Australasian Transport Research Forum 2022 Proceedings
28-30 September, Adelaide, Australia
Publication website: http://www.atrf.info

A comparative road safety study of seven Adelaide metropolitan high schools

Andrew Allan[1], Hrvoje Videka[1], Ali Soltani[2], Arsham Bassiri Abyaneh[1]

[1]UniSA Creative, University of South Australia

[2] UniSA Business, University of South Australia

Email for correspondence: andrew.allan@unisa.edu.au

Abstract

Active transport to school amongst high school students is very low in Australia. Multiple studies have shown that the distance between home and school, is a key factor in predicting likelihood of cycling. Parental concerns over traffic collisions are also a strong contributing factor. Efforts to increase walking/cycling rates have focused on educational campaigns, rather than making improvements to the built form. This study quantitatively assessed seven Adelaide metropolitan high schools in order to determine their suitability for active transport, and to establish straightforward methods for ranking schools, and identifying targeted areas for improvement. The siting of the schools has been shown to be the most important factor, as it dramatically effects the two most important factors of distance to be travelled, and traffic collisions. Five of the seven schools scored favourably in terms of travel distance, with two schools lacking connection with residential areas. Generally, all schools in the study were located very close to highly trafficked roads, with high rates of crashes. Casualties amongst high school children near schools is low, most likely as a result of low active transportation rates, rather than a safe environment. If active transport rates increase substantially without corresponding improvements in the built form, casualties would be likely to increase. In order to achieve a substantial increase in walking/cycling to school, future schools should be sited close to high density residential areas, and away from busy, high-speed main roads.

Keywords: school safety; cycling routes; metropolitan Adelaide High Schools.

1. Introduction

It has been widely accepted that in order for Australian society to see benefits derived from an active lifestyle, as well as meet current and future CO2 emission targets, cycling as a form of transport (as opposed to recreational cycling) needs to increase substantially (Chapman et al. 2018; Soltani et al. 2022a). Current levels of cycling amongst high-school-aged children (12-18) as a means of travelling to school in Australia is far behind leading European nations (Goel et al. 2022); motorised transport dominates the streets around the high schools, particularly private motor vehicles.

The 30-Year Plan for Greater Adelaide (30YPGA) has identified cycling as an important part of the improvement of the quality of life for its inhabitants, with cycling (or derivatives of) being mentioned in the plan on 51 occasions (Department of Planning, Transport and Infrastructure, 2017). High school students are of the age where habits can become life-long, and there has been a continuing trend of children and adolescents being chauffeured to school by parents, with only a minority participating in active travel (Gilbert et al. 2022). There are substantially more pedestrians than cyclists on the high-school commute, which is in-part a result of social interactions and a desire to be part of a crowd. Although walking to school is viewed as an attractive alternative to the family car, the practical limitation of walking means that it is not likely to be an alternative for children that live further than a short distance from school. Cycling is the most efficient form of transportation (when viewed simply as energy input vs distance travelled) and expands to practical distance for active commuting greatly when compared to walking (i.e., potentially fourfold). Adelaide's mild topographic and climatic characteristics makes it one of the most naturally conducive places in the world to cycle; when compared to the global leaders of commuter cycling (The Netherlands, Denmark, and Germany), Adelaide's climate is much more favourable to depending on a bicycle for year-round transportation.

The purpose of this paper is to select seven high schools located in metropolitan Adelaide, and to quantitatively observe and identify physical characteristics of the school site and immediate area. A buffer zone of 800 metres was selected based on the comfortable commuting distance for a child of only average fitness levels, and to set a practical limit for where the streets and urban environment blends more into average suburbia without a defined precinct boundary, rather than an area that is more closely associated with a school presence.

This paper is largely based on secondary data sources provided at Data SA (South Australian Government Data Directory). Datasets that have been utilised have predominantly contained data on vehicle crashes, traffic volumes, casualty data, traffic signals, and bicycle networks and infrastructure. A weighted matrix table of key characteristics of each school site has been produced, and the intent is to use the matrix as a basis for a quantitative method of categorising a school on its suitability for students to commute by bike.

2. Background

2.1. Big picture

In Australia, physical activity amongst children and adolescents is far below the recommended amount of daily physical activity of 60 minutes, with only 19.4% meeting or exceeding the recommended time (Australian Bureau of Statistics, 2013). Active commuting for young children and adolescents has been identified as a desirable way to increase the amount of moderately vigorous physical activity to be performed on a regular basis (Mitra & Buliung 2012). Historically, Australian children performed much of their daily requirement of physical exercise by walking or cycling to and from school; the 1970's was a time when the majority of transport to and from school was active, as opposed to the dominance of being driven to school in the family car today (Garrard, 2016).

The active transport rate amongst NSW schoolchildren is less than half during a week, and on any individual day the rate of active transport falls to below a third; by contrast 66% of the children included in the survey travelled to school purely via motorised transport (Merom et al. 2006).

Active transport to school has shown to positively influence the likelihood of adolescents participating in active transport outside of the school commute, with an approximate increase of 30% in active transport of South Australian adolescents (Dollman & Lewis, 2007).

2.2. Parental attitudes towards active transport

The role of the parent is an important factor when considering the likelihood of a child or adolescent using active transport as a regular method of getting to and from school. Parents often make decisions on whether to encourage or even allow their children to walk or cycle to school based on social factors, such as whether other parents or family members have a favourable attitude to the parent that is allowing their child greater mobility and personal responsibility by being allowed to navigate their own way to and from school (Garrard, 2016). Apart from social pressures, the perceived risks of injury have a strong bearing on parental attitudes, however the actual risks are often lower than the perceived risk; for this reason, many attempts to increase cycling rates have involved awareness campaigns, rather than directing effort to physical changes to cycling infrastructure and the built form more generally (Garrard, 2016).

The built form can have a strong influence on parent's perception of danger, with parents' concerns regarding the safety of children cycling to school impacted by there being a perceived lack of designated crossings or pedestrian traffic lights. The presence of a high vehicular trafficked road as part of the route to school negatively impacted the perceived safety of active transport. (Merom et al. 2006). As well as a shorter travel distance, Panter et al. (2010) identified that the presence of pedestrian crossings and shared cycle paths had a positive effect on cycling to school rates.

A recurring theme that is seen in various studies regarding active transport is that parents' concern for their children's well-being is generally unfounded, and that the health benefits of active transport outweigh the risks. In fact, the tragedy of children being injured on the roads is very real; in the world's wealthy countries, road traffic crashes represent a large proportion of child injuries and fatalities. The World Health Organisation (WHO) has identified that improving road safety is an integral component in improving health outcomes for children in countries such as Australia (Towner & Towner 2002). It would appear to be counter-productive to downplay parents' concern for their children, and therefore effort may be better targeted towards physical improvements to the built environment, rather than attempting to educate parents to change their perceptions.

The perception of the safety of the neighbourhood with regard to walking and cycling can vary dramatically. A study by Carver et al. (2005) interviewed adolescents and their parents about their attitudes as to whether their neighbourhood was safe to walk or cycle; 32% of parents believed that the neighbourhood was safe compared with 90% of adolescents feeling safe to walk or cycle. There is a much greater safety fear from parents, as adolescents feel very safe walking and cycling.

Many studies have focused on the perception of active transport safety amongst both students and their parents, however many of these studies do not put a serious emphasis on the realities of the dangers involved for children whilst travelling directly to and from school. The rate of injury during active transport to and from school is significant, with the proportion of pedestrian injury amongst children immediately before or after school at around 65% for 4–12-year-olds, and 49% for children aged 13-18 (Morris, Wang & Ilja 2001).

2.3. Distance as a critical factor

Any form of active transport is going to be heavily influenced by distance. As distance increases, the physical demands of riding go up, and the number of dangerous roads and intersections to be navigated increase proportionally. The distance from home to school is a clear indicator of likelihood of active travel. Amongst NSW primary school children, 77.2% of those that lived less than 750m from school were travelling to school actively at least once per week, compared to 56.9% for children that lived further than 1.5km (Merom et al. 2006). Specifically relating to cycling only, for each kilometre extra that was required to cycle, the level of cycling dropped at a significant rate of 0.7; interestingly this was only observed amongst boys, whilst the influence on girls' rate of cycling was insignificant (Trapp et al. 2011). In the case of determining a ridable distance, it is important to note that studies have often focused on the distance that is travelled by children that regularly participate in active transport. Care needs to be taken in the Australian context, particularly if the goal is to get children that are not currently meeting recommended exercise levels to participate in active travel, then the realistic distance that they will be able to commute may be significantly less than their European counterparts that are fitter due to higher levels of daily activity.

Walking and cycling to school are commonly grouped together in studies, however the factors that influence cycling are somewhat different to walking, as cycling allows children to travel much farther (Trapp et al. 2011). Amongst 11–12-year-old children in Belgium, a feasible active commuting distance was determined to be 1.5km for walking and 3km for cycling; it is noted that Belgium has superior cycling infrastructure compared to Australia, so the 3km threshold may not be directly applicable to an Australian context (D'Haese et al. 2011); however, given that cycling multiplies human mobility effort at least fourfold, the Belgium findings appear conservative in relation to cycling's potential.

2.4. The importance of the built form

Physical environment is a key factor in the likelihood of children in participating in active travel to and from school. Whilst individual and social barriers rate highly (up to 48.3% and 59.7% respectively) on the list of parents' concerns for active travel, fear of children being involved in a road accident is 69.2%; the key specific environmental factors of concern are drivers exceeding local speed limits (64.2%), too much traffic in the local area (53.2%), and not enough controlled road crossings on the school route (43.9%) (Salmon et al. 2017). Many of the concerns expressed by parents involve the need for children to share a roadway with cars, or the need to cross a significant number of roads on the way to and from school.

There have been studies that have confirmed that a built environment that incorporates infrastructure to encourage walking and cycling has increased rates of active transport amongst adults, however, there has been little evidence to show a similar effectiveness for children (Mitra & Buliung 2012).

A before and after study in Sweden demonstrated that raising bicycle road crossings by between 0.04m and 0.1m had a substantial improvement in the usage and safety of the road crossing; the net result was a reduction in risk of 30% compared to the crossing that was at the same elevation as the road (Gårder, Leden & Pulkkinen 1998). There is a general lack of dedicated infrastructure around Adelaide's schools (e.g. elevated zebra crossings), and there could be significant real (and perceived) gains in risk reduction by having a substantial number of raised road crossings on routes to and from schools.

The presence of a crossing guard may have some limited positive impact on active transportation to school. A study by Gutierrez et al. (2014) showed that the presence of paid crossing guards had no measurable improvement in the rate of active transport or parents' attitude towards walking/cycling, however it was observed that children were more likely to follow designated safe routes when a professional crossing guard was present. It is feasible to believe that the long-effect of children sticking to designated safe routes may have a measurable improvement in safety, which may positively influence parents' attitude towards the risk of active travel, and therefore increase rates of active travel to school.

In a review of 12 previous studies, Larouche (2015) found a lack of research into characteristics of the built form that played a significant role in cycling to school, apart from the strong influence on distance from home to school. A New Zealand study found that distance to school had the strongest influence on active transport, with a sharp decline in the number of adolescents walking to school beyond a distance of 2.25 km; by contrast the study found that cycling increased beyond the 2.25km distance, with a peak cycling rate of 7.7% when adolescents lived from 2.25 to 4km from school (Mandic et al. 2020). Amongst adolescents, walking was the preferred method of active transport, and it appears that cycling was chosen for trips beyond the practical limit of walking range distance (i.e. greater than 2.25km).

The characteristics of the road network in the area surrounding a school is a strong predictor of active transportation rates. When considering the presence of motorway, main street, and side street crossing on the path to school, their presence has been shown to favour non-active modes of transport to a factor of 1.7, 2.2, and 0.9 for motorway, main street, and side street crossings respectively (Bringolf-Isler et al. 2008). Where there is a 200m buffer of paths around a school, this has also been shown to influence non-active transportation, with factors of 1.0, 1.3, and 0.6 for motorways, main streets, and side streets respectively (Bringolf-Isler et al. 2008). Interestingly, the Bringolf-Isler et al. (2008) study showed that motorways had less of a negative impact than main roads, both in regard to their presence and also when the path to school crossed them. In the context of Adelaide, the bulk of the roads within schools are regarded as main streets or side streets, as there is a minimal presence of motorways.

Studies generally focus on what are considered macro environmental characteristics, however there may other measures on a much smaller scale that can increase the appeal of cycling. Mertens et al. (2015) found that middle-aged cyclists had a preference for roads with a posted speed limit of 30km/h, featured a cycle path that was continuous in elevation, and had a hedge as a barrier to traffic, as opposed to 50-70km/h speed limit, a cycle path with step-ups and step-downs, and a concrete curb to separate them from traffic (Mertens et al. 2015).

Roundabouts are of particular concern regarding bicycle and motorised vehicle collisions, with a study of 90 intersections converted to roundabouts in Belgium having a significant increase in the number of crashes with cyclist, including an increase in the severity of injury as a result compared to collisions at other types of intersections (Daniels et al. 2009).

A Victorian study by Carver et al. (2015) identified that amongst school children that bicycle ownership was almost 100%, however less than half of the children surveyed used their bicycle at least once per week. The presence of separate bicycle paths for routes to school has a positive influence on the number of active trips to school by bike (Carver et al. 2015).

Amongst children that were already actively cycling to school regularly, they, and their parents identified that physical features such as bicycle paths separated from roads by some form of physical barrier, continuity of cycling networks, dedicated cyclist crossing points, and low speed limits encouraged cycling; by contrast, the presence of intersections and roundabouts had a negative effect on cycling for children (Ghekiere et al. 2014).

When looking at Germany, Denmark, and The Netherlands, it is clear that in order to build and maintain a high rate of non-recreational cycling, there needs to be a significant emphasis and investment in creating a built environment that is conducive to safe cycling as a form of daily transportation. These three European nations have taken some of the following measures; extensive bicycle path network in cities and surrounding regions, advance green lights to give cyclists priority to pass through controlled intersections ahead of cars, short cuts for cyclists ahead of intersections, traffic calming involving speed limits of 30km/h for residential neighbourhoods, bicycle streets that give bicycles right of way over motor vehicles, and zones with a 7km/h speed limit where cars must give way to pedestrians and bicycles at all times (Pucher & Beuhler 2008).

3. Data and Methodology

The aim of the study was to use secondary data sources to create a weighted matrix table to quantitatively rank the individual schools in terms of cycling safety, and to identify areas of each school that could be addressed to improve safety.

As can be seen in Figure 1, based on the factors mentioned in the literature review and available secondary datasets at the South Australian Government Data Directory, the conceptual framework of the study has been developed. The datasets were in the CSV or SHP formats and included ‘Road Crash Data’, ‘Bike Direct Network’, ‘Pedestrian Crossings, ‘Road Crash Locations in SA’ and ‘Traffic Lane Vehicle Counts at Signalised Intersections and Pedestrian Crossings’. Ten different built environment characteristics have been divided into two main groups including six criteria which have positive impacts as well as four criteria which negatively affect the safety of cycling to school.

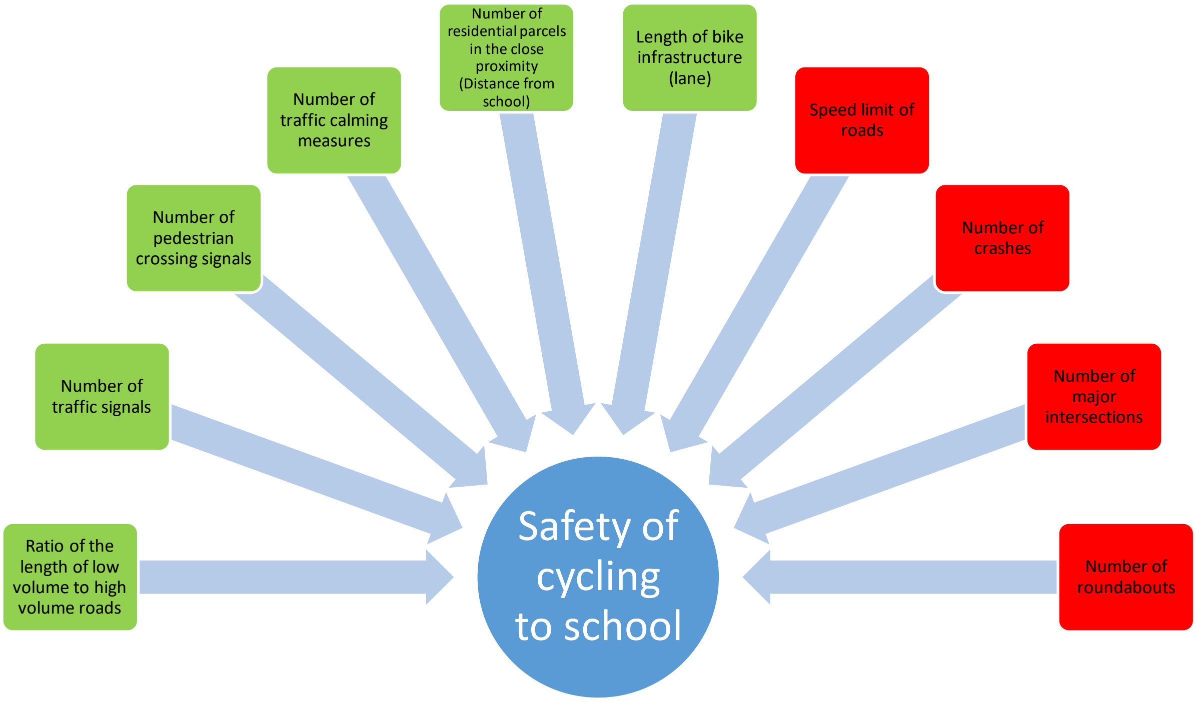


Figure 1: Variables analysed in the study (source: authors)

The Excel data was imported to ArcGIS Pro in order for the data to be identified and selected spatially based on an 800m buffer from each school. Key data from the ArcGIS project was exported to Excel, with a table displaying key attribute for each school that are key in objectively assigning a score and ranking for the cycling safety of each school. As can be seen in Figure 2, seven schools analysed in this paper are Adelaide High School, Brighton Secondary School, Christies Beach High School, Marryatville High School, Parafield Gardens High School, Roma Mitchell Secondary College and Woodville High School. The main reason for choosing these high schools is that they witnessed the highest level of road crashes on their 800-m buffers in comparison with other South Australia's schools.

Figure 2: The location of seven high schools in the Greater Adelaide Metropolitan Area (source: authors)

4. Case Study Analysis

4.1. Rush hour

In order to determine overall risks for children to cycle to school, it is important to identify overall road safety trends in South Australia. Figure 3 displays the total number of crashes that occur on South Australian roads, with the time categories selected based on school start and finish times in 2019. The overall trend for the volume of crashes through 2015 to 2019 is largely the same, with a strong spike in the number of crashes between the hours of 8am and 9am. The high volume of crashes in this morning period is not surprising, as traditionally this is the time that workers (in particular white-collar workers since blue-collar workers often start earlier) will travel to work, and this also coincides with school drop-off times. Even though the results are not particularly surprising, the data shows that the time when children are to be cycling to school is by far the most hazardous time of morning, and this indicates that the problem around safety on the roads is very real. In order to mitigate the increased collision risk at this time of morning it is reasonable to believe that the ideal solution would be to isolate cyclist from motorised vehicles, through the use of segregated paths and safe controlled crossing points. The trend in the afternoon is perhaps a little more surprising, when the number of crashes from 3pm to 4pm are greater than the traditional "peak hour" of 5pm to 6pm. The high rate of crashes in the time coinciding with the end of school is of concern, as it indicates that the time when children would be on their way home is potentially a very hazardous time to be sharing roads with motorised vehicles.

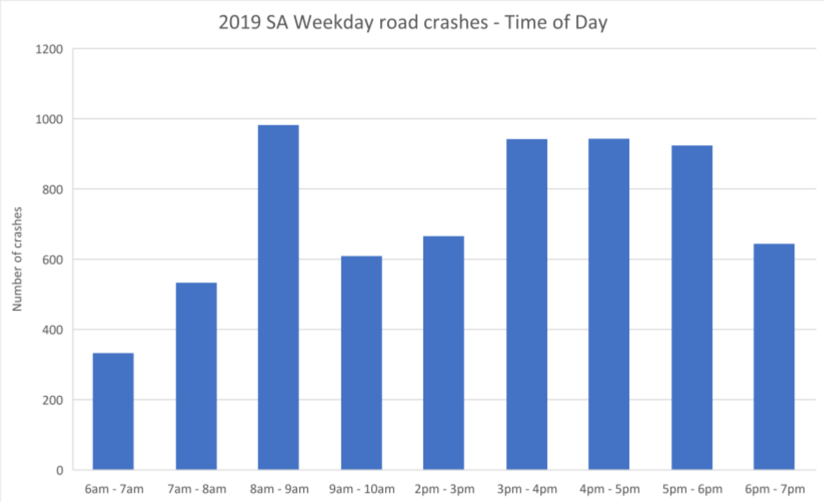


Figure 3: 2019 crash data around school times (source: Government of South Australia, Department of Infrastructure and Transport 2019)

4.2. Road crash hotspots around selected schools

The occurrence of collisions within the vicinity of each selected school gives an indication of the relative safety of the road networks that are most likely to be utilised by active commuters. All the schools in the study are situated on at least one very high traffic road, with an associated high number of crashes.

Figure 4A shows the frequency of crashes along West Terrace, which is one of Adelaide's busiest roads, carrying more than 60,000 vehicles daily. Brighton Secondary School (Figure 4B) is situated along a Brighton Road, which also has a very high frequency of crashes (particularly just south of Ilfracombe Avenue). Apart from Brighton Road, the other roads surrounding the school show a comparatively low number of crashes, indicating that there are more safe route options for active commuters compared to Adelaide High.

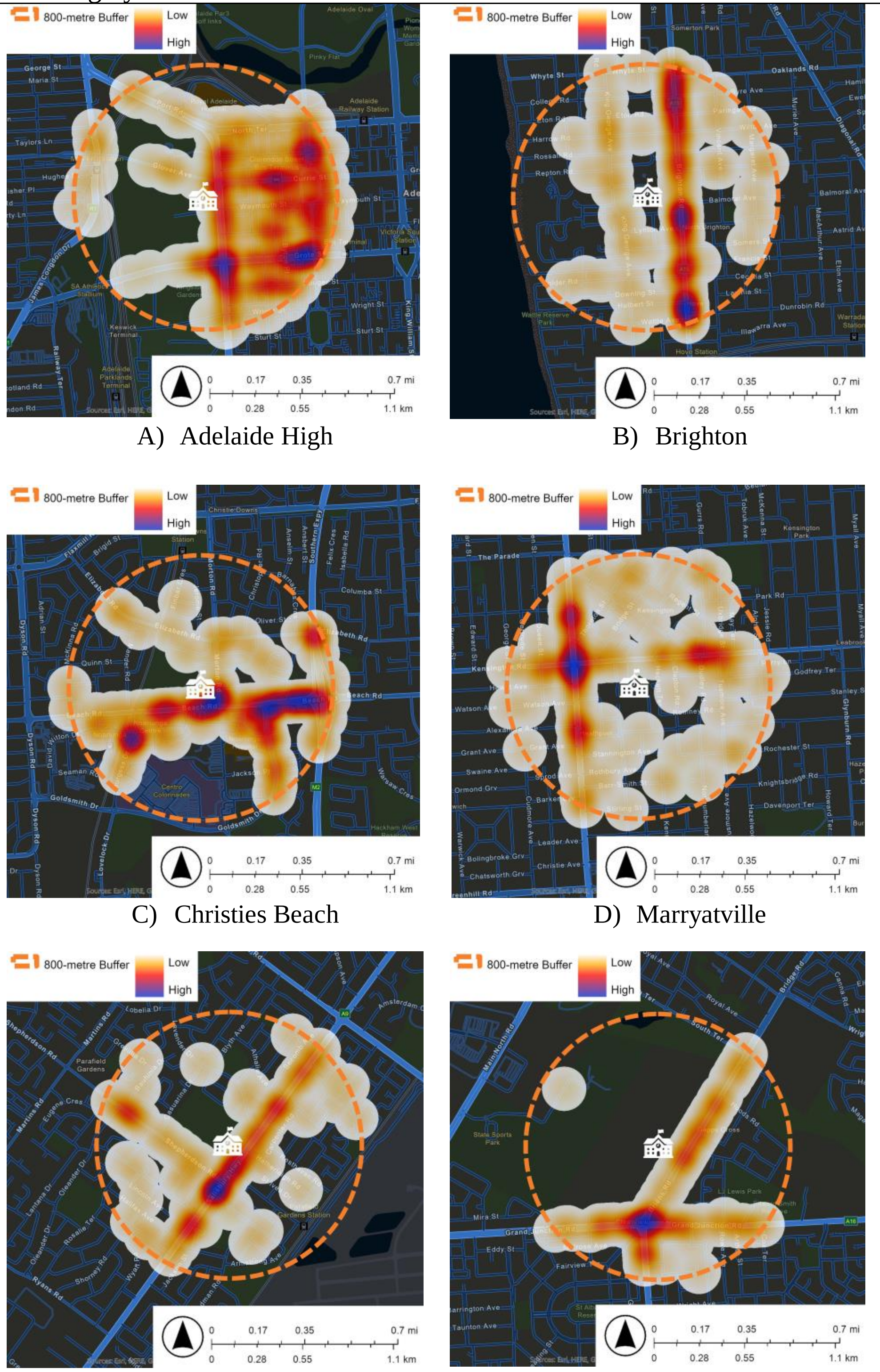
Looking at Figure 4C, Christies Beach High School is situated near a crash hotspot on Beach Road, with a high number of crashes extending north from the intersection with Morton Road, which is within a very short distance of the school. The presence of a major shopping centre just south of the school is likely to be a high contributor to traffic flows, and high crash rates.

Marryatville High School (Figure 4D) has Kensington Road on its northern boundary, and there is a concentration of collisions on this stretch of road, just to the east of the school boundary. Portrush Road is located within 500m of the school to the west. Portrush Road forms part of National Highway 1, which means that the bulk of heavy trucks (predominantly B-doubles) pass on this stretch of the road. The very high number of collisions along Portrush Road indicates that there is a significant risk to active commuters. Directly to the south of Marryatville High, minor roads show a very low frequency of collisions, which would indicate that the roads would be highly suitable for active commuters.

Parafield Gardens High School (Figure 4E) is situated on a very high traffic road (Salisbury Highway) and features a very high concentration of collisions. On the southwestern boundary of the school is Shepherdson Road (a minor road), which also displays a very high concentration of collisions over the 5-year period 2015-2019. Apart from these two roads, the remaining streets in the vicinity of the school appear to have very low accident rates.

Roma Mitchell High is situated on high-traffic Briens Rd (Figure 4F) and displays a very high number of collisions. Just to the south of the school is the intersection between Hampstead Road and Grand Junction Road; this intersection also features a very high concentration of collisions. Hampstead Road/ Grand Junction Road also form part of National Highway 1, and carries a very high number of heavy vehicles, much the same as Portrush Road. East of the school, over Briens Road, are minor roads that have no crashes over the period; many of these roads are no through roads.

Woodville high School (Figure 4G) has a very high number of crashes present on Woodville Road (adjacent school), as well as Torrens Road and Hanson Road which are in close proximity. These three main roads all present a significant safety risk to school students travelling by bike.



A) Adelaide High

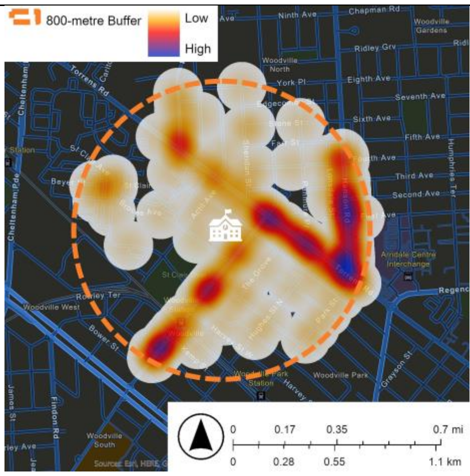
B) Brighton

C) Christies Beach

D) Marryatville

E) Parafield Gardens

F) Roma Mitchell



G) Woodville

Figure 4: The heatmap of crash points around selected schools (Source: authors)

4.3. Adolescent casualties travelling to and from school

A major aim of this study is to identify any characteristics that may contribute to creating a risk to student cyclists that would be considered unreasonable. In analysing the distribution of motor vehicle collisions as a function of time of day, and also as a function of proximity to the selected schools, there is a strong indication that the sites that the schools are situated on are indeed in high-risk areas, and that increased rates of cycling could result in an undesirable increase in casualties. Crash data has been filtered according to age (12 to 18 years old), weekdays, and times of 8am to 9am, and 3pm and 4pm. The low numbers of active commuters make it difficult to draw too many conclusions from the casualties incurred. However, Table 1 shows some key attributes of each casualty, with a relatively even spread of age and gender. There are only two cyclists compared to 8 pedestrians, and this is most likely a result of similar proportions of cyclists versus pedestrians. There are more collisions after school, but the sample size is too small to draw any conclusions. Interestingly, only one casualty collision was in a 25km/h zone, and this may be an indication of the reduced likelihood of collision, and also less chance of physical injury when speed limits are substantially lower.

Table 1: Pedestrian and cyclist casualties 12 to 18 years old within 800m of school directly before or after school 2015-2019 (source: Government of South Australia, Department of Infrastructure and Transport 2019)

School name	Type	Day of week	Before or after school	Age	Gender	Speed limit	Raining	Wet road	Traffic controls	Intersection	Injury extent
Christies Beach High	Pedestrian	Thurs	After	13	F	50	Not raining	Dry	No controls	No	Hospitalised
Christies Beach High	Pedestrian	Thurs	After	13	M	60	Not raining	Dry	Traffic signals	T-junction	Hospitalised
Christies Beach High	Pedestrian	Tues	Before	12	M	25	Not raining	Dry	No controls	No	Hospitalised
Christies Beach High	Pedestrian	Tues	After	15	M	60	Not raining	Dry	Traffic signals	T-junction	Hospitalised
Adelaide High	Cyclist	Tues	Before	15	F	60	Not raining	Dry	Traffic signals	Cross	Hospitalised
Adelaide High	Pedestrian	Tues	After	17	M	50	Not raining	Dry	No controls	No	Hospitalised
Woodville High	Pedestrian	Fri	After	13	M	60	Not raining	Dry	No controls	No	Hospitalised
Woodville High	Pedestrian	Thurs	After	15	M	60	Not raining	Dry	No controls	No	Hospitalised
Marryatville High	Pedestrian	Fri	After	15	F	50	Not raining	Dry	No controls	T-junction	Hospitalised
Marryatville High	Cyclist		Before	18	M	50	Not raining	Dry	No controls	No	Hospitalised

4.4. Identifying key characteristics

In order to accurately populate the matrix table (Table 2), all of the appropriate data was imported into ArcGIS, and data points were selected spatially using an 800m buffer around each school individually. The attributes of each selection were then collated via Excel.

Adelaide High School has several key defining characteristics: it is situated on a highly trafficked road, and is very close to a major intersection, both of which are not conducive to safe cycling. The lowest speed limit adjacent to the school is 60km/h, and there is no dedicated school pedestrian crossing. The main signal-controlled crossing points near the school are crossing West Terrace and Glover Avenue. There are no clear signs for motorists that may alert them to the fact that there may be a significant number of school children. The road conditions around Adelaide High are of concern from a safety perspective. One positive attribute for Adelaide High is the significant amount of separate bike lanes, however these are concentrated on the western side of West Terrace, and there is a lack of separate bike paths for students travelling east (as is often the case). The number of residential land parcels within 800m is quite low (80), which indicates that there are not many students that live in close proximity to the school.

Brighton Secondary School is located in a very typical suburban Adelaide suburb. The surrounding area has a high number of residential land parcels (135) and a low number of total crashes in the 5-year period of 2015 to 2019. Brighton features the second-best ratio of low traffic to high traffic volume of 16.87, and this figure is important as it not only considers the absolute presence of busy roads, but rather it takes into consideration the likelihood of there being a low-trafficked road as an option. The only characteristic where the school ranked poorly is the low amount of separate bicycle paths.

Christies Beach High School scored well in regard to low traffic to high traffic volume ratios, indicating that there are a significant number of quiet streets to ride on instead of needing to share busy roads. The amount of dedicated cycle paths (4.61km) also improved the score. The main drawback that the school has is the low number of residential land parcels (71) in the vicinity, and this indicates that the majority of the students do not live nearby. The presence of a major shopping centre to the south of the school is perhaps a defining characteristic and is the main factor limiting the number of residential land parcels.

Marryatville High School had the highest number of residential land parcels, and considering the importance of commuting distance, this factor alone helped the school score well. The area is characterised by many well-connected side streets, that feature very low crash rates, making them ideal candidates for bicycle use. The main drawback is the high traffic flows of Portrush Rd, and the associated high crash rates, although this may be effectively mitigated with the high number of dedicated signal-controlled pedestrian crossings near the school. Marryatville high also features 25km/h zones combined with several speed humps to calm traffic.

Parafield Gardens High has many characteristics that are similar to Marryatville High. Parafield Gardens High features a large number of side streets that have low accident rates. One feature where Parafield Gardens differs compared to Marryatville is the connectivity of the streets. Marryatville is an older development as is characterised by straight interconnected streets, whereas Parafield Gardens has lower connectivity and the dominance of cul-de-sac street layouts. A lack of separate bike paths hinders the achievement of bicycle-friendly nature.

Roma Mitchell Secondary School was founded in 2011 and was initially described as a "super" school, as it was formed by amalgamating three other schools. The site appears to have been chosen based on a general proximity to now defunct schools (approx. 2km distant), and the fact that the site was vacant state government-owned land. The site is characterised by vast amounts of vacant land, apart from residential housing on the eastern side of Briens Road. There are only 63 residential land parcels within 800m of the school, and this is not a strong indicator of high rates of active transport to school. The school is a short distance from National

Highway 1, and this road features a very high number of heavy vehicles, and the intersection of Grand Junction, Briens, and Hampstead Roads feature a high number of collisions. However, if the surrounding vacant land was developed with high density (by Adelaide standards) dwellings, it would strongly improve the score of the school; Roma Mitchell Secondary School shows strong potential in the future if the surrounding land is developed appropriately.

Woodville High can be considered as one of the most suitable schools in terms of bikeability and scored well due to a high number of residential land parcels, and a reasonable total distance of separate bike paths. However, as with the other schools, the presence of busy main roads (Woodville Road, Torrens Road, and Hanson Road) and associated high rates of road crashes impedes the potential for active transport.

Table 2: Safety specifications of selected schools (source: authors)

School names	Total length of road by traffic volume (km)			Ratio of low volume to high volume roads (Med considered neutral)	Lowest speed limit adjacent school	Number of crashes (2015-2019)	Number of major intersections	Number of roundabouts	Number of traffic signals	Number of pedestrian crossing signals	Number of traffic calming measures	Number of residential land parcels	Length of bike infrastructure (km)	
	High*	Med	Low										Part of road	Separate from road
				A	B	C	D	E	F	G	H	I		J
Adelaide High	9.5	4.64	22.6	2.38	60	366	15	0	47	3	2	80	16.38	13.79
Brighton Secondary	2.75	0.9	46.32	16.87	25	101	1	2	5	5	2	135	12.08	1.51
Christies Beach High	1.46	0.92	28.58	19.64	25	86	4	4	5	2	0	71	7.16	4.61
Marryatville High	4.3	3.26	47.16	10.96	25	212	1	3	9	8	3	201	16.17	0.06
Parafield Gardens High	2.97	0	36.55	12.31	25	122	1	9	2	6	1	121	6.79	1.1
Roma Mitchell High	6.23	0	17.41	2.79	60	134	1	0	5	6	0	63	9.13	4.39

Woodville High	3.93	1.06	35.18	8.95	25	199	4	3	10	5	1	133	14.31	4.61

*: According to Department for Infrastructure and Transport (2022), Traffic Volumes is the sum of traffic travelling in both directions on a two-way road passing a roadside observation point over the period of a full year divided by the number of days in the year. This variable was divided in to three categories using the Natural Breaks (Jenks) method which are Low (<10900), Med (10900-29600) and High (>70600).

4.5. Assigning values to different criteria

In order to compare and rank the seven high schools against analysed characteristics, all criteria of Table 2 were normalised using the mean and standard deviations. To assign logical weights to each criterion based on its level of significance in terms of safety of cycling to school, both positive and negative group of criteria (based on the conceptual framework) ranked separately. Then, the ranking scores converted to weighted coefficients using percentage calculator. As a result, the formula of final score of safety of cycling to school was developed which can be seen below:

$$TOTAL\ SCORE = \{(0.190 * [A\_Zscore]) + (0.047 * [F\_Zscore]) + (0.095 * [G\_Zscore]) + (0.142 * [H\_Zscore]) + (0.285 * [I\_Zscore]) + (0.238 * [J\_Zscore])\} - \{(0.3 * [B\_Zscore]) + (0.4 * [C\_Zscore]) + (0.2 * [D\_Zscore]) + (0.1 * [E\_Zscore])\}$$

Table 3: Normalised values and final scoring (source: author)

School names	Ratio of low volume to high volume roads	Lowest speed limit	Number of crashes	Number of major intersections	Number of roundabouts	Number of traffic signals	Number of pedestrian crossing signals	Number of traffic calming measures	Number of residential land parcels	Length of Separate bike infrastructure	**TOTAL SCORE**
Adelaide High	-1.353	1.581	2.137	2.353	-1.060	2.412	-1.080	0.693	-0.778	2.235	**-1.531**
Brighton Secondary	1.045	-0.632	-0.817	-0.603	-0.353	-0.470	0	0.693	0.4500	-0.655	**-0.785**
Christies Beach High	1.503	-0.632	-0.984	0.030	0.353	-0.470	-1.620	-1.248	-0.979	0.074	**0.110**
Marryatville High	0.066	-0.632	0.420	-0.603	0	-0.196	1.620	1.664	1.924	-0.997	**0.212**
Parafield Gardens High	0.290	-0.632	-0.582	-0.603	2.121	-0.676	0.540	-0.277	0.137	-0.752	**0.226**
Roma Mithchell High	-1.285	1.581	-0.449	-0.603	-1.060	-0.470	0.540	-1.248	-1.158	0.022	**0.847**
Woodville High	-0.266	-0.632	0.275	0.030	0	-0.127	0	-0.277	0.405	0.074	**0.919**

Table 3 shows that two High Schools of Woodville (0.919) and Roma Mitchell (0.847) have the best score for cycling to school. By contrast, Adelaide High School (-1.531) and Brighton Secondary (-0.785) are the least safe schools for cycling.

5. Conclusions and Recommendations

A consistent theme of studies in the field of active school transport, is the importance of proximity to school, and the parental concern of their children being injured in a road traffic crash. The trend of school consolidations has resulted in high schools with a very high number of students, with a comparatively low number of dwellings within a distance conducive to active transportation; in other words, when looking at the most important characteristic of distance, these schools do not rate well. For instance, Christies Beach High and Roma Mitchell High are located in suburbs with a low residential densities. The low-density nature of Adelaide is a contributing factor; however, the state government appears to choose school sites based on where conveniently available vacant land is, with little forethought given as to how this will affect use of active modes of transport. If this is to improve, the siting of schools designed to optimise take-up of active transport modes by school students, should be of prime importance, with sites chosen at locations with higher densities, or alternatively, areas close to existing schools could be developed to include much higher densities.

For existing schools, adaptation is needed that could include rerouting heavy through traffic away from sensitive school precincts, traffic calming measures and a 30km/h speed limit in the precinct within which the school is located, developing active transport corridors to the School from nearby main traffic routes and nearby traffic generators, increasing secure bicycle parking on school grounds and increasing residential densities for family oriented households with children enrolled in that school. There may be a role for technology in the future with wifi based vehicle to pedestrian/cyclist communication, providing warnings to all road users of potential conflict situations.

A common characteristic of the schools in this study is the proximity to a highly trafficked road(s), with an associated high rate of vehicle collisions. Adelaide High and Marryatville High witnessed the highest level of road crashes between 2015 to 2019. As a fear of road crashes is a major concern to parents (appears to be somewhat well-founded), the siting of schools in the future will need to take this into account, as siting schools away from busy roads has the potential to reduce actual risk, which may then in turn influence the parents of students and students themselves to have less perceived safety risk of using active transport modes in the long-term.

On a positive note, the majority of the schools in this study displayed many characteristics that should encourage cycling, and perhaps can highlight deficiencies; the net result could be that funds and resources are directed to the physical features that are likely to have the greatest impact.

Attempts at increasing cycling rates through education and awareness campaigns should be undertaken with care; if there is a push to increase cycling rates without addressing physical hazards, then there is a risk of putting children in harm’s way and any resulting casualties could further heighten parents’ fears and be counterproductive in encouraging cycling amongst children. Hence, as Soltani et al. (2022b) stated, encouraging cycling policies, particularly for teenagers should not be applied in isolation.

References

Australian Bureau of Statistics, (2013). Australian Health Survey: Physical Activity, 2011-12. Cat No. 4364.0.55.004. ABS, Canberra.

Bringolf-Isler, B, Grize, L, Mäder, U, Ruch, N, Sennhauser, FH & Braun-Fahrländer, C (2008), 'Personal and environmental factors associated with active commuting to school in Switzerland', Preventive Medicine, vol. 46, no. 1, pp. 67–73.

Carver, A, Salmon, J, Campbell, K, Baur, L, Garnett, S & Crawford, D (2005), 'How Do Perceptions of Local Neighborhood Relate to Adolescents' Walking and Cycling?', American Journal of Health Promotion : AJHP., vol. 20, no. 2, pp. 139–147.

Carver, A, Timperio, AF & Crawford, DA (2015), 'Bicycles gathering dust rather than raising dust – Prevalence and predictors of cycling among Australian schoolchildren', Journal of Science and Medicine in Sport, vol. 18, no. 5, pp. 540–544.

Chapman, R., Keall, M., Howden-Chapman, P., Grams, M., Witten, K., Randal, E. and Woodward, A., (2018). A Cost Benefit Analysis of an Active Travel Intervention with Health and Carbon Emission Reduction Benefits. *International Journal of Environmental Research and Public Health*, 15(5), p.962.

Daniels, S, Brijs, T, Nuyts, E & Wets, G (2009), 'Injury crashes with bicyclists at roundabouts: influence of some location characteristics and the design of cycle facilities', Journal of Safety Research, vol. 40, no. 2, pp. 141–148.

Department of Planning, Transport and Infrastructure, (2017). *The 30-Year Plan for Greater Adelaide*. Government of South Australia.

D'Haese, S, De Meester, F, De Bourdeaudhuij, I, Deforche, B & Cardon, G (2011), 'Criterion distances and environmental correlates of active commuting to school in children', The International Journal of Behavioral Nutrition and Physical Activity., vol. 8, no. 1.

Dollman, J & Lewis, NR (2007), 'Active Transport to School as Part of a Broader Habit of Walking and Cycling among South Australian Youth', Pediatric Exercise Science, vol. 19, no. 4, pp. 436–443.

Ducheyne, F, De Bourdeaudhuij, I, Lenoir, M & Cardon, G (2014), 'Effects of a cycle training course on children's cycling skills and levels of cycling to school', Accident Analysis and Prevention, vol. 67, pp. 49–60.

Gårder, P., Leden, L. and Pulkkinen, U. (1998) 'Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology', Transportation Research Record, 1636(1), pp. 64–70. doi: 10.3141/1636-10.

Garrard J (2016) Walking, riding, or driving to school: what influences parents' decision making? Technical report, South Australian Department of Planning, Transport, and Infrastructure

Ghekiere, Ariane, Van Cauwenberg, Jelle, de Geus, Bas, Clarys, Peter, Cardon, Greet, Salmon, Jo, … Barengo, Noel Christopher (2014), 'Critical Environmental Factors for Transportation Cycling in Children: A Qualitative Study Using Bike-Along Interviews', PloS One., vol. 9, no. 9.

Gilbert, H., Lanng, D., Wind, S. and Allan, A., (2022). Understanding the complexity of children's everyday mobilities: non-instrumental aspects in sustainable transport and planning policy making in Australia. *Applied Mobilities*, pp.1-20.

Goel, R., Goodman, A., Aldred, R., Nakamura, R., Tatah, L., Garcia, L., Zapata-Diomedi, B., de Sa, T., Tiwari, G., de Nazelle, A., Tainio, M., Buehler, R., Götschi, T. and Woodcock, J., (2021). Cycling behaviour in 17 countries across 6 continents: levels of cycling, who cycles, for what purpose, and how far?. *Transport Reviews*, 42(1), pp.58-81.

Government of South Australia, Department for Infrastructure and Transport, (2017). *Traffic Lane Vehicle Counts at Signalised Intersections and Pedestrian Crossings*. Available at: https://data.sa.gov.au/data/dataset/e6c1f446-de74-4270-811d-5dc5ec79643b

Government of South Australia, Department for Infrastructure and Transport, (2019). *Road Crash Data*. Available at: https://data.sa.gov.au/data/dataset/road-crash-data/resource/0f522af2-ad29-47b4-82dc-12c9cbe79796

Government of South Australia, Department for Infrastructure and Transport, (2020a). *Bike Direct Network*. Available at: https://data.sa.gov.au/data/dataset/6bfd0d67-6abc-43d7-bf87-dea7a0710208
Government of South Australia, Department for Infrastructure and Transport, (2020b). *Pedestrian Crossings*. Available at: https://data.sa.gov.au/data/dataset/2d972378-33e0-4be3-a412-c65a02fccb25
Government of South Australia, Department for Infrastructure and Transport, (2021). *Road Crashes 2015-2019*. Available at: https://data.sa.gov.au/data/dataset/cf8d8549-b976-4523-88ad-46dd32053696
Gutierrez, CM, Slagle, D, Figueras, K, Anon, A, Huggins, AC & Hotz, G (2014), 'Crossing guard presence: Impact on active transportation and injury prevention', Journal of Transport & Health., vol. 1, no. 2, pp. 116–123.
Larouche, R (2015), 'Built Environment Features that Promote Cycling in School-Aged Children', Current Obesity Reports., vol. 4, no. 4, pp. 494–503.
Mandic, S, Hopkins, D, García Bengoechea, E, Flaherty, C, Coppell, K, Moore, A, … Spence, JC (2020), 'Differences in parental perceptions of walking and cycling to high school according to distance', Transportation Research., vol. 71, pp. 238–249.
Merom, D, Tudor- Locke, C, Bauman, A & Rissel, C (2006), 'Active commuting to school among NSW primary school children: implications for public health', *Health & Place.*, vol. 12, no. 4, pp. 678–687.
Mertens, Lieze, Van Cauwenberg, Jelle, Ghekiere, Ariane, Van Holle, Veerle, De Bourdeaudhuij, Ilse, Deforche, Benedicte, … Matisziw, Timothy C (2015), 'Does the Effect of Micro-Environmental Factors on a Street's Appeal for Adults' Bicycle Transport Vary across Different Macro-Environments? An Experimental Study', PloS One., vol. 10, no. 8.
Mitra, R & Buliung, RN (2012), 'Built environment correlates of active school transportation: neighborhood and the modifiable areal unit problem', Journal of Transport Geography, vol. 20, no. 1, pp. 51–61.
Morris, J., Wang, F. and Lilja, L. (2001) 'School Children's Travel Patterns: A Look Back and a Way Forward', Transport Engineering in Australia. Engineers Australia, 7(1/2), pp. 15–25. https://search.informit.org/doi/10.3316/informit.470034740172518.
Mulvaney, CA, Smith, S, Watson, MC, Parkin, J, Coupland, C, Miller, P, … McClintock, H (2015), 'Cycling infrastructure for reducing cycling injuries in cyclists', The Cochrane Library.
Panter, JR, Jones, AP, Van Sluijs, EM & Griffin, SJ 2010, 'Neighborhood, Route, and School Environments and Children's Active Commuting', American Journal of Preventive Medicine, vol. 38, no. 3, pp. 268–278.
Pucher, J & Buehler, R (2008), 'Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany', Transport Reviews., vol. 28, no. 4, pp. 495–528.
Salmon, J. et al. (2007) 'Associations among Individual, Social, and Environmental Barriers and Children's Walking or Cycling to School', American Journal of Health Promotion, 22(2), pp. 107–113. doi: 10.4278/0890-1171-22.2.107.
Soltani, A, Allan, A, Javadpoor, M & Lella, J (2022a), 'Space Syntax in Analysing Bicycle Commuting Routes in Inner Metropolitan Adelaide', Sustainability (Basel, Switzerland), vol. 14, no. 6, p. 3485.
Soltani, A, Allan, A, Pojani, D, Khalaj, F & Mehdizadeh, M (2022b), 'Users and non-users of bikesharing: how do they differ?', Transportation Planning and Technology, vol. 45, no. 1, pp. 39–58.
Towner, E & Towner, J (2002), 'UNICEF's child injury league table. An analysis of legislation: more mixed messages.', IP Online : Injury Prevention., vol. 8, no. 2, pp. 97–100.

Trapp, G.S., Giles-Corti, B., Christian, H.E. et al. (2011) On your bike! a cross-sectional study of the individual, social and environmental correlates of cycling to school. Int J Behav Nutr Phys Act 8, 123.