Spatial aspects of a comparative study of Active Transport to School and Motorized Transport

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1.0   INTRODUCTION

Active transport to school (ATS) is a convenient way to integrate physical activity into everyday life, maintain or increase physical activity level and may develop into environmentally sustainable travel practices over a lifetime. Adolescents' transport choices to school are influenced by demographic, individual, family, school, social and environmental factors. Age (Pabayo et al, 2011), male gender (Babey et al, 2009; Larsen et al, 2009), fewer vehicles at home (McDonald, 2008), low socio-economic status (SES) (Babey et al, 2009; McDonald, 2008), neighbourhood social environment (Hume et al, 2009), shorter distances from home to school (Babey et al, 2009; Larsen et al, 2009; McDonald, 2008), lack of parental concerns for safety are positively associated with a higher likelihood of ATS (Carver, 2010). More recent studies identified environmental factors associated with ATS including neighbourhood factors, route to school (Panter et al, 2010), distance to school (Babey et al, 2009; Larsen et al, 2009; Bringolf-Isler et al, 2008; Timperio et al, 2006), topography, street connectivity (Timperio et al, 2006), land use mix (Larsen et al, 2009; Panter et al, 2010), residential density (Larsen et al, 2009), busy intersections, intersection density (Timperio et al, 2006), and neighbourhood walkability (Kerr et al, 2006). This study compared individual characteristics and objective measures of built environment between ATS users and motorised transport (MT) users in Otago adolescents living within 4.8 km from their school.

2.0   METHODS

The study sample combined data from participants from Otago School Students Lifestyle Surveys 1 and 2 recruited from 22 schools in the Otago region, New Zealand. Students (n=2018) in school years 9 to 13 completed an anonymous online questionnaire. In this analysis we included the 1,325 students who lived within 4.8 km from school (the maximum distance for which ATS is likely to occur – McDonald, 2007). Students answered questions related to demographics, transport to school, physical activity and sedentary activities, and perceived peer and parental support for active transport to school. Environmental factors included urban versus rural residential area, safety perceptions, distance to school, and objectively measured built environment variables related to the home neighbourhood, school neighbourhood and route to school.

2.1   Distance from Home to School

Distances from home to school was one of the variables and were calculated on the connected transport network using ESRI ArcGIS 10. In a comparison study set in Australia, GIS-calculated distances were found to be statistically similar to distances measured from GPS data collected by the students on their route to school (Duncan and Mummery, 2007). These results agree with Stigell and Schantz's (2011) comparative study in Stockholm, though these authors note that both GIS and GPS-derived distances significantly differ from the map-measured identified commuter routes used as truth. Briefly, the students' home addresses were geocoded to give a mapped home location. School address points were extracted from reference spatial data. In the next step, an integrated and connected road and track network was constructed in the GIS. The home and school point locations were attached to this network. Finally, Python scripting was used to calculate the shortest travel distance on the network for each subject, using the edges (roads, tracks) and nodes (home, school, road / track intersection points) forming the network.

2.2   Intersection Density

The intersection density variable was calculated as a count of intersections along the route from home to school. The junction layer from the dissolved network dataset was used as it contains a junction point for every location where three or more roads intersect. Each route, calculated previously, was then intersected with the junction data to obtain a count of only those junctions that fall on the route. This process was repeated with a 200m buffer around the route to obtain the buffered intersection density variable. In this case, a 200m buffer along the route was generated, this buffered region was intersected with the junction data and a count of those junctions within the buffered region was obtained. This section of work was performed using the route and junction shape files generated previously in ArcGIS 10.0 and code written in R 2.16.1.

2.3   Residential Density

The residential density variable was calculated using a 400m buffer around each student address. This buffer was intersected with the reference address data used previously to obtain a count of all address points that fall within a 400m radius of each students' home address. An assumption has been made in the calculation of this variable: that a single address point in the reference data represents a single residence (though there are some address points which potentially represent multiple residences). Land parcel data was considered as alternative reference data, but many single land parcels had multiple addresses, and some had none.

2.4   Land Use Mix

The land use mix variable along the school routes was calculated as the mean land use mix entropy. For each route from home to school as calculated earlier, the land use mix was evaluated and the mean land use mix entropy was calculated according to the formula:

(1) *Mean land use mix entropy* $= \left\{ \sum_k \left[\sum_J P_{jk} \ln(p_{jk}) \right] / \ln(J) \right\} / K$ (Cervero,1997, p. 206)

where: p_{jk}= proportion of land-use category j within a half-mile radius of the developed area surrounding hectare grid cell k; j = number of land-use categories; and K= number of actively developed hectares in tract.

The Dunedin City Council reference data was used for these calculations. This only covers the Dunedin region and therefore the land use mix variable was unable to be calculated for students attending schools outside the Dunedin region (545 students). The land use reference data classifies the land into broad classes such as

residential, commercial and industrial. The mean entropy calculation results in a value for each route of between 0 (the land use mix along the route is of a single class) and 1 (the land use mix along the route is evenly distributed among all land use classes). This section of work was performed using the route shape files generated previously in ArcGIS 10.0 and code written in R 2.16.1.

2.5   Topography

The topography of each route was evaluated through the altitude difference and total altitude gain variables. Several steps were undertaken to obtain the altitude along each route from home to school calculated previously. The first four steps were performed using tools in ArcGIS 10.0: 1) The Densify tool was used to insert vertices along the route. 15m intervals were used in order to match the resolution of the digital elevation model. The digital elevation model used was (the University of Otago School of Surveying 15 metre resolution DEM – Columbus et al, 2011); 2) The Feature Vertices to Points tool was then used to create points at each of the vertices along the route; 3) The digital elevation model was then used with the Add Surface Information tool to interpolate heights for each of the vertices; 4) The elevation values along the route were output for subsequent evaluation; and 5) The final step was performed using R to read the elevation values and obtain the difference in altitude between home and school, and the total altitude gain (amount of altitude climbed in total) along the route for each student. Differences between ATS and motorized transport (MT) users were compared using the Mann-Whitney test (for continuous variables) and chi-square analysis (for categorical variables).

3.0   RESULTS

A total of 1,325 students (age 14.9±1.3 years; 53.9% boys; 74.1% urban) who lived within 4.8 km from school were included in these analyses. Among these students, 55.4% of students used ATS (51.2% walking and 4.2% cycling), 10.1% bus, and 34.5% car. Rural students were more likely to use ATS compared to students living in urban areas (72.6% vs. 49.4%; p<0.001). Compared to MT users, ATS users lived closer to school (1.3±1.0 vs. 3.0±1.2 km; p<0.001) and in areas with greater residential density (376±167 vs. 340±182 houses within 400 m; p=0.027) and less altitude gain on the route to school (19.7±101.5 vs. 48.7±42.4 m; p<0.001). Intersection density on the shortest route to school (ATS: 7.3±2.9 vs. MT: 7.2±2.4 intersections/km; p=0.154), number of intersections around the school (ATS: 4.8±3.0 vs. MT: 5.3±3.7 intersections; p=0.468) and residential density in the school neighbourhood (ATS: 75.3±30.0 vs. MT: 77.9±37.9 houses; p=0.064) were not different between ATS and MT groups. In urban areas, a lower land mix use index was observed both in the home neighbourhood (ATS: 0.22±0.10 vs MT: 0.26±0.11; p<0.001) and school neighbourhood (ATS: 0.24±0.13 vs. MT: 0.29±0.14; p<0.001) of ATS users compared to MT users.

4.0   CONCLUSIONS

Adolescents who live within 4.8 km from school and use ATS live attend schools in neighbourhoods with a more favourable built environment for ATS compared to MT users. ATS users live closer to school and in areas of greater residential density. In urban environments, ATS users live in neighbourhoods and attend schools in the areas of lower land-mix use compared to MT users. However, not all indicators, intersection density for example, were significant.

Future school- and community-based ATS interventions should focus on implementing changes in the physical environment to improve pedestrian and cycling infrastructure and traffic safety in school neighbourhoods and on the common routes to school. The factoring of busy roads and intersections should also be a feature of further study, though Duncan and Mummery's (2007) study has noted that there is significant difference between count of busy intersections gained by GIS as opposed to GPS means, so a change of data collection strategy is implied too.

One other factor for future investigation is how active transport to school behavior has changed over time. One would anticipate a greater proportion of students walking to school in the past, with motorized transport not being so prevalent. An exploration of this allied with possibly changing societal attitudes may yield interesting results.

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