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The socio-ecological determinants of change in school travel mode over the transition from childhood to adolescence and the association with physical activity intensity

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ABSTRACT

School active travel contributes to young people's physical activity levels, yet the prevalence is low, and declines with age. Based on determinants from the social-ecological model we investigated changes in school travel behaviour over the transition from childhood to adolescence in participants from the baseline and four-year follow-up of the SPEEDY cohort. Descriptive analysis examined how travel behaviours changed and were related to physical activity. Multinomial logistic regression investigated determinants. Some 38% of participants changed travel mode; 66% from active to passive. Passively traveling participants at follow-up showed a decrease in physical activity. Several social-ecological domains were associated with change. Findings suggest multi-component interventions are required to support active travel in youth.

1. Background

It is well established that physical activity is positively associated with young people's health (Landry and Driscol, 2012; Longmuir et al., 2014). Benefits include improved cardiorespiratory function (Baquet et al., 2004), muscle strength (Fritz et al., 2016), body composition (Lazaar et al., 2007), bone mass (Vicente-Rodríguez, 2006), mental health (Larun et al., 2006), academic performance (Trost, 2009), prevention of cardiovascular disease (Eisenmann et al., 2005) and lowered death rates in adulthood (Ruiz et al., 2009). Despite these benefits, 91% of boys and 98% of girls are not meeting UK recommendations of 60 minutes of moderate-to-vigorous physical activity per day (Cooper et al., 2015; National Institute for He, 2009).

Active travel, defined as traveling by walking, cycling, or other physically active means, can be an important contributor to young people's total daily activity (Cooper et al., 2005). Children who actively travel to school have higher overall daily activity levels and are more likely to meet the UK recommendations (Faulkner et al., 2009). Over the last 40 years, the percentage of UK children walking to school as their main method of transport has fallen by 22%, likely contributing to the overall decline in physical activity levels (Department for Transport., 2016; Department for Transport., 2015a). The school commute is therefore a potential target to increase young people's physical activity (Larouche et al., 2014; Cale and Harris, 2006).

Another important target is the transition from childhood to adolescence where physical activity levels decline by 7% annually (Dumith et al., 2011). Each year, an average of 10 minutes of daily activity is replaced by sedentary time (Corder et al., 2015). Furthermore, physical activity behaviours developed during childhood are often carried through to adult life (Telama et al., 2005; Corder et al., 2019). Public health interventions to improve whole population levels of physical activity should therefore target young people as exercise behaviours develop to ensure that physical activity levels do not decline and are carried on through adult life (World Health Organisation, 2010; Ding et al., 2016).

It is important that any factors influencing this decline in young people's physical activity levels are fully understood to inform interventions for the future health of the population. One model that is useful in describing the diversity of factors associated with health behaviours is the social-ecological model. This model, originally formulated in the early part of the 20th century, bridges the gap between behavioural theories that focus on small settings and population-wide

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theories and was originally formulated as a reaction to a perceived narrow scope of research in the field of developmental psychology. From a public health perspective, the model depicts how more proximal characteristics of the individual, immediate family, social networks, alongside more distal characteristics associated with the environments where people live, work, and study as well as how national policies and priorities influence health and related behaviours at an individual level (Gold and Earp, 2012). It is frequently used in health promotion campaigns (Wold and Mittelmark, 2018; Rothwell et al., 2010), and was adopted here as it provides a useful framework to understand the varied and multi-level drivers of changes in active travel behaviour.

Several previous studies have identified correlates of active travel in youth including distance travelled (Rothman et al., 2018; Panter et al., 2008, 2010a, 2013; Pont et al., 2009), socioeconomic status (Panter et al., 2008, 2013; Pont et al., 2009), parental perceptions (Panter et al., 2008, 2010a; Carlson et al., 2014) and social support (Panter et al., 2008, 2010a). However, evidence on the magnitude of change in active travel behaviour is limited, particularly over the transition from primary to secondary school. One of the only papers addressing this found that a change from walking to being driven to school was associated with a decline in total daily physical activity levels (Cooper et al., 2012). However, the determinants of this change were not considered which limits our ability to intervene and try and prevent the decline observed.

Few studies have investigated the determinants of a change in active travel in young people. One analysis, with 2-year follow-up, found that children with parents who had neighbourhood friends and adolescents with parents who perceived routes as safe were more likely to increase the number of times they actively travelled to school each week (Hume et al., 2009). Elsewhere, children attending both primary and secondary school with an environment supporting active travel were reportedly more likely to maintain active travel at 1-year follow-up (Coombes et al., 2014). Key limitations of this evidence include the short follow-up excluding school transition which is known to be a dynamic and key period of change in a young person's life (Dumith et al., 2011; Corder et al., 2015). Another limitation is the lack of environmental heterogeneity, with the current research being undertaken in either rural or urban locations without any studies that investigate both locations together. This limits the use of this evidence to the settings in which they were undertaken which may make it difficult to influence nationwide policies.

The Sport, Physical activity and Eating behaviour: Environmental Determinants in Young people (SPEEDY) study is a population-based, longitudinal cohort of children in Norfolk which recruited schools based on environmental hetrogeneity (Van Sluijs et al., 2008). A previous analysis of this data, over a 12-month period, found that shorter distances, parental convenience of driving, lower socioeconomic status and parental perceived road safety were associated with uptake of active travel at primary school (Panter et al., 2013). This paper extends this work by using the four-year follow-up data to 1) determine change in school travel behaviours over the transition from childhood to adolescence, 2) identify the degree to which any change is associated with change in total moderate-to-vigorous physical activity levels, and 3) investigate the determinants of change in travel mode.

2. Method

2.1. Study design & recruitment

Details on the method of data collection for the SPEEDY study are described elsewhere (Van Sluijs et al., 2008). In brief, the SPEEDY study was an observational study undertaken in Norfolk, England, set up to examine physical activity and dietary behaviour in a large population of British children and adolescents. The data has a one and four-year follow-up of initially 9–10-year-old children (undertaken between 2007 and 2011). At baseline, 96 primary schools were recruited using purposive sampling of urban-rural status, area deprivation and school enrolment size. From these schools, all children and their parents were invited to participate, with 57% of those approached taking part in the study. Data collection included researcher measured variables, child, parental and head-teacher questionnaires, accelerometer data and geographic information systems (GIS), explained in further detail in the following sections.

At four-year follow-up, all participants who had not actively withdrawn and had a valid postal address were re-contacted (N = 1964). The University of East Anglia Faculty of Health Ethics Committee gave ethical approval for the SPEEDY study and all participants gave assent in addition to written parental informed consent. In total, 2064 children took part at baseline and 490 (23.7%) at four-year follow-up, having moved to secondary school.

This analysis uses data from the baseline and four-year follow-up where children were aged 9–10 and 13–14 respectively. This is compatible with the World Health Organisation definitions of children (≤10 years) and adolescents (>10 years)(World Health Organisation, 2017).

2.2. Assessment of travel mode

Assessment of change in travel mode was the primary outcome of this study. At baseline and follow-up, children were asked 'How do you usually travel to school?' and self-reported usual travel mode as 'by foot', 'by bicycle', 'by bus/train' or 'by car'. Responses were collapsed into 'active' for walking and cycling or 'passive' for traveling by bus/train or car. To assess change, participants were grouped into those that 'remained passive' (passive at baseline and follow-up), 'remained active' (active at baseline and follow-up), 'became passive' (active at baseline and passive at follow-up), or 'became active' (passive at baseline and active at follow-up).

2.3. Physical activity measures

To examine how changes in reported travel behaviour were associated with the spectrum of physical activity intensity, secondary outcomes were changes in objectively measured movement during the total day (between 6am and 11pm) as well as during the commuting period (between 8 and 9am and 3 and 4pm) on weekdays. At both time points, physical activity levels were measured using ActiGraph Activity accelerometers (GT1M, ActiGraph LCC, Pensacola, US), set to record at 5 second intervals. Children wore these for one week during waking hours, excluding bathing or swimming. Variables measured were average counts per minute (CPM, a continuous measure of movement intensity recorded by the ActiGraph), minutes of sedentary time (SED), defined as <100 cpm, and minutes of moderate to vigorous intensity physical activity (MVPA), defined as ≥2000 cpm, equating to the amount of movement when a child walks at 4 kph (Trost et al., 2011). Periods of accelerometer none-wear were identified as those for which zero counts were measured for a continuous period of 60 minutes or more and these were removed from further analysis.

2.4. Explanatory variables

23 explanatory variables were selected from the SPEEDY data representing different levels of the social-ecological model based on theoretical frameworks or previous evidence of associations. They were divided into four categories: individual (Panter et al., 2008, 2010a, 2013; Davidson et al., 2008), school (Panter et al., 2008, 2010b; Coombes et al., 2014; Ward et al., 2015; Hinckson and Badlam, 2011), parental (Panter et al., 2008, 2010a, 2013; Pont et al., 2009; Carlson et al., 2014; Hume et al., 2009; Davidson et al., 2008; Wareham et al., 2003; Lorenc et al., 2008; Timperio et al., 2006), and route environment (Rothman et al., 2018; Panter et al., 2008, 2010a, 2013; Pont et al., 2009; Hume et al., 2009; Davidson et al., 2008; Timperio et al., 2006; Schlossberg et al., 2006; Harrison et al., 2014). S1 in the supplementary

material shows those variables included, and their method of assessment. Time invariant variables, for example sex, were measured at baseline only, whilst variant variables, such as distance travelled, were measured at both baseline and follow-up to assess how a change was associated with change in travel mode. These 11 variant variables ('baseline and follow-up' measurements in S1) were then coded with options of 'increased', 'no change', and 'decreased' to describe how they changed over the two time points. Only baseline measures of school characteristics were included due to missingness as some secondary schools did not complete follow-up questionnaires.

2.5. Data analysis

Descriptive statistical analyses were completed using SPSS V23. To determine how travel behaviours changed, the prevalence of each travel mode was calculated at baseline and four-year follow-up. To assess associations between change in travel mode and activity levels, the accelerometer data was grouped by participant travel mode at baseline and follow-up (e.g. active-active or active-passive) with differences tested using regression modelling with robust standard errors to adjust for clustering at school level. Multilevel multinomial regression models, also adjusted for clustering at school level, and with 'remained passive' as reference outcome category, were fitted with STATA IC V11 to examine the relationship between the categorical outcomes of switching from or to active and passive travel modes and the potential explanatory variables.

Unadjusted models were fitted to examine the relationship between the outcome and each individual variable. The analysis was then partially adjusted for other variables in that domain (e.g. child or school factors). Variables associated at $p < 0.1$ in these partially adjusted models were included in a maximally adjusted model, which was developed into a best fit model by dropping variables in order of statistical significance so that only those with $p < 0.05$ remained. Improvement in model fit was assessed using changes in Log likelihood with the chi-square test.

A multi-stage best fit modelling approach was used as this approach is useful when analysis is being undertaken using variables across different domains. This allowed models to be built up sequentially which was particularly important as there was no strong a-priori beliefs around which variables from which domains would show associations. The best fit models retained factor variables with multiple levels where inclusion of the overall measure led to a statistically significant improvement in model fit based on the reduction residual deviance rather than each category showing a statistically significant difference to the reference. As a result, some coefficients in the final model were not statistically significant. The coefficients created by the model were converted into relative risk ratios to aid their interpretation. Multicollinearity was partly addressed by the use of domain-specific initial models which ensured that similar measures from the same domain were not included in the final model and was supported by multicollinearity testing that ensured that the stepwise addition of a variable in the final model did not lead to a substantive change in the direction of effect or statistical significance of other variables contained therein.

The SPEEDY dataset had missing values for several variables. To limit the consequent loss of sample size, the mean was substituted for the missing value of 8 variables; parental PA (N = 20), parental BMI (34), parental perception of road safety (60), parental perception of child safety (61), parental perceived car convenience (63), parental availability to drive (59), NEWS-A score (46), distance travelled to school (89), green space on route (89) and crossing a busy road (89). The missingness mainly arose from poorly completed parental questionnaires with multiple missing variables from the same participants (16 at baseline and 41 at follow-up). Change in parental travel to work had 63 missing values and these were conservatively coded as 'unchanged'.

A sensitivity analysis was undertaken to assess the impact of this imputation process and to determine the impact of eliminating those missing from the model. This led to a loss of statistical power, but not to a substantial change in the interpretation of findings based on the subjective opinion of the research team. Tests of the characteristics of participants with missing data (not reported) did not suggest the presence of any bias associated with the exclusion of individuals with incomplete records.

3. Results

3.1. Sample characteristics

Of the 490 participants at the four-year follow-up, 474 (96.7%) provided complete travel mode data and so were included in the analysis. Those 474 included did not differ from the 16 not included at baseline in gender (55.3% vs 54.4% female, p = 0.765), mean age (9.75 ± 0.43 vs 9.76 ± 0.44 years, p = 0.312) or mean distance travelled to school (2.60 km ± 3.85 vs 2.60 km ± 3.76, p = 0.985). However, they had fewer siblings (3.01 ± 1.30 vs 2.76 ± 1.46, p = 0.001) and less educated parents (39.9% vs 45.0% of parents leaving education <16y, p < 0.001). Table 1 shows the demographic characteristics at both time points. Mean distance travelled to school increased by 130% (+3.38 km, 95% CI: 2.64–4.13, p < 0.001).

3.2. Change in travel mode

Fig. 1 shows school travel modes at baseline and four-year follow-up. Travel by bus/train increased, with decreases in all other travel modes. In total, 182 participants (38.4%) changed travel modes; 57 (12.0%) from traveling by car, 5 (1.1%) from traveling by bus/train, 28 (5.9%) from traveling by bicycle and 92 (19.4%) from traveling by foot. 170 (35.9%) children used passive travel at both time points, 122 (25.7%)

Table 1
Participant characteristics at baseline and four-year follow-up.

Variable	Baseline	Follow-up
Child		
Female % (n)	54.22 (257)	54.22 (257)
Mean Age (SD)	9.75 (±0.43)	14.32 (±0.29)
Mean BMI (SD)	18.02 (±3.05)	20.90 (±4.04)
0 siblings at home % (n)	–	15.58 (74)
Dog at home % (n)	34.43 (163)	42.74 (203)
Bicycle at home % (n)	96.00 (456)	92.21 (438)
Car at home % (n)	90.53 (430)	87.58 (416)
Mean distance travelled to school in km (SD)	2.61 (±3.85)	5.99 (±7.03)
Mean sedentary time 6am-11pm (SD)	484.30 (±53.33)	516.79 (±61.71)
Mean MVPA 6am-11pm (SD)	73.81 (±23.77)	65.50 (±26.25)
Mean CPM 6am-11pm (SD)	615.54 (±193.83)	478.38 (±182.75)
Mean sedentary time 8am–9am (SD)	31.41 (±5.79)	34.32 (±7.61)
Mean MVPA 8am–9am (SD)	7.47 (±4.34)	9.49 (±7.30)
Mean CPM 8am–9am (SD)	706.12 (±300.08)	748.11 (±4.79)
Mean sedentary time 3pm–4pm (SD)	31.74 (±5.77)	33.79 (±6.69)
Mean MVPA 3pm–4pm (SD)	8.73 (±4.56)	10.01 (±6.54)
Mean CPM 3pm–4pm (SD)	821.37 (±426.46)	812.74 (±457.90)
Parental		
Mean BMI (SD)	25.50 (±3.41)	–
Mean PA index (Wareham et al., 2003) (SD)	2.86 (±0.82)	–
Number actively traveling to work % (n)		
0	74.53 (354)	69.47 (330)
1	18.32 (87)	20.21 (96)
2	1.68 (8)	1.26 (6)
Income % (n)		
£10,000	–	7.4 (35)
£10–30,000	–	23.0 (109)
£30–50,000	–	25.1 (119)
>£50,000	–	17.7 (84)
Do not wish to share	–	26.8 (127)

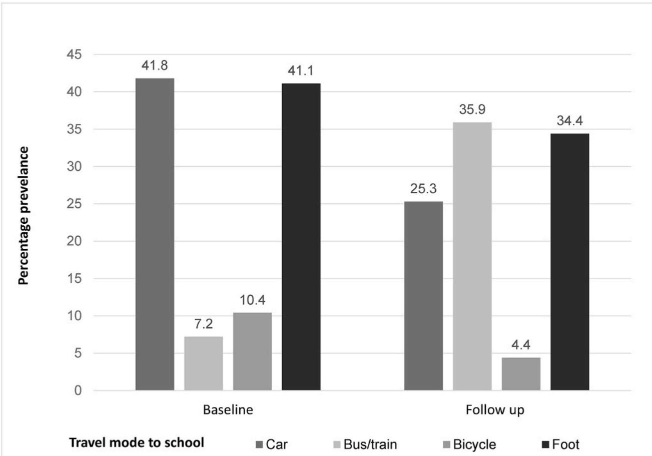

Fig. 1. Participant travel mode at baseline and four-year follow-up (%).

travelled in an active manner at both, 120 (25.3%) changed from an active to a passive manner and 62 (13.1%) changed from a passive to an active manner.

3.3. Change in active travel and change in intensity of activity levels

Table 2 shows objectively measured activity in relation to travel modes undertaken at each time point. During the morning commute, participants who remained passive for their travel and those that became passive showed statistically significant increases in sedentary time (4.63 min, 95% CI: 2.86–6.42, $p < 0.01$ and 6.55 min, 95% CI: 4.73–8.37 $p < 0.01$ respectively). Those who remained active and those that became active showed mean increases of 5.43 (95% CI: 2.69–8.17, $p < 0.01$) and 7.36 (95% CI: 4.78–9.95, $p < 0.01$) minutes of MVPA respectively during the morning commute. Similar changes were seen in the afternoon.

During the day (6am–11pm), all groups increased their sedentary time. Those who remained passive (−10.75 min, 95% CI: −16.61- −4.88, $p < 0.01$) or became passive (−17.74 min, 95% CI: −24.21- −11.27, $p < 0.01$) also saw a statistically significant decline in their total MVPA.

3.4. Correlates of change in active travel

Table 3 shows the fully adjusted multinomial logistic regression model. A diverse range of factors showed associations with change in active travel after adjustment. Changes in parental support appeared important. An increase in support for active travel by one unit (e.g. from no change to more supportive) was associated with participants being more likely to become active travellers with an increase by a factor of 5.08 (95% CI: 1.68–15.38, $p < 0.01$). The reverse was seen with a decline in support (e.g. from no change to less supportive) where the odds of becoming passive were increased by a factor of 5.64 (95% CI: 2.55–12.49, $p < 0.01$). Parental perceptions of road safety were associated with a range of changes in behaviour, although the direction of effects were sometimes counterintuitive. For example, an increase in parental perception of traffic led to a 3.40 (95% CI: 1.49–7.75, $p < 0.01$) increase in odds of becoming passive. However, a decrease in parental perception of cycle path safety led to an increase in the odds of remaining active by 4.46 (95% CI: 1.71–11.63, $p < 0.01$). Although school support for active travel was associated with increased odds of participants actively traveling at both timepoints, it was also associated with a transition from active to passive travel. Variables from each of the four domains remained statistically significant in the final model.

Table 2
Objectively measured physical activity during the commuting period (8am–9am and 3pm–4pm) and total day (6am-11pm) in relation to change in travel mode at baseline and four-year follow-up. Values are average minutes per school day (+-SD). Bold = P value of <0.05.

	Baseline	4 year follow-up	Change (95% CI)	P value
8am–9am				
SED				
Remain active	30.69 (±5.69)	29.46 (±7.57)	−1.23 (−3.98, 1.53)	0.37
Remain passive	32.22 (±5.18)	36.85 (±6.27)	4.63 (2.86, 6.41)	**<0.01**
Became passive	30.81 (±6.36)	37.36 (±6.66)	6.55 (4.73, 8.37)	**<0.01**
Became active	32.50 (±4.97)	31.05 (±7.09)	−1.45 (−4.93, 2.04)	0.39
MVPA				
Remain active	9.86 (±4.73)	15.29 (±8.06)	5.43 (2.69, 8.17)	**<0.01**
Remain passive	5.68 (±2.63)	5.87 (±3.60)	0.19 (−0.55, 0.94)	0.60
Became passive	7.94 (±4.76)	6.56 (±5.50)	−1.36 (−2.79, 0.07)	0.06
Became active	6.20 (±3.46)	13.56 (±7.19)	7.36 (4.78, 9.95)	**<0.01**
CPM				
Remain active	832.76 (±294.79)	1134.03 (±549.61)	301.27 (116.52, 486.02)	**<0.01**
Remain passive	604.00 (±235.89)	516.22 (±238.57)	−87.78 (−141.83, −33.73)	**<0.01**
Became passive	745.80 (±321.90)	542.93 (±336.80)	−202.88 (−300.34, −105.39)	**<0.01**
Became active	615.16 (±255.81)	1000.79 (±429.31)	385.62 (198.10, 573.14)	**<0.01**
3pm-4pm				
SED				
Remain active	30.34 (±5.19)	30.34 (±6.04)	<0.01 (−1.61, 1.61)	0.99
Remain passive	33.03 (±5.58)	35.12 (±6.00)	2.08 (0.70, 3.46)	**<0.01**
Became passive	30.54 (±5.92)	36.45 (±6.64)	5.97 (3.79, 8.15)	**<0.01**
Became active	32.65 (±4.99)	31.03 (±5.59)	−1.92 (−4.24, 0.40)	0.10
MVPA				
Remain active	10.19 (±4.05)	14.64 (±6.36)	4.45 (2.38, 6.51)	**<0.01**
Remain passive	7.18 (±3.45)	7.04 (±4.64)	−0.15 (−1.48, 1.19)	0.83
Became passive	10.02 (±4.83)	7.82 (±5.55)	−2.20 (−3.69, −0.71)	**<0.01**
Became active	8.15 (±4.75)	13.12 (±6.65)	4.96 (2.35, 7.57)	**<0.01**
CPM				
Remain active	908.99 (±351.58)	1120.99 (±469.04)	212.01 (67.74, 356.27)	**<0.01**
Remain passive	717.97 (±355.85)	634.91 (±349.62)	−83.05 (−185.70, 19.59)	0.11
Became passive	944.41 (±573.75)	655.39 (±383.20)	−289.04 (−408.72, −169.31)	**<0.01**
Became active	781.25 (±415.18)	996.83 (±445.97)	215.58 (73.04, 358.12)	**<0.01**
6am-11pm				
SED				
Remain active	483.74 (±55.90)	509.80 (±56.62)	26.05 (10.77, 41.34)	**<0.01**
Remain passive	489.12 (±54.79)	520.16 (±55.15)	31.06 (20.41, 41.70)	**<0.01**
Became passive	478.93 (±49.93)	525.32 (±68.60)	46.39 (30.66, 62.11)	**<0.01**
Became active	491.11 (±50.09)	502.51 (±68.59)	11.40 (−10.33, 33.13)	0.28
MVPA				
Remain active	79.95 (±24.88)	80.26 (±29.11)	0.31 (−6.21, 6.83)	0.92

(*continued on next page*)

Table 2 (*continued*)

	Baseline	4 year follow-up	Change (95% CI)	P value
Remain passive	67.62 (±22.16)	56.87 (±21.12)	−10.75 (−16.61, −4.88)	**<0.01**
Became passive	76.52 (±23.93)	58.78 (±21.90)	−17.74 (−24.21, −11.27)	**<0.01**
Became active	72.50 (±24.97)	72.31 (±26.81)	4.52 (−2.57, 11.61)	0.20
CPM				
Remain active	648.25 (±212.58)	544.82 (±168.54)	−103.43 (−154.46, −52.40)	**<0.01**
Remain passive	580.69 (±191.79)	437.46 (±140.81)	−143.23 (−187.60, −98.87)	**<0.01**
Became passive	636.04 (±189.88)	436.09 (±138.82)	−199.96 (−252.64, −147.27)	**<0.01**
Became active	579.70 (±189.02)	540.56 (±311.19)	−39.14 (−133.67, 55.40)	0.40

SED = Sedentary time, MVPA = Moderate to vigorous physical activity, CPM = Counts per minute.

4. Discussion

This is one of the first studies to investigate change in school travel mode over the transition period from childhood to adolescence addressing the current gap in the literature. Almost 40% of participants changed travel mode, highlighting this key period of change. Of these, two-thirds changed from an active travel mode to a passive one, which is associated with decreases in overall daily activity levels (Faulkner et al., 2009). The prevalence of cycling to school decreased by more than half (10.4% to 4.4%), with a smaller drop in those walking to school (41.1% to 34.4%). The findings showed a 5-fold increase in travel by bus/train (7.2% to 35.9%), illustrating the impact of greater distances travelled to secondary school and the availability of buses, consistent with data (Larouche et al., 2014; Cale and Harris, 2006).

Our results confirm that changes in travel modes were associated with changes in activity levels not only during travel times, but maintained over the full day. Those who either maintained or took up active travel became more active and less sedentary, whilst the reverse was seen in those who remained passive or took up passive travel modes. This highlights the importance of active travel to maintain young people's physical activity levels, particularly over this transition period. It is important to understand the nature of observed changes in travel behaviour to enable the design and implementation of public health interventions to prevent a reduction in physical activity of young people.

This study identified factors from multiple domains of the social-ecological model of health that were associated with changes in active travel that may help influence future interventions. Many variables (e.g. peer support, parents less able to drive, school encouragement, route environment and school-based interventions) were associated with increased odds of changing to an active travel mode. Some results were counterintuitive (e.g. a lower reporting of cycle path safety at follow-up compared to baseline was associated with higher odds of maintaining active travel). It is possible that those who are regular cyclists may have greater awareness of the infrastructure and hence be more likely to report negatively on it. Environmental factors identified were change in distance travelled and gaining or losing the need to cross a busy road. As expected, increased distance travelled to school was negatively associated with maintenance and uptake of active travel, whilst children who had gained crossing a busy road at secondary school were more likely to take up passive travel.

Importantly, social support was a determinant of maintenance and uptake of active travel. Children with parents who were more supportive of active travel were more likely to take up active travel as well as be less likely to take up passive travel. Increased peer support was also associated with both the maintenance and uptake of active travel. Parental perceptions appeared to be important; factors including parental

Table 3
Final multinomial multiple logistic regression models showing the adjusted relationships using 'remained passive' as the reference outcome category. Confidence intervals produced using robust standard errors (OR (95% CI). Bold = P value of <0.1.

Variable (n, reference category)	Remain active	P value	Became passive	P value	Became active	P value
Childhood						
Change in parental support (no change)						
More supportive (75)	1.03 (0.33, 3.21)	0.97	**0.16 (0.03, 0.72)**	**0.02**	**5.08 (1.68, 15.38)**	**<0.01**
Less supportive (124)	0.74 (0.31, 1.74)	0.49	**5.64 (2.55, 12.49)**	**<0.01**	2.05 (0.50, 8.37)	0.32
Change in peer support (no change)						
More supportive (81)	**3.32 (1.31, 8.44)**	**0.01**	1.08 (0.31, 3.79)	0.90	**3.51 (1.24, 9.93)**	**0.02**
Less supportive (98)	1.20 (0.47, 3.10)	0.70	1.27 (0.53, 3.01)	0.60	1.31 (0.30, 5.80)	0.72
Parental						
NEWS-S (Panter et al., 2010a)	**1.09 (1.04, 1.14)**	**<0.01**	1.03 (0.98, 1.08)	0.22	**1.05 (1.00, 1.11)**	**0.06**
Change in travel mode to work (no change)						
More active (40)	2.18 (0.58, 8.15)	0.25	**4.49 (1.22, 16.54)**	**0.02**	1.01 (0.23, 4.37)	0.99
Less active (30)	1.96 (0.45, 8.55)	0.37	2.66 (0.67, 8.18)	0.87	1.88 (0.17, 21.24)	0.61
Change in perceived road safety (no change)						
More traffic (114)	0.64 (0.21, 1.94)	0.43	**3.40 (1.49, 7.75)**	**<0.01**	1.16 (0.25, 5.51)	0.85
Less traffic (131)	1.03 (0.47, 2.26)	0.95	0.76 (0.27, 2.09)	0.59	1.04 (0.48, 2.26)	0.93
More safe cycle paths (148)	**6.49 (2.97, 14.20)**	**<0.01**	1.61 (0.80, 3.23)	0.18	**7.93 (2.83, 22.19)**	**<0.01**
Less safe cycle paths (81)	**4.46 (1.71, 11.63)**	**<0.01**	**2.38 (0.91, 6.20)**	**0.08**	2.15 (0.57, 8.15)	0.26
More safe pavements (100)	**0.41 (0.16, 1.06)**	**0.07**	0.70 (0.22, 2.23)	0.55	0.75 (0.28, 2.06)	0.58
Less safe pavements (108)	**0.28 (0.08, 0.91)**	**0.04**	1.41 (0.61, 3.22)	0.42	0.30 (0.05, 1.62)	0.16
Change in perceived car convenience (no change)						
More convenient (72)	**0.15 (0.04, 0.64)**	**0.01**	1.33 (0.58, 3.04)	0.50	*	*
Less convenient (144)	**0.04 (0.01, 0.12)**	**<0.01**	**0.09 (0.03, 0.23)**	<0.01	1.41 (0.59, 3.35)	0.44
Change in being available to drive (no change)						
Around more (33)	0.80 (0.19, 3.30)	0.75	1.19 (0.32, 4.35)	0.77	0.51 (0.04, 6.42)	0.60
Around less (289)	**4.50 (2.07, 9.76)**	**<0.01**	**2.65 (1.34, 5.26)**	<0.01	**3.47 (1.28, 9.36)**	0.02
Environmental						
Change in distance to school	**0.74 (0.64, 0.85)**	**<0.01**	1.04 (0.97, 1.12)	0.26	**0.69 (0.57, 0.83)**	**<0.01**
Change of crossing a busy road on route (no change)						
Gain crossing a		0.20		**<0.01**		0.84

(*continued on next page*)

Table 3 (*continued*)

Variable (n, reference category)	Remain active	P value	Became passive	P value	Became active	P value
busy road (202)	1.78 (0.74, 4.26)		**3.88 (1.67, 9.02)**		0.89 (0.27, 2.89)	
Lose crossing a busy road (7)	**0.00 (0.00, 0.00)**	**<0.01**	**0.00 (0.00, 0.00)**	**<0.01**	1.47 (0.21, 10.31)	0.70
School at SPEEDY 1						
Attitudes to physical activity	**0.67 (0.53, 0.84)**	**<0.01**	0.88 (0.69, 1.11)	0.29	0.90 (0.70, 1.14)	0.37
Encourage AT to school	**3.78 (1.57, 9.11)**	**<0.01**	**2.22 (0.92, 5.33)**	**0.08**	1.42 (0.60, 3.43)	0.42
Travel plan in place	1.70 (0.46, 6.26)	0.43	**8.28 (1.47, 46.72)**	**0.02**	2.39 (0.37, 15.42)	0.36

*Not estimated due to zero cell count.

perceived safety of the route to school, perceived convenience of driving and being available to drive were significant correlates of change in travel mode. Children with parents who perceived an increase in safety of cycle paths were more likely to maintain and take up active travel. The reverse was seen with uptake of passive travel which was associated with parental perception of increased traffic on route.

The 38.4% of participants that changed travel mode in this study is higher than the 15.0% observed when examining the same children over 1 year (Panter et al., 2013). This likely is a result of the longer follow-up period combined with transition from primary to secondary school. Analysis from the PEACH cohort of similar age English children, found 28.8% of participants changed travel mode over the transition from primary to secondary school (Cooper et al., 2012). This data was from city dwelling children only and smaller increases in distance travelled to school were seen compared to this study (1.80 km vs 3.51 km), likely explaining the lower levels of change (Panter et al., 2008, 2013; Pont et al., 2009).

Several of the correlates of change that were identified in this study have been previously associated with travel behaviour, although in a more limited set of studies. Distance is consistently associated with travel mode (Panter et al., 2008, 2013; Pont et al., 2009) and our data identifies the importance of distance travelled over the longer duration of our 4-year follow-up. At primary school, the average distance our participants travelled was 2.6 km. This greatly increased to 6.0 km at secondary school and was negatively associated with maintenance and uptake of active travel. In the PEACH cohort, around 60.0% of participants with journeys of less than 2.5 km walked to school (Cooper et al., 2012). Above this distance, most travel was undertaken by car and bus. We found that only 45.7% of our cohort that lived less than 2 km away from school walked, possibly reflecting the rural nature of our study setting.

The reduction in the number of adolescents walking to school is closely linked to the increase in distance travelled, although it appears, as would be expected, that they are prepared to walk further than children. Another paper using the same cohort as this paper found that the distance threshold for active travel was approximately 1.4 km for children and 3 km for adolescents (Chillon et al., 2015). This reduction in adolescents walking to school may be linked to the lower number of secondary schools covering larger catchment areas leading to longer commutes. Therefore, the consideration of the impact of distance should be an essential component of interventions to encourage active travel to school and the size of catchment areas and current provision for active travel within these areas must also be considered.

Social support has also been previously shown to be a correlate of active travel (Panter et al., 2010a). In this study, peer support was associated with both maintenance and uptake of active travel, whereas parental support was associated with uptake of active travel and switches to passive modes. The difference in influence of parental and peer support is interesting; physical activity in adolescence has been shown to be more strongly affected by peer influence than parental influence and so this may explain the differences seen (Beets et al., 2006; Prochaska et al., 2002).

The association between parental perceptions of active travel and child behaviour is well supported by previous literature. For example, several studies have demonstrated an association between perceived road safety and active travel (Panter et al., 2008, 2013; Carlson et al., 2014; Hume et al., 2009; Lorenc et al., 2008; Timperio et al., 2006). Parental availability to drive has also been associated with both maintenance and uptake of active travel and decreased parental car convenience was negatively associated with loss of active travel (Panter et al., 2008, 2013; Pont et al., 2009). A previous cross-sectional analysis of the SPEEDY cohort showed an association between child active travel and parental availability and parental car convenience at distances of up to 2 km to school (Panter et al., 2010a).

In our study, we classified travel using public transport as “passive” despite the fact there is evidence from studies that physical activity energy expenditure from such trips can be similar to that observed in walking and cycling trips (Owen et al., 2012). Public transport journeys to and from school tend to be over longer distances yet have benefit from a public health perspective that they typically involve some element of walking to and from the transit stop, which leads to the accrual of physical activity (Pabayo et al., 2012). As evidenced by Fig. 1, we found bus/train trips increased and car trips declined between baseline and follow-up, which may be associated with some positive benefits. Nevertheless, these trips will still involve less physical activity compared to walking and cycling an equivalent distance. Given there is some evidence that physical activity behaviours used in childhood are more likely to track into adulthood (Evans et al., 2009), we believe that shorter school journeys, where walking or cycling are feasible, should be wholly walked or cycled with longer journeys using public transport in combination with, typically, walking.

Key strengths of this paper include the four-year follow-up investigating the change in travel behaviours over the transition period from childhood to adolescence, and the incorporation of a wide range of potential predictors selected from a relevant theoretical framework. The longer duration of follow-up has captured the transition from primary to secondary school, a period not previously well-studied. Our consideration of this key time in the lives of adolescents provides evidence to suggest that the changes that occur during this time period are long lasting and persist into secondary school. The extended period of follow up coupled with the fact that data was collected at the same time of year to avoid seasonal change in travel behaviours, and the usual travel mode provided further stability in travel mode estimates. Nevertheless, seasonal variation has been shown to affect travel mode (Dalton et al., 2011) and our findings may have been different if data collection had occurred in winter.

Another important strength is that the SPEEDY sample included a wide mix of both urban and rural areas; setting has been shown to be a determinant of travel mode chosen (Giles-Corti, 2006; Parks et al., 2003). Many previous studies have been undertaken in solely urban settings (Cooper et al., 2012), so our findings may be more generalisable to heterogeneous environments which is important when devising nationwide policies. Our use of objective physical activity measurements via accelerometery avoided the problems of self-report.

There are however some notable limitations. Almost all the participants identified with a white British ethnicity, decreasing the generalisability of the results to more diverse population. Loss to follow-up meant that this analysis was undertaken in a subset of 490 of the 1019 children who provided baseline data (48.1%). This may have introduced bias into the analysis although a comparison of the analysis sample with the full cohort did not show statistically significant differences. Many of the baseline variables were not collected at both time points (e.g. sibling number or parental physical activity levels) and these may have changed over time, although it is unlikely these factors would change substantially.

The modelled measurements for distance travelled to school, based on the shortest available route, may not represent the actual routes undertaken. However, there is evidence to suggest that such estimates show a good association with the length of the actual route taken (Badland et al., 2010; Duncan and Mummery, 2007). Another limitation was that the precise period of school travel could not be established and therefore accelerometery captured between 8am and 9am and 3pm and 4pm was assumed to be commute related. Some commuting may have occurred outside these times, if children attended school clubs before or after lessons, and similarly not all physical activity recorded was necessarily associated with the commute. The impact of this assumption is likely minor as government guidance states that every school day must have two sessions divided by a break in the middle of the day (Department for Education., 2020). The length of each session, break and the school day is determined by the school's governing body. These cut off times were chosen in consultation with schools and the examination of daily patterns of data from the accelerometers that the children wore. A limitation of the self-report travel mode used was that multi-modal travel was not captured; for example, traveling by bus has been shown to be associated with higher levels of physical activity than the car (Rissel et al., 2012), but was coded as 'passive' here.

A final limitation of this analysis is that the data was collected some time prior to the production of this manuscript. Data from the United Kingdom National Travel Survey (Department for Transport., 2020) shows that between 2005/9, a period equating to when the data was collected, and 2015/19, the most recent for which data is available, the mean distance travelled to school remained unchanged at 2.4 miles. Data comparing travel mode to and from school in 2002/6 and 2015/19 (Department for Transport., 2015b) is also available from the National Travel Survey, although only for 5–16-year-olds combined. This shows little change; between those periods the percentage of trips by bicycle remained unchanged at 2.0%, the percentage by car rose slightly from 31.0 to 35.0% whilst the percentage walked declined slightly from 48.0 to 44.0%. We do not think these changes are of a magnitude that are likely to mean that our findings are not applicable to the present situation, although the possibility of some contextual change cannot be ruled out.

Our data revealed that non-wear time differed from baseline to follow up. It is possible that some of the change we observed with respect to physical activity was an artefact of missing data rather than a true effect. However, as we have no data for the non-wear periods, we are unable to ascertain if any bias occurred. Sample size considerations precluded detailed stratification. There was low prevalence of certain characteristics (e.g. 3.8% of participants did not have access to a car), and associated associations associated should be interpreted with caution. Finally, the measures of changes in explanatory factors and changes in active travel were ascertained concurrently so we cannot say which proceeded the other.

5. Conclusion

This study identifies potential foci to improve the declining levels of active travel in young people. Whilst our study is descriptive in nature, we recommend follow-on research, using either natural experiential approaches or trials of interventions, to identify how the statistical associations that we have presented may translate into real-world behaviour change. Action in multiple domains may be needed to support active travel over the transition period. Interventions will require transdisciplinary co-operation with those who plan and undertake public health interventions, those who determine school policies and those who develop infrastructure and road safety systems. Achieving such collaboration amongst agencies can be challenging but should be pursued.

Declaration of competing interest

None.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2021.102667.

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