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Adolescents' School Travel and Unhealthy Snacking: Associations with School Transport Modes, Neighbourhood Deprivation, and Body Weight

Margaretha L. Situmorang [1,2,*], Kirsten J. Coppell [1], Melody Smith [3], Michael Keall [4], Sandra Mandic [2,5,6]

[1] Department of Medicine, University of Otago, P.O. Box 56, Dunedin 9054, New Zealand; kirsten.coppell@otago.ac.nz
[2] Centre for Sustainability, University of Otago, P.O. Box 56, Dunedin 9054, New Zealand; sandy.mandic@aut.ac.nz
[3] School of Nursing, University of Auckland, Auckland 1010, New Zealand; melody.smith@auckland.ac.nz
[4] Department of Public Health, University of Otago, Wellington 6242, New Zealand; michael.keall@otago.ac.nz
[5] School of Sport and Recreation, Faculty of Health and Environmental Sciences, Auckland University of Technology, Auckland 1010, New Zealand
[6] AGILE Research Ltd., Wellington 6012, New Zealand
* Correspondence: margaretha.situmorang@postgrad.otago.ac.nz

Abstract: Active transport to and/or from school (ATS), alone or combined with motorised transport, provides an opportunity to increase adolescents' physical activity levels to prevent obesity. However, travel through and exposure to an unhealthy food environment en route to school may have unintended consequences, specifically unhealthy snacking. This study examined the association between adolescents' unhealthy snack food/soft drink purchases/consumption during the journey to and from school and their school transport modes, neighbourhood deprivation, and body weight. Adolescents (n = 660, age: 15.3 ± 1.3 years, 51.7% female) from 11 schools in the Otago region, New Zealand, completed an online survey and anthropometry. Data were analysed using χ^2 test and logistic regression. Overall, 36.7% of adolescents purchased/consumed unhealthy snack foods and 25.9% purchased/consumed soft drinks at least once during their weekly school trips. ATS and mixed transport users reported more frequent unhealthy snack food/soft drinks purchases/consumption on the way to school than motorised transport users. Neighbourhood deprivation, but not body weight, was positively associated with unhealthy snack food/soft drink purchases/consumption during the school journey. Our findings highlight the importance of considering not only travel mode shift but also the obesogenic environment and unhealthy food/drinks purchases/consumption during adolescents' school journeys, particularly in lower socio-economic areas, to prevent obesity.

Keywords: adolescents; unhealthy snacking; school transport modes; neighbourhood characteristics; obesity

Citation: Situmorang, M.L.; Coppell, K.J.; Smith, M.; Keall, M.; Mandic, S. Adolescents' School Travel and Unhealthy Snacking: Associations with School Transport Modes, Neighbourhood Deprivation, and Body Weight. *Sustainability* **2022**, *14*, 7038. https://doi.org/10.3390/su14127038

Academic Editors: Fernando Fonseca, Paulo Ribeiro, Elisa Conticell and George N. Papageorgiou

Received: 5 May 2022
Accepted: 6 June 2022
Published: 8 June 2022

1. Introduction

Active transport (typically walking or cycling) to and/or from school (ATS) solely or combined with motorised transport is a convenient way to incorporate physical activity into adolescents' lives and may help adolescents meet the minimum physical activity recommendations of at least 60 min of moderate-to-vigorous physical activity per day [1]. ATS is also associated with higher adolescents' cardiorespiratory fitness and better cognitive performance [2,3]. Moreover, active travel supports a more sustainable environment through less greenhouse gas emissions compared to traveling with motorised transport modes [4,5]. However, ATS through an obesogenic environment increases adolescents' exposure to health-related harms [6]. Townshend and Lake [7] have highlighted the importance of the school journey and exposure to obesogenic environments, which have been associated with an increased risk of obesity in adolescents [8].

The worldwide prevalence of obesity in adolescents increased ten-fold between 1975 and 2016 [9]. In New Zealand, 34% of young adolescents (10–14 years) and 47% of older adolescents (15–24 years) were classified as overweight or obese in 2020/21 [10]. Adolescence is a crucial period for forming healthy habits, including being physically active and developing healthy dietary behaviours, that can last into adulthood [11]. However, the environment may not always facilitate and support the development of healthy habits [7]. The environment through which adolescents travel to and from school has the potential to have a negative influence on their diet and lifestyle, even though it is a relatively 'small window of time', as recently reported by the Royal Society for Public Health, UK [12].

The "obesogenic environment" is a term coined to describe environments that promote obesity, for example, those with a high density of fast-food outlets [13]. In New Zealand, areas around many schools have a high number of food outlets, such as convenience stores and takeaways [14,15], particularly in lower socio-economic areas [16]. This is more evident in urban than rural areas [15]. The accessibility, availability, and affordability of unhealthy snack food and soft drinks, as well as exposure to unhealthy food advertising and promotion, may facilitate the purchase and consumption of such food among adolescents [17,18].

Unhealthy snacking—the consumption of snack food and soft drinks high in sugar, fat, and calories—contributes to obesity in adolescents [19,20]. Snacking, defined as the consumption of small portions of food between regular mealtimes [21], is common among adolescents, and can contribute up to one-third of their daily energy intake and energy surplus [22]. While socioeconomic status and body weight have been associated with unhealthy snacking in adolescents [19,23], less is known about their unhealthy snacking in specific contexts, such as during their journey to and from school [24,25].

Understanding the relationship between school transport modes and unhealthy snacking on the school journey has the potential to inform obesity prevention initiatives. The primary aim of this study was to investigate the association between school transport modes and adolescents' unhealthy snacking on the way to or from school. The secondary aim was to examine whether area-level socioeconomic status (i.e., home neighbourhood deprivation) and adolescents' body weight are associated with unhealthy snacking during the school journey.

2. Materials and Methods

2.1. Study Setting and Participants

Adolescents were recruited as part of the Built Environment and Active Transport to School (BEATS) Rural Study conducted in 11 public secondary schools across the Otago region, southern New Zealand, between February and September 2018 [26]. Otago is the second largest region in New Zealand by land area and has one city (Dunedin) and four districts. All schools across Otago outside of Dunedin were invited to participate in the BEATS Rural Study, and 11 of 15 schools agreed. Participating schools were located in different settlements within the four districts (Figure 1). Settlements were classified into one of five types using Statistics New Zealand definitions: major urban (> 100,000 population), large urban (30,000–99,999 population), medium urban (10,000–29,999 population), small urban (1000–9999 population), and rural areas (< 1000 population) [27]. Ethics approval was obtained from the University of Otago Human Ethics Committee (Reference: 17/178).

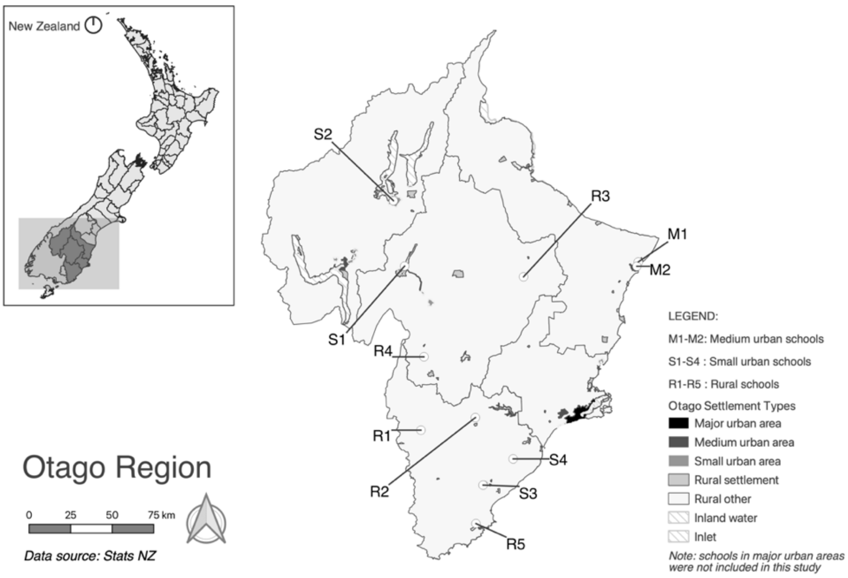

Figure 1. The Otago region, New Zealand, with the classification of settlement types and the locations of the 11 participating schools in the BEATS Rural Study (Source: Statistics New Zealand).

The BEATS Study research methodology is described in detail elsewhere [26,28]. In brief, adolescents (aged 13–18 years who attended participating schools) were recruited through their schools. They received study information and consent forms 2–3 weeks prior to data collection, and those who accepted the invitation to participate provided written consent. Parental consent was not required. A total of 1014 adolescents consented to participate, of which 660 were included in this analysis (Figure 2). The main reasons for exclusion were missing student consent, an invalid survey, did not participate in the survey component, boarding at school or privately, an invalid home address, missing dietary habits data, missing height or weight measurements, classified as being underweight, missing neighbourhood deprivation data, and invalid school transport modes data.

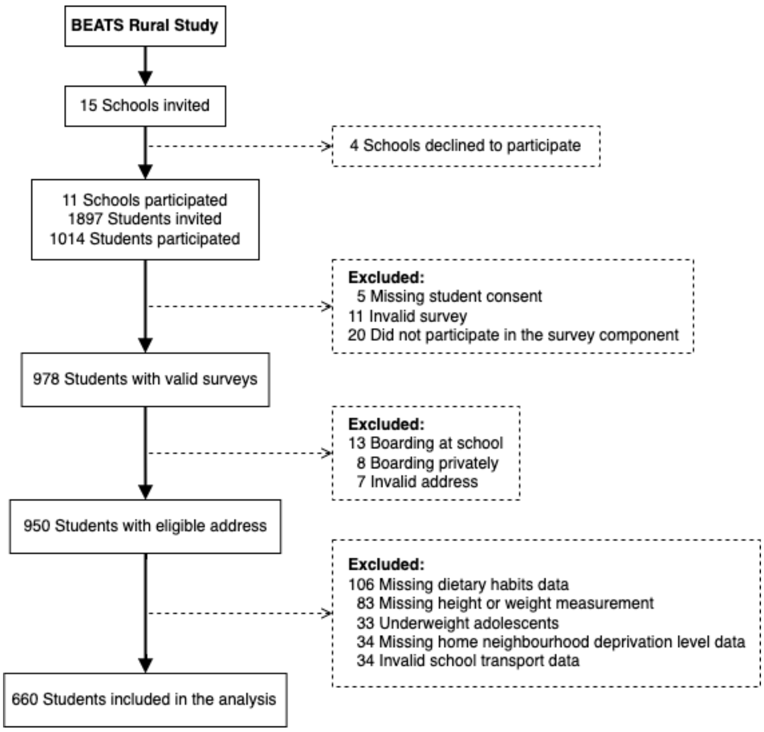

Figure 2. Flow chart of study participants count and sample selection.

2.2. Measures

2.2.1. Student Survey

Adolescents completed a 30–40 min online questionnaire during a school period supervised by research staff. The survey included items related to sociodemographic characteristics, including age, gender, and ethnicity, mode(s) of transport to and from school, and unhealthy snacking behaviours. Adolescents' home addresses were obtained to calculate home neighbourhood deprivation using the New Zealand Index of Deprivation (NZDep) [29]. NZDep was expressed in deciles, then grouped into tertiles for this study: deciles 1 to 3 (low), deciles 4 to 6 (mid), and deciles 7 to 10 (high).

School transport mode information was obtained for travel to and from school using questions *"How do you usually travel TO school?"* and *"How do you usually travel FROM school?"*, respectively. Participants were asked to indicate the frequency of use of each of nine transport mode options (*"on foot"*, *"by bike"*, *"by car (driven by others)"*, *"by car (driving myself)"*, *"by school bus"*, *"by public transport"*, *"by bus and on foot"*, *"by car and on foot"*, and *"other modes or combinations"*) using five response categories (*"never"*, *"rarely"*, *"sometimes"*, *"most of the time"*, and *"all of the time"*), as described previously [30]. Based on their dominant transport mode (i.e., used *"most of the time"* or *"all of the time"*), adolescents were categorised into one of three transport groups: active transport only (*"on foot"* and/or *"by bike"*), motorised transport only (*"by car (driven by others)"*, *"by car (driving myself)"*, *"by school bus"*, and/or *"by public transport"*), and mixed transport modes (*"by bus and on foot"*, *"by car and on foot"*, and *"other modes or combinations"*) when both active and motorised transport mode combinations were used [30].

Adolescents were asked about the frequency of purchasing and consuming unhealthy snack food (e.g., sweets, chips, or ice creams) and beverages (e.g., soft drinks, energy drinks, or fruit juice) on their journey to and from school, separately. From here on, the descriptor soft drinks also includes energy drinks and fruit juices. Snacking frequency was obtained using questions beginning with *"How often do you usually…?"* with six response categories ranging from zero to five times per week for each survey item.

2.2.2. Anthropometric Measurements

Anthropometric measurements were undertaken by trained research assistants at the time of the survey in a screened off area of the classroom. Adolescents wore their school uniforms but removed their shoes and school blazer or jacket prior to taking the measurements. Height was measured in centimetres with a portable SECA stadiometer (SECA 213, SECA Corp). Weight was measured in kilograms using an electronic scale (A&D Scale UC321, A&D Medical). Height and weight were measured twice, and the average calculated as described in detail elsewhere [31]. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared ($kg \cdot m^{-2}$), then categorised as underweight, healthy weight, and overweight/obese using international age- and gender-specific cut-points [32]. Adolescents categorised as underweight were excluded from this analysis.

2.3. Statistical Analysis

Demographic data were analysed using descriptive statistics. Continuous data were reported as mean ± standard deviation (SD). Categorical data were reported as frequency (%). Categorical variables were compared using the χ^2 test. The difference between adolescents' unhealthy snack food and/or soft drink purchases/consumption during the journey to or from school was assessed using a Wilcoxon sign-rank test. Binary logistic regression models were used to estimate the odds of purchase/consumption of unhealthy snack food and soft drinks combined on the journey TO or FROM school separately. Unadjusted models were fitted for the independent variables of school travel modes, neighbourhood deprivation, and BMI separately. Adjusted models incorporated all independent variables and included potential confounders age, gender, and school location settlement type. A p-value <0.05 was considered statistically significant. Data were analysed using SPSS software (version 27.0).

3. Results

Of the 660 adolescents (aged 15.3 ± 1.3 years) included in the analysis, 48.3% were males, 74.8% were New Zealand Europeans, 76.5% had a healthy weight, 67.3% went to schools in small urban areas, and 46.5% lived in the least socioeconomically deprived neighbourhoods (Table 1). Approximately one-third used active transport (mostly walking) to (28.8%) and from (30.9%) school.

Table 1. Sociodemographic characteristics of study participants.

Variables	Overall (n = 660)
Age (years)	15.3 ± 1.3
Gender	
Boys	319 (48.3%)
Girls	341 (51.7%)
Ethnicity (n = 659)	
New Zealand European	493 (74.8%)
Māori	84 (12.7%)
Pacific Islands	25 (3.8%)
Asian	14 (2.1%)
Other	43 (6.5%)
Body mass index category	
Healthy weight	505 (76.5%)
Overweight	113 (17.1%)
Obese	42 (6.4%)
Home neighbourhood deprivation level	
Low	307 (46.5%)
Mid	245 (37.1%)
High	108 (16.4%)
School settlement type	
Medium urban area	80 (12.1%)
Small urban area	444 (67.3%)
Rural settlement	136 (20.6%)
Transport modes TO school	
Active transport only	190 (28.8%)
Motorised transport only	336 (50.9%)
Mixed transport modes	134 (20.3%)
Transport modes FROM school	
Active transport only	204 (30.9%)
Motorised transport only	342 (51.8%)
Mixed transport modes	114 (17.3%)

Overall, 36.7% of adolescents purchased/consumed unhealthy snack foods and 25.9% purchased/consumed soft drinks at least once during their weekly school trips. The proportion of adolescents who purchased and consumed unhealthy snack food or soft drinks on the school journey by frequency and trip mode is shown in Table 2. Overall, a higher proportion of adolescents snacked on the way from school (unhealthy snack food: 32.3%; soft drinks: 23.9%) than to school (unhealthy snack food: 17.1%; soft drinks: 12.4%).

Unhealthy snack food or soft drinks were purchased and consumed significantly more often during the journey from school (mean rank = 112.8) than to school (mean rank = 106.1), Z = –6.3, $p < 0.001$, and unhealthy snack food was more frequently purchased and consumed (mean rank = 93.8) than soft drinks (mean rank = 81.3) (Z = –6.4, $p < 0.001$).

Overall, during the journey to school, a significantly higher proportion of adolescents who used ATS purchased and consumed unhealthy snack food and soft drinks (unhealthy snack food: 23.2%; soft drinks: 17.4%) compared with motorised (unhealthy snack food: 13.4%; soft drinks: 8.3%) and mixed transport (unhealthy snack food: 17.9%; soft drinks: 11.7%) users. In contrast, during the journey from school a higher proportion of those who used mixed transport snacked (unhealthy snack food: 42.1%; soft drinks: 35.1%) compared with active (unhealthy snack food: 27.5%; soft drinks: 22.5%) or motorised (unhealthy snack food: 31.9%; soft drinks: 21.1%) transport users (all $p < 0.05$). Overall, a higher proportion of adolescents who used ATS purchased and consumed unhealthy snack food or soft drinks frequently (3–5 days/week) compared with motorised or mixed transport users (Table 2). When compared specifically within the same gender, a significantly higher proportion of boys who used mixed transport compared to those who used ATS or motorised transport purchased and consumed soft drinks 1–2 days per week on the way to (mixed / ATS / motorised: 17.5% / 16.7% / 10.6%; p = 0.010) and from school (mixed / ATS / motorised: 41.5% / 26.4% / 25.0%; p = 0.035) (Table 2). There were no statistically significant differences observed for girls (Table 2).

Table 2. The proportion of adolescents who purchased and consumed unhealthy snack food or soft drinks by different transport modes TO and FROM school.

	School Transport Modes				
	Total Sample	**Motorised Transport**	**Active Transport**	**Mixed Transport**	***p-value****
On the Way TO School					
Frequency of Purchasing and Consuming Unhealthy Snack Food (days/week)					
Total Sample:	(n = 660)	(n = 336)	(n = 190)	(n = 134)	
Never	547 (82.9%)	291 (86.6%)	146 (76.8%)	110 (82.1%)	
1 to 2 days	78 (11.8%)	32 (9.5%)	27 (14.2%)	19 (14.2%)	**0.025**
3 to 5 days	35 (5.3%)	13 (3.9%)	17 (8.9%)	5 (3.7%)	
Boys:	(n = 319)	(n = 160)	(n = 102)	(n = 57)	
Never	247 (77.4%)	134 (83.8%)	71 (69.6%)	42 (73.7%)	
1 to 2 days	48 (15.0%)	17 (10.6%)	20 (19.6%)	11 (19.3%)	0.087
3 to 5 days	24 (7.5%)	9 (5.6%)	11 (10.8%)	4 (7.0%)	
Girls:	(n = 341)	(n = 176)	(n = 88)	(n = 77)	
Never	300 (88.0%)	157 (89.2%)	75 (85.2%)	68 (88.3%)	
1 to 2 days	30 (8.8%)	15 (8.5%)	7 (8.0%)	8 (10.4%)	0.256
3 to 5 days	11 (3.2%)	4 (2.3%)	6 (6.8%)	1 (1.3%)	
Frequency of Purchasing and Consuming Soft Drinks (days/week)					
Total Sample:	(n = 660)	(n = 336)	(n = 190)	(n = 134)	
Never	578 (87.6%)	308 (91.7%)	157 (82.6%)	113 (84.3%)	
1 to 2 days	61 (9.2%)	24 (7.1%)	21 (11.1%)	16 (11.9%)	**0.005**
3 to 5 days	21 (3.2%)	4 (1.2%)	12 (6.3%)	5 (3.7%)	
Boys:	(n = 319)	(n = 160)	(n = 102)	(n = 57)	
Never	259 (81.2%)	141 (88.1%)	76 (74.5%)	42 (73.7%)	
1 to 2 days	44 (13.8%)	17 (10.6%)	17 (16.7%)	10 (17.5%)	**0.010**
3 to 5 days	16 (5.0%)	2 (1.3%)	9 (8.8%)	5 (8.8%)	
Girls:	(n = 341)	(n = 176)	(n = 88)	(n = 77)	
Never	319 (93.5%)	167 (94.9%)	81 (92.0%)	71 (92.2%)	
1 to 2 days	17 (5.0%)	7 (4.0%)	4 (4.5%)	6 (7.8%)	0.267
3 to 5 days	5 (1.5%)	2 (1.1%)	3 (3.4%)	0 (0.0%)	
On the Way FROM School					
Frequency of Purchasing and Consuming Unhealthy Snack Food (days/week)					
Total Sample:	(n = 660)	(n = 342)	(n = 204)	(n = 114)	
Never	447 (67.7%)	233 (68.1%)	148 (72.5%)	66 (57.9%)	
1 to 2 days	182 (27.6%)	96 (28.1%)	48 (23.5%)	38 (33.3%)	**0.044**

		School Transport Modes			
	Total Sample	Motorised Transport	Active Transport	Mixed Transport	*p-value**
3 to 5 days	31 (4.7%)	13 (3.8%)	8 (3.9%)	10 (8.8%)	
Boys:	(n = 319)	(n = 160)	(n = 106)	(n = 53)	
Never	198 (62.1%)	104 (65.0%)	68 (64.2%)	26 (49.1%)	
1 to 2 days	102 (32.0%)	49 (30.6%)	31 (29.2%)	22 (41.5%)	0.248
3 to 5 days	19 (6.0%)	7 (4.4%)	7 (6.6%)	5 (9.4%)	
Girls:	(n = 341)	(n = 182)	(n = 98)	(n = 61)	
Never	249 (73.0%)	129 (70.9%)	80 (81.6%)	40 (65.6%)	
1 to 2 days	80 (23.5%)	47 (25.8%)	17 (17.3%)	16 (26.2%)	0.053
3 to 5 days	12 (3.5%)	6 (3.3%)	1 (1.0%)	5 (8.2%)	
Frequency of Purchasing and Consuming Soft Drinks (days/week)					
Total Sample:	(n = 660)	(n = 342)	(n = 204)	(n = 114)	
Never	502 (76.1%)	270 (78.9%)	158 (77.5%)	74 (64.9%)	
1 to 2 days	135 (20.5%)	64 (18.7%)	35 (17.2%)	36 (31.6%)	**0.007**
3 to 5 days	23 (3.5%)	8 (2.3%)	11 (5.4%)	4 (3.5%)	
Boys:	(n = 319)	(n = 160)	(n = 106)	(n = 53)	
Never	211 (66.1%)	115 (71.9%)	69 (65.1%)	27 (50.9%)	
1 to 2 days	90 (28.2%)	40 (25.0%)	28 (26.4%)	22 (41.5%)	**0.035**
3 to 5 days	18 (5.6%)	5 (3.1%)	9 (8.5%)	4 (7.5%)	
Girls:	(n = 341)	(n = 182)	(n = 98)	(n = 61)	
Never	291 (85.3%)	155 (85.2%)	89 (90.8%)	47 (77.0%)	
1 to 2 days	45 (13.2%)	24 (13.2%)	7 (7.1%)	14 (23.0%)	0.058
3 to 5 days	5 (1.5%)	3 (1.6%)	2 (2.0%)	0 (0.0%)	

p-values* are for a χ^2 test of independence between rows and columns of each 12-celled sub-table. Statistically significant results are marked with **bold** font.

The proportions of adolescents who purchased and consumed unhealthy snack food or soft drinks by neighbourhood deprivation and body weight are shown in Table 3. Unhealthy snack food or soft drinks were purchased and consumed during adolescents' school journeys by a significantly higher proportion of those living in high-deprivation neighbourhoods compared with those living in mid-deprivation and low-deprivation neighbourhoods. Among boys, those who lived in high-deprivation neighbourhoods compared with those living in mid-deprivation and low-deprivation neighbourhoods had a higher proportion of purchasing and consuming unhealthy snack food and soft drinks on the way to school, but not from school. Among girls, a significantly higher proportion of those who lived in high-deprivation neighbourhoods compared with those living in mid-deprivation and low-deprivation neighbourhoods purchased and consumed soft drinks, but not unhealthy snack food, on the way to and from school. While higher proportions of adolescents with overweight/obesity reported purchasing and consuming unhealthy snack food or soft drinks on the school journey than those with a healthy weight, this finding was only statistically significant for the purchase and consumption of soft drinks on the journey to school. A higher proportion of girls with overweight/obesity purchased and consumed unhealthy snack food and soft drinks on the way to school than those with a healthy weight (Table 3).

Table 3. The proportion of adolescents who purchased and consumed unhealthy snack food or soft drinks by level of neighbourhood deprivation and body weight.

	Neighbourhood Deprivation Level				Body Mass Index Category		
	Low	Mid	High	*p-value**	Healthy weight	Overweight/ Obese	*p-value**
On the Way TO School							
Frequency of Purchasing/ Consuming Unhealthy Snack Food (days/week)							
Total Sample:	(n = 307)	(n = 245)	(n = 108)		(n = 505)	(n = 155)	
Never	267 (87.0%)	201 (82.0%)	79 (73.1%)		424 (84.0%)	123 (79.4%)	
1 to 2 days	31 (10.1%)	31 (12.7%)	16 (14.8%)	**0.003**	57 (11.3%)	21 (13.5%)	0.360

	Neighbourhood Deprivation Level				Body Mass Index Category		
	Low	**Mid**	**High**	*p-value**	**Healthy weight**	**Overweight/ Obese**	*p-value**
3 to 5 days	9 (2.9%)	13 (5.3%)	13 (12.0%)		24 (4.8%)	11 (7.1%)	
Boys:	(n = 152)	(n = 119)	(n = 48)		(n = 249)	(n = 70)	
Never	126 (82.9%)	94 (79.0%)	27 (56.3%)		193 (77.5%)	54 (77.1%)	
1 to 2 days	20 (13.2%)	17 (14.3%)	11 (22.9%)	**<0.001**	40 (16.1%)	8 (11.4%)	0.273
3 to 5 days	6 (3.9%)	8 (6.7%)	10 (20.8%)		16 (6.4%)	8 (11.4%)	
Girls:	(n = 155)	(n = 126)	(n = 60)		(n = 256)	(n = 85)	
Never	141 (91.0%)	107 (84.9%)	52 (86.7%)		231 (90.2%)	69 (81.2%)	
1 to 2 days	11 (7.1%)	14 (11.1%)	5 (8.3%)	0.526	17 (6.6%)	13 (15.3%)	**0.048**
3 to 5 days	3 (1.9%)	5 (4.0%)	3 (5.0%)		8 (3.1%)	3 (3.5%)	
Frequency of Purchasing/ Consuming Soft Drinks (days/week)							
Total Sample:	(n = 307)	(n = 245)	(n = 108)		(n = 505)	(n = 155)	
Never	287 (93.5%)	209 (85.3%)	82 (75.9%)		452 (89.5%)	126 (81.3%)	
1 to 2 days	16 (5.2%)	27 (11.0%)	18 (16.7%)	**<0.001**	38 (7.5%)	23 (14.8%)	**0.018**
3 to 5 days	4 (1.3%)	9 (3.7%)	8 (7.4%)		15 (3.0%)	6 (3.9%)	
Boys:	(n = 152)	(n = 119)	(n = 48)		(n = 249)	(n = 70)	
Never	134 (88.2%)	93 (78.2%)	32 (66.7%)		205 (82.3%)	54 (77.1%)	
1 to 2 days	14 (9.2%)	19 (16.0%)	11 (22.9%)	**0.013**	31 (12.4%)	13 (18.6%)	0.415
3 to 5 days	4 (2.6%)	7 (5.9%)	5 (10.4%)		13 (5.2%)	3 (4.3%)	
Girls:	(n = 155)	(n = 126)	(n = 60)		(n = 256)	(n = 85)	
Never	153 (98.7%)	116 (92.1%)	50 (83.3%)		247 (96.5%)	72 (84.7%)	
1 to 2 days	2 (1.3%)	8 (6.3%)	7 (11.7%)	**<0.001**	7 (2.7%)	10 (11.8%)	**<0.001**
3 to 5 days	0 (0.0%)	2 (1.6%)	3 (5.0%)		2 (0.8%)	3 (3.5%)	
On the Way FROM School							
Frequency of Purchasing/ Consuming Unhealthy Snack Food (days/week)							
Total Sample:	(n = 307)	(n = 245)	(n = 108)		(n = 505)	(n = 155)	
Never	215 (70.0%)	163 (66.5%)	69 (63.9%)		347 (68.7%)	100 (64.5%)	
1 to 2 days	78 (25.4%)	74 (30.2%)	30 (27.8%)	0.216	137 (27.1%)	45 (29.0%)	0.408
3 to 5 days	14 (4.6%)	8 (3.3%)	9 (8.3%)		21 (4.2%)	10 (6.5%)	
Boys:	(n = 152)	(n = 119)	(n = 48)		(n = 249)	(n = 70)	
Never	98 (64.5%)	74 (62.2%)	26 (54.2%)		153 (61.4%)	45 (64.3%)	
1 to 2 days	44 (28.9%)	41 (34.5%)	17 (35.4%)	0.341	83 (33.3%)	19 (27.1%)	0.416
3 to 5 days	10 (6.6%)	4 (3.4%)	5 (10.4%)		13 (5.2%)	6 (8.6%)	
Girls:	(n = 155)	(n = 126)	(n = 60)		(n = 256)	(n = 85)	
Never	117 (75.5%)	89 (70.6%)	43 (71.7%)		194 (75.8%)	55 (64.7%)	
1 to 2 days	34 (21.9%)	33 (26.2%)	13 (21.7%)	0.558	54 (21.1%)	26 (30.6%)	0.137
3 to 5 days	4 (2.6%)	4 (3.2%)	4 (6.7%)		8 (3.1%)	4 (4.7%)	
Frequency of Purchasing/ Consuming Soft Drinks (days/week)							
Total Sample:	(n = 307)	(n = 245)	(n = 108)		(n = 505)	(n = 155)	
Never	248 (80.8%)	185 (75.5%)	69 (63.9%)		390 (77.2%)	112 (72.3%)	
1 to 2 days	52 (16.9%)	53 (21.6%)	30 (27.8%)	**0.002**	100 (19.8%)	35 (22.6%)	0.291
3 to 5 days	7 (2.3%)	7 (2.9%)	9 (8.3%)		15 (3.0%)	8 (5.2%)	
Boys:	(n = 152)	(n = 119)	(n = 48)		(n = 249)	(n = 70)	
Never	107 (70.4%)	77 (64.7%)	27 (56.3%)		167 (67.1%)	44 (62.9%)	
1 to 2 days	39 (25.7%)	36 (30.3%)	15 (31.3%)	0.153	69 (27.7%)	21 (30.0%)	0.739
3 to 5 days	6 (3.9%)	6 (5.0%)	6 (12.5%)		13 (5.2%)	5 (7.1%)	
Girls:	(n = 155)	(n = 126)	(n = 60)		(n = 256)	(n = 85)	
Never	141 (91.0%)	108 (85.7%)	42 (70.0%)		223 (87.1%)	68 (80.0%)	
1 to 2 days	13 (8.4%)	17 (13.5%)	15 (25.0%)	**0.002**	31 (12.1%)	14 (16.5%)	0.101
3 to 5 days	1 (0.6%)	1 (0.8%)	3 (5.0%)		2 (0.8%)	3 (3.5%)	

p-values* are for a χ^2 test of independence between rows and columns of each 9-celled and 6-celled sub-table. Statistically significant results are marked with **bold** font.

The results from the unadjusted and adjusted logistic regression models showed similar effects for the odds of adolescents' purchase and consumption of unhealthy snack food or soft drinks by school transport modes (Table 4). In the unadjusted model, ATS users had 91% higher odds of purchasing and consuming unhealthy snack food or soft drinks on the way to school compared to motorised transport users, but no significant difference in the adjusted model. Mixed transport users had higher odds of purchasing and consuming unhealthy snack food and soft drinks on the way from school than motorised transport users with slightly attenuated effect in the adjusted models (odds ratio (OR) 1.65, 95% confidence interval (CI) 1.06 – 2.57). Adolescents who lived in high-deprivation compared to low-deprivation neighbourhoods had higher odds of purchasing and consuming unhealthy snack food or soft drinks during the school journey, with a slightly strengthened effect after adjustment for confounders (to school: OR 2.85, 95% CI 1.62 – 4.98; from school: OR 1.87, 95% CI 1.15 – 3.05). The interaction term analysis between school transport modes and neighbourhood deprivation did not show a statistically significant association with adolescents' purchase and consumption of snack food and soft drinks during the school journey (to school: p = 0.162; from school: p = 0.677). The odds of adolescents purchasing and consuming unhealthy snack food and soft drinks during the school journey did not differ between those with a healthy or unhealthy (overweight/obese) weight.

Table 4. Associations between adolescents' purchase and consumption of unhealthy snack food and soft drinks by school travel mode, neighbourhood deprivation score, and body weight.

	Unadjusted Model						**Adjusted Model[1]**					
	Buy and Consume Unhealthy Snack Food or Soft Drinks on the Way TO School			**Buy and Consume Unhealthy Snack Food or Soft Drinks on the way FROM School**			**Buy and Consume Unhealthy Snack Food or Soft Drinks on the Way TO School**			**Buy and Consume Unhealthy Snack Food or Soft Drinks on the Say FROM School**		
	OR	**95% CI**	***p-value***	**OR**	**95% CI**	***p-value***	**OR**	**95% CI**	***p-value***	**OR**	**95% CI**	***p-value***
School Transport Mode												
Motorised Transport Only (Ref)												
Active Transport Only	**1.91**	**1.23 – 2.95**	**0.004**	0.82	0.57 – 1.19	0.305	1.42	0.88 – 2.29	0.154	0.68	0.46 – 1.03	0.068
Mixed Transport Modes	1.35	0.81 – 2.25	0.256	**1.74**	**1.13 – 2.67**	**0.011**	1.27	0.74 – 2.16	0.384	**1.65**	**1.06 – 2.57**	**0.027**
Neighbourhood Deprivation												
Low (Ref)												
Mid	**1.70**	**1.09 – 2.64**	**0.020**	1.21	0.85 – 1.72	0.290	**1.65**	**1.02 – 2.66**	**0.041**	1.40	0.96 – 2.06	0.081
High	**2.82**	**1.68 – 4.74**	**<0.001**	**1.61**	**1.03 – 2.52**	**0.038**	**2.85**	**1.62 – 4.98**	**<0.001**	**1.87**	**1.15 – 3.05**	**0.012**
Body Mass Index Category												
Healthy Weight (Ref)												
Overweight/Obese	1.46	0.95 – 2.24	0.086	1.25	0.86 – 1.80	0.240	1.51	0.96 – 2.37	0.072	1.24	0.85 – 1.82	0.271

[1]Adjusted for age, school settlement types, and gender. OR: odds ratio. CI: confidence interval. Statistically significant results are marked with **bold** font.

4. Discussion

This study examined whether the purchase and consumption of unhealthy snack food or soft drinks during the journey to or from school was associated with school transport modes, neighbourhood deprivation, and body weight among adolescents attending schools in medium and small urban areas and rural settlements in Otago, New Zealand. The key findings were: (1) the odds of adolescents purchasing and consuming unhealthy snack food or soft drinks was significantly higher among ATS users (mostly walking) on the way to school and among mixed transport users on the way from school compared to motorised transport users, (2) adolescents reported purchasing and consuming unhealthy snack food or soft drinks more frequently on the way from school than to school, (3) adolescents who lived in high-deprivation neighbourhoods had a higher odds of purchasing and consuming unhealthy snack food and/or soft drinks during the school journey than those from mid-deprivation and low-deprivation neighbourhoods, and (4) there was a significant difference between the proportion of adolescents with a healthy weight and those with overweight/obese body weight in the purchase and consumption of soft drinks on the way to school, but not on the way from school.

Adolescents who use ATS (mostly walking) or mixed transport modes to/from school and purchase and consume unhealthy snack food and soft drinks during the school journey may potentially compromise the health benefit of ATS [1]. Although using ATS or mixed transport modes to/from school facilitates regular health-promoting physical activity for adolescents [1], in this study higher proportions of adolescents using these transport modes purchased and consumed unhealthy snack food or soft drinks en route to/from school compared to motorised transport users. These results may be partly explained by time constraints before school, particularly when using ATS, and the convenient availability of food en route to school and around the school neighbourhood [33]. The difference in the proportions of adolescents who purchased and consumed soft drinks by school transport modes was found to be statistically significant among boys, but not girls. This finding is consistent with previous studies which have reported that, although boys were likely to have higher physical activity levels, the quality of their diet was lower [34], particularly in relation to sugar-sweetened beverage consumption [18].

This study focused on unhealthy energy-dense snack foods that are often readily accessible, available, and affordable in food outlets in the school neighbourhood [17]. The results showed a greater proportion of adolescents purchased and consumed unhealthy snack food and/or soft drinks on the way from school than to school. Possible explanations for this observation are that adolescents may feel hungrier after school than before school and it is likely that they have more time after school to visit food outlets [17]. Time and places spent socialising with friends after school can also be a facilitator for unhealthy snacking [17]. Although unhealthy snacking during the school journey may appear to be a small portion of overall daily dietary intake, consuming energy-dense snacks like sweets and soft drinks can contribute up to one-third of an adolescent's daily energy intake and energy surplus [20,22], and is associated with the likelihood of skipping healthy regular meals [35].

It is important to consider adolescents' environmental exposures and psychological sensitivity to the food environment around the school neighbourhood [6]. Although the unhealthy food environment and advertising in rural areas in New Zealand may not be as pervasive as in urban areas [14,15], it is highly likely that there is at least one food outlet close to schools in rural areas [15]. Adolescents have previously reported that the proximity and convenience of food outlets to their school may facilitate the purchase and consumption of food [17], which may be affordable but not always healthy [8]. While this study did not collect environmental data on the school journey, it is possible that higher odds of unhealthy snack food and soft drink purchase and consumption among adolescents using ATS and mixed transport compared to motorised transport users were influenced by the environment they travelled through during the school journey.

In this study, adolescents who lived in high-deprivation versus low-deprivation neighbourhoods had significantly higher odds of purchasing and consuming unhealthy snack food or soft drinks during their school journey. This observation is consistent with previous studies that have shown a positive association between neighbourhood deprivation and adolescents' unhealthy snack food and/or soft drink purchases and consumption [23,36]. Schools located in low socioeconomic areas have a higher prevalence of unhealthy food outlets [14,15], which is likely to encourage unhealthy snacking and soft drink consumption [17]. Unhealthy snacking among adolescents in the present study could also be attributed to other individual level socioeconomic factors such as access to pocket money or disposable income [37], and/or dietary preferences [38].

A significant difference between adolescents with a healthy weight and overweight/obesity was only found in the purchase and consumption of soft drinks on the way to school, but not on the way from school. This finding is not unexpected since earlier studies have observed a similarly inconsistent association between adolescents' snacking behaviour and body weight [20,23]. However, this finding is consistent with studies that have specifically investigated soft drink consumption in adolescents [39,40]. A possible explanation for the insignificant association between unhealthy snack food and obesity is the tendency to under-report dietary intake among individuals with obesity [41]. In addition, the participants with missing height or weight measurements who were excluded from the data analysis may have included a relatively high proportion of adolescents with overweight/obesity. Moreover, the exclusion of adolescents with underweight from the analysis was intended to be aligned with our study focus of examining increased risk of obesity-related behaviours during the adolescents' school journey.

4.1. Implications

The present study contributes to the literature on adolescents' school travel behaviour and obesity prevention by examining adolescents' school transport modes and their purchase and consumption of unhealthy snack food and/or soft drinks on the journey to and from school and provides an understanding of context-specific health behaviours of adolescents during their school journey. As health-related studies with adolescents from rural areas are less common [42], this study provides insights into adolescents' school travel and unhealthy snacking behaviour in rural and small to medium urban settlement types, which may be different from large urban areas and major urban centres. Adolescents' school travel represents a small proportion of time during the day, but the transport mode is important for greenhouse gas emission impact [43], physical activity levels [1], and development of travel habits later in life [44]. The results of this study highlight the need to consider not only travel mode shift to increase regular PA, but also the need for careful examination of the home to school neighbourhood environment [45] in obesity prevention strategies to minimise unintended consequences such as unhealthy snacking, particularly in lower socioeconomic areas. Initiatives such as healthy nutrition education at school along with improvements in the school food environment [46] will also help to promote healthy dietary behaviours in adolescents.

4.2. Study Strengths and Limitations

The strengths of this study include the participation of adolescents attending schools located across a relatively large geographical area, a high school participation rate (73%), a large sample size, measured body height and weight, and the assessment of unhealthy snack food and soft drinks purchases and consumption during journeys both to and from school. This study is further strengthened by the examination of unhealthy snack food and soft drinks separately. Study limitations include the lack of built and food environment data for each adolescents' school journey, the use of self-reported unhealthy snacking habits, and small numbers of high-deprivation neighbourhoods in rural and small to medium urban areas in this study. The lack of built and food environment data prevented a description and discussions of any obesogenic environment exposures that may have influenced adolescents' unhealthy snacking behaviours. Self-reported survey data on dietary habits is prone to response bias; however, surveys are a common and convenient method to acquire data from a large sample. This study was unable to examine the consumption of snack food and soft drinks brought from home or provided by caregivers during the school journey as questions relating to this were not included in the survey. A small number of participants from high-deprivation neighbourhoods may explain why some observations were not statistically significant. Further, the findings from this study may not be generalisable to large and major urban areas in New Zealand or other countries. These data must be interpreted with caution because the density of food outlets around schools and along adolescents' school journey routes is likely to be greater in urban than rural areas and our findings may underestimate the situation or relationship between exposure to an obesogenic environment and unhealthy snacking for adolescents attending schools in cities.

5. Conclusions

This study provides insights for context-specific health behaviours of adolescents, particularly school travel behaviour and unhealthy snacking during the school journey. While active travel is beneficial for improving physical activity levels and reducing carbon emissions, it may facilitate opportunities for unhealthy snacking when travelling to and from school, particularly in high-deprivation neighbourhoods. Future initiatives for liveable cities development need to consider interventions within the window of adolescents' school journey that not only increase regular physical activity through active travel mode shift but also minimise the impact of the obesogenic environment exposures during the school journey and in the school neighbourhood.

Author Contributions: Conceptualization, M.L.S., K.J.C., and S.M.; Methodology, M.L.S., K.J.C., S.M., M.S., and M.K.; Investigation, M.L.S., K.J.C., S.M., M.S., and M.K.; Writing – Original Draft Preparation, M.L.S.; Writing – Review & Editing, M.L.S., K.J.C., S.M., M.S., and M.K.; Supervision, K.J.C., S.M., M.S., and M.K.; Project administration, S.M. All authors have read and agreed to the published version of the manuscript.

Funding: The first author (M.L.S) received a doctoral study scholarship funded by Health Research Council (grant number 19/173) and a Transport Research Scholarship 2022 funded by Te Manatū Waka – Ministry of Transport and Waka Kotahi – New Zealand Transport Agency. The data collection for the BEATS Rural Study was funded by University of Otago Research Grant (UORG 2018) and Otago Energy Research Centre Seed Grant 2018.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the University of Otago Human Ethics Committee (Reference: 17/178).

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data presented in this study are not publicly available due to data confidentiality and participants having been given assurances that the collected data will not be shared.

Acknowledgments: This research was part of the Built Environment and Active Transport to School: BEATS Research Programme. The BEATS Rural Study was a collaboration between the Dunedin Secondary Schools' Partnership, Otago Secondary Schools' Principals' Association, Dunedin City Council, New Zealand Transport Agency, and University of Otago. We would like to acknowledge our research team members: BEATS investigators, the members of the BEATS Study Advisory Board, research personnel (research assistants, students, and volunteers), and all participating schools and adolescents.

Conflicts of Interest: Sandra Mandic is the founder and the director of the research consultancy AGILE Research Ltd. (Wellington, New Zealand; www.agileresearch.nz) and Principal Advisor Transport Strategy at Wellington City Council (Wellington, New Zealand). Other authors declare no conflicts of interest.

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