model and results obtained from the multinomial logistic regression analysis of mode choice behavior are provided in Table 3. The model estimated the odds of a student using: (1) school bus; (2) public transport; and (3) active travel, relative to the reference mode, private motor vehicle. Model results are summarized in Table 5.

Table 5. Multinomial logistic regression analysis with travel modes as dependent variables

Explanatory factors	Main mode of transport used (ref: private motor vehicle)								
	School Bus			Public Transportation			Active Travel		
	Coeff.	p > |z|	RRR	Coeff.	p > |z|	RRR	Coeff.	p > |z|	RRR
Public school (ref: private school)	-0.23	0.08	0.79	0.14	0.44	1.15	**0.40**	**<0.05**	**1.50**
Trip distance(continuous)	**0.06**	**<0.001**	**1.06**	**0.09**	**<0.001**	**1.10**	**-1.21**	**<0.001**	**0.30**
Urban form variables									
At residential location									
PTLOS (continuous)	-0.04	0.32	0.96	**0.25**	**<0.001**	**1.29**	0.03	0.361	1.03
Junction Counts(continuous)	**-0.01**	**<0.05**	**0.99**	**-0.01**	**<0.05**	**0.99**	0.00	0.39	1.00
Proportion of freeways & highways(continuous)	0.26	0.81	1.30	0.96	0.47	2.61	-0.17	0.86	0.85
Proportion of bike/ walkways(continuous)	1.25	0.26	3.48	1.36	0.40	3.91	1.73	0.15	5.66
At school location									
Junction Counts(continuous)	-0.00	0.44	1.00	0.01	0.11	1.01	-0.00	0.60	1.00
Proportion of freeways & highways(continuous)	0.50	0.59	1.65	**2.55**	**<0.01**	**12.78**	1.18	0.162	3.26
Proportion of bike/ walkways(continuous)	-1.51	0.24	0.22	0.43	0.76	1.54	2.04	0.07	7.70
Socio-demographic variables									
Household size(continuous)	-0.02	0.64	0.98	**0.19**	**<0.01**	**1.21**	-0.05	0.28	0.95
Number of vehicles per household(continuous)	**-0.31**	**<0.001**	**0.73**	**-0.48**	**<0.001**	**0.62**	**-0.29**	**<0.001**	**0.75**
Age(continuous)	**0.24**	**<0.001**	**1.27**	**0.34**	**<0.001**	**1.40**	**0.26**	**<0.001**	**1.30**
Male (ref: female)	0.06	0.61	1.07	0.23	0.19	1.25	**0.24**	**<0.05**	**1.27**
Model Statistics									
Obs.	3699								
AIC	4663.1								
Log likelihood value	-2289.6								
McFadden R²	0.275								

Note: RRR, Relative Risk Ratio.; Coeff., coefficients; Obs., Observations; AIC, Akaike information criterion.
Variables in **bold** are significant with at least 95% confidence.
Underline coefficients are significant at the 0.1 level.

A key finding from the logistic model is that, compared to the reference mode (private motor vehicle), public school students are 1.5 times more likely to travel to school by walking or cycling than their private school counterparts, after controlling for trip distance and the other urban/socio-demographic variables. As such, the one-way relationship between school type and active travel appears

to hold after the multi-variate analysis. Table 5 also shows that public school students are 1.27 times less likely to use school bus than private school students. However, this finding is significant only at the 0.1 level. By contrast, the one-way relationships between school type and Public Transportation mode dissipate once one controls for trip distance and these other factors. In other words, Hypothesis 1 fails to hold when looking at the results of the multivariate analysis, but Hypothesis 2 is still supported. The findings, therefore, validate the difference in mode choice behavior to school between private and public school students. More importantly, the findings suggest that school types have the ability to influence students' use of active transport to school – even after controlling for trip distance and the other urban/socio-demographic variables.

Why is active transport different? Along with trip distance, the final model controlled for car ownership (which is strongly correlated with household income), household size and age, so one cannot look to those as the main reason for the difference in probability of walking and cycling to school across school types. Though the reasons are unclear, at least three possible explanations could be at play:

i) *extra-curricular activities*, which are often a key aspect of private schooling's appeal to parents and students, may require additional carriage of musical instruments, sporting gear, computers and other equipment, which just make walking or cycling inconvenient;

ii) private school parents may have *different attitudes* towards these mode choices from their public school counterparts, including a different social norm as to what it means to be a "good parent" in terms of driving one's child to school or letting them use active transport; and/or,

iii) the results might be picking up the effects of the large and long-running Brisbane City, Gold Coast, Ipswich and Noosa Shire "*Active School Travel*" programs, that seek to influence parent and student attitudes, and which are predominantly run in public primary schools. Such effects are likely, given some of the schools involved achieve large mode share shifts to walking and cycling (>20% per day for some of the schools in the Brisbane scheme).

Other possible factors might be trip chaining effects and students' attitudes. Other than trip-chaining, the datasets do not provide any means to explore the effect of such factors, which is an issue for future research agendas.

Most other results shown in Table 5 are consistent with our expectations. For instance, trip distance, public transportation level of service, vehicle numbers per household, gender and age are all associated with students' mode choices.

Based on the information presented in Table 5, the following observations are formulated:

- Male students are more likely to walk/cycle to school than female students
- Older students are less likely to travel to school by private motor vehicle than younger students
- Better public transportation supply around residential neighborhood can improve students' tendency toward taking public transport to school (odds: 1.29).
- The number of junctions counts around residential neighborhood appear to have a significant negative association with students choosing public transportation while junction counts around school neighborhood do not have a significant impact on students' mode choice behaviors.
- •he probability of students' choosing active transport over private motor vehicle can increase by more than 7 times (odds: 7.70) if we increase the proportion of bike/walkways at school location (though this was only statistically significant at the 0.1 level).

The built environment clearly affects the students' active travel propensity and public transportation propensity. Nevertheless, the same built environment characteristics at residential location and at school location do not have the same relationship with mode choice. Moreover, some findings do seem to be contradictory to expectations. For instance, the proportion of freeways/highways over all roads at

school neighborhood level shows a strong positive correlation with the odds of students' choosing public transportation over private motor vehicle to school (odds ratio 12.78). This is a quirk of geography in SEQ. The Southeast Busway – the most used public transport corridor in the entire region – runs parallel to the Southeast Freeway. Key rail corridors, such as the Ipswich, Springfield, Airport and Gold Coast Lines, also run parallel with freeways for long sections.

5   Discussion

The study makes important applied contributions for the Australian school system. Most obviously, there is now strong empirical evidence that mode choice and travel distance behaviors of private school students in the SEQ region are significantly less sustainable than public school students. The rise in private schooling in Australia appears to have been highly problematic for sustainable and active transport. For nations like Australia, school type (public or private) should now be regularly considered in and amongst the other factors known to influence travel behavior, including children's socio-economic characteristics, adults' perceptions about children's travel, parental escort and "licensing" decisions, other urban form and road safety factors (Ermagun et al., 2015; Giles-Corti et al., 2011; Mackett, 2013; McMillan et al., 2006; Ridgewell et al., 2009; Schlossberg et al., 2006). Within Southeast Queensland school travel accounts for a high proportion of all urban trip-making, and is happening in the morning peak hour (at the time when traffic congestion is its greatest) suggesting that the increasing proportion of private school students is disproportionately contributing to growth in vehicle-km-traveled, and to traffic congestion. Empirical modelling of congestion effects is a priority for future research. At a broad scale, evidence from this research clearly indicates school types need to be taken into consideration when promoting active travel to school and should be considered in future modelling of school travel in city/region travel forecasting models.

A number of other findings have important implications for school travel research. Another contribution of the research is in further confirming the role of the built environment surrounding the school as playing an influential role in children's journeys-to-school, along with the much better understood role of the built environment surrounding children's homes. Most of the other findings are in line with previous research on mode choice behavior of school trips. For instance, school location substantially influences travel distance, which in turn influences mode choices (Giles-Corti et al., 2011; McMillan et al., 2006; Wilson et al., 2010). Our findings also further confirm the role of a number of other built environment factors, including the role of public transport level of service and junctions counts, which are proxies for public transport supply and for urban design, respectively (Panter et al., 2010; Wong et al., 2011).

This study makes one other modest methodological contribution in determining how to spatially match household travel survey trip records to a geo-coded education department database of school locations, by type, for the first time, allowing one to categorize travel as being to public or private schools. This method opens up further opportunities to explore school type effects in future.

5.1   Implications for school policy

Our findings have direct implications for future school planning and funding models. Debates about the proportion of private schools that are desirable, should now include consideration of these transport impacts. Problems with how schools are funded, planned, located, and the ways in which many private schools are exempted from infrastructure charges, may all need to be confronted to produce more active school travel and reduce congestion, road safety and the other negative externalities. Current Commonwealth school funding policies appear to be an as yet unrecognized contributor to congestion effects in

Australia. The direct congestion costs of private schooling have not been modelled in this paper. But any benefits obtained from subsidizing high rates of private schooling may not counterweigh the disadvantages of the travel patterns they produce. Education departments should be considering transport costs in their decision-making. This may lead to changes such as reintroducing stronger school catchment policies, and policy changes to Commonwealth school funding for private schools, such as not subsiding new private schools located in non-transit-oriented locations, or incentivizing private schools to provide bus options for their students.

Private schooling could produce better transport outcomes if such schools are tightly clustered along public transport corridors, households are encouraged to co-locate along these lines and parents dissuaded from driving their children to school. If the results pertaining to active transport differences by school type do indeed relate to parental attitudes, then extending "Active School Travel" programs to private schools could be helpful. These could be re-tuned to further promote other alternatives to every parent driving their child to school each day. New apps such as Parachute are coming to market that encourage car- and van-pooling to school at private schools, which could markedly improve transport outcomes and alleviate the burden of chauffeuring for many parents. Private schools in Queensland and Victoria in Australia are helping trial and co-develop such technologies. These are clear research agendas for the field.

There is one key limitation in extending the findings to other nations. In some countries, the rate of private schooling is so high that transport-land use relationships may actually be quite similar to education systems where private schooling is almost non-existent. In Hong Kong or Ireland, where state public schools are the minority, and almost all schooling is privatized, the private school catchment distances are much smaller than for private schools in Australia, and more akin to those of the Australian state school system. In nations like Ireland, the influence of private schools on travel behavior is likely less problematic.

As this research was based on schools in Southeast Queensland, some other findings are highly context specific (i.e., the unexpected results regarding the proportion of road links that are highway/expressway, which is due to the somewhat unique layout of freeways and public transport routes in parallel across much of the region). Empirical research is needed to understand mode choice behaviors between private and public school students in other Australian contexts.

There are a few more remaining limitations due to the approach and methods used. The methods (i.e., PTLOS, a lack of data on bicycle ownership) provide only a limited understanding of mode availability on children's travel. Though relationships are identified between school type and mode choice, the methods do not allow identification of any causal relationship. The travel behavior differences observed could be due to some other variable not yet considered in the analysis, including parent/guardian preferences or residential self-selection effects (including households moving into desirable public school catchments). At this stage, household travel datasets have a paucity of data describing subjective factors. These are all avenues for further research.

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