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Sustainable Steps in the Snow: Exploring factors associated with active school commuting in Finland

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ABSTRACT

Physical inactivity of children and youth is a major health problem. Active commuting could increase the amount of physical activity and be a more environmentally friendly traffic mode choice compared with motorized vehicles. Parents have an integral role in determining the options a child has for commuting. We explored parental barriers and motivators associated with the active commute of their children.

This cross-sectional study used the CLIMATE NUDGE Survey data of parents with school-aged children. A set of 25 possible influencing factors included demographic factors, social aspects, and pro-environmental attitudes, and questions about the motivating role of journey characteristics and health effects. The data were analyzed with two multinomial logistic regression analyses (N = 320): first, comparing those who either never or sometimes commute actively to those who always do so, and second, those who always or sometimes commute actively to those who never do so.

Results indicated the strongest determinants to differentiate those who always and those who never use active commute, were commute distance and parental beliefs about social commute norms. The longer the commute distance was, the more likely the child was to belong to the never active commuter group and less likely to belong to the always active commuter group. The more parents believed their child's peers commuted actively, the more likely it was that their child always commuted actively and less likely they never did so.

We found several factors associated with active commuting, yet somewhat surprisingly neither environmental attitudes nor climate change related reasons were significantly associated with active commuting. To conclude, instead of highlighting environmental aspects to promote active commute, we recommend highlighting social norms and perception of the commute distance, and addressing weather-related barriers and health related motivators.

1. Introduction

Active commuting addresses two large societal issues: the escalating greenhouse-gas (GHG) emissions and the detrimental health effects of physical inactivity. Traffic-related emissions constitute about a fifth of the global energy sector's GHG emissions (Ritchie, 2020). At the same time, in Europe, two-thirds of children and adolescents are reported to be physically less active than recommended (Steene-Johannessen et al., 2020). The numbers are concerning, as physical activity in daily life, including active commuting,

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significantly contributes to both physical and mental health (Kleszczewska et al., 2020; Lubans et al., 2011; Saunders et al., 2013). To promote physically active adulthood, it is important to increase physical activity already in childhood.

Encouraging active commuting in childhood sets the foundation for a lifelong habit: physical activity in childhood persists into more active adulthood (Cleland et al., 2012; Evans et al., 2009; Telama et al., 2005; Telama, 2009), even though some decline is observed (Corder et al., 2019). While children may have some autonomy in their commute choices, parents play a crucial role in shaping the boundaries within which children make these decisions. Since the school commute mode is ultimately a parental decision influenced also by the parent's own habits (Rodríguez-López et al., 2013; Kobel et al., 2019), parents are a relevant target when examining the reasons behind school commute mode choices.

While there are some direct determinants of active commuting observed in many countries, there are nonetheless also notable differences. A study comparing twelve geographically, economically and culturally diverse countries, revealed that the geographical location of the country moderates the relationship between some environmental and individual variables connected to children's commuting behavior (Larouche et al., 2015). Different countries had different determinant profiles for active school commuting; for example, lower parental education was associated with active school commuting only in the United States, while having a lower number of siblings was associated with less active school commuting only in Brazil and South Africa (Larouche et al., 2015). A child's gender, neighborhood walkability, and the social environment exhibited similarly varying impacts on commuting behavior across different contexts (Larouche et al., 2015). Despite these variations, there is a degree of similarity in the determinants of active commuting across different nations. Longer distance to school and travel time seems to consistently and negatively correlate with active school commuting across different countries (González et al., 2020b; Larouche et al., 2015). Conversely, traffic and crime-related safety, built environment, and lack of social support have been identified as common parental barriers for active school commuting in many countries (Aranda-Balboa et al., 2020).

To evaluate the generalizability of these results, it is sensible to look at the prevalence of active commute in different countries. To illustrate some major baseline differences, a study based on the 2017 National Household Travel Survey in the USA, where numerous school commute studies have been conducted, revealed that only 10 % of students typically walked and 1 % usually biked to school, while approximately half of the students reached school by car (Kontou et al., 2020). In contrast, studies from Nordic countries like Finland and Sweden indicate a much higher prevalence of active commuting: 31 %–79 % in Finland and 50 %–76 % in Sweden (Heltimo, 2017; Johansson et al., 2012; Kallio et al., 2016). A study comparing 49 countries found three distinct active commute profiles: the first profile was characterized by a low prevalence of active commuting, but high a human development index (HDI) and low inequality in income distribution (Gini index) (e.g., USA, Canada, England) (González et al., 2020a). The second profile was characterized by a high prevalence of active commuting, but a low or middle HDI and a high Gini index (e.g., Nigeria, Ethiopia). The third profile included some of the most successful countries in active commuting, yet it was characterized by a large variability in the socioeconomic variables, including both very high and very low Gini index and HDI countries, (e.g., Finland, Denmark, Japan, Zimbabwe, and Nepal). This highlights the need to look further into the determinants of active commuting especially in these highly active countries. We need to understand the enabling or disabling factors that affect children's active commuting in these culturally and socioeconomically diverse nations.

Finland, and Nordic countries in general, offer a valuable study location for active commuting because of the combination of harsh winters and the relatively high prevalence of active commuting despite this. Cycling is known to decrease also in Finland during winter conditions compared to summer (Perälä, 2003; Kallio, et al., 2016). However, based on the only available (not peer-reviewed) report conducted in Finland about the barriers and motivators for winter cycling, slightly cold weather is not a major barrier for winter cyclists: only 5 %–37 % (variations between cities) of winter cyclists considered temperatures warmer than −20° Celsius (−4° Fahrenheit) as too cold for cycling (Perälä, 2003). The most common barriers for those who did not cycle in winter conditions were slippery roads, cold, perception of winter cycling as dangerous, and poorly plowed roads. The non-winter cycling group also responded that better upkeep of the roads, a better bike, and a shorter distance would motivate them to cycle in the winter. Most common motives for winter cyclists, in turn, were the exercise benefits, speed, and low costs of winter cycling. A recent study looking into parental barriers for active commuting in similar climate conditions of Sweden found winter conditions as barriers for children's active commuting, while it was also seen as providing benefits, such as better health and increased time spent outdoors (Forsberg et al., 2020).

A recent non-peer reviewed report in Finland surveyed parents of school-aged children about the motives of school commute modes (Turunen et al., 2023). Parents who reported active commuting as one of the main ways their child commutes chose from a predefined list one or more reasons they considered to be behind the active commute mode choice. Between 75 % and 85 % of the parents chose "a suitable commute distance" among the reasons. For example, 56 % of 4–6 graders' parents stated that 3–5 km would be a suitable distance for their children to cycle, whereas only 4 % stated that this distance could be even longer. Other popular reasons reported by parents for choosing active commute mode included the child getting exercise (57 %–59 %), cycling being fast and easy (56 %), and the journey being safe (48 %–53 %). Active commuting can also be seen as a pro-environmental action. Studies that examine the correlates of active commuting rarely take into account factors connected to other pro-environmental behaviors. For example, influencing descriptive norms, i.e., the way the majority is perceived to act, has been found effective in increasing pro-environmental behavior (Farrow et al., 2017). Environmental values and climate change-related feelings might also contribute to pro-environmental behavior. For example, the perceived threat of climate change combined with climate change-related self-efficacy should encourage people toward pro-environmental action (See: Ma et al., 2023; Sarrina Li & Huang, 2020; Witte, 1992). Certain demographic factors, such as educational level and economic situation, have also been connected to the level of household carbon footprints (Ivanova et al., 2017).

Taken together, studying the motivators and barriers for active commuting is important due to both health and environmental benefits, as well as the notion that childhood physical activity seems to be linked to physical activity later in life. In this study, our

primary goal was to explore the critical determinants of active school commuting in Finland, with a specific focus on understanding the factors that act as barriers and motivators for parents in their children's school commute choices, taking into account possible pro-environmental factors.

We explored a pool of likely relevant factors to discover which of them are connected to the amount of active commuting to school, i.e., which factors separate the active and passive commuters. Based on previous research showcasing consistent findings between countries, we hypothesized that commute distance is a highly relevant factor. We expected all included variables to correlate with active commuting yet did not have a hypothesis on which factors remain significant when analyzed together.

2. Materials and methods

2.1. Study design and participants

The data were drawn from the cross-sectional CLIMATE NUDGE survey, collected by Kantar TNS in April-May 2022. The target group consisted of approximately 50.000 Kantar TNS panel members, who represent Finnish population in regard to gender, age, and living area. The planned sample size was 3.500 participants, and 3.600 responded to the survey. The order of question blocks in the survey was partly randomized to reduce item order effects. More detailed information about the survey and data collection procedures can be found at https://osf.io/3s8uc. The CLIMATE NUDGE survey received ethical approval from the Ethics Committee of Humanities and Social Sciences at the University of Turku, Finland.

To analyze parental factors affecting commuting to school, we included respondents who reported having school-aged children (N = 490). However, due to missing values and listwise deletion in the main analysis, the final sample was 320 respondents ($n_{female} = 163$, $n_{male} = 157$), aged 19–70 years (M: 44, SD: 8). Most of the participants completed the survey in Finnish ($n = 313_{Finnish}$; $n = 6_{Swedish}$; $n = 1_{English}$).

2.2. Measures

Exploratory analyses were used to assess parental predictors connected to active school commuting of their children. The level of active commuting was measured by the question "How often on average does your child travel to school by foot or by bicycle?". The participants responded on a 5-point Likert scale ranging from 1) Never, 2) Less than once a week, 3) Approximately once a week, 4) A

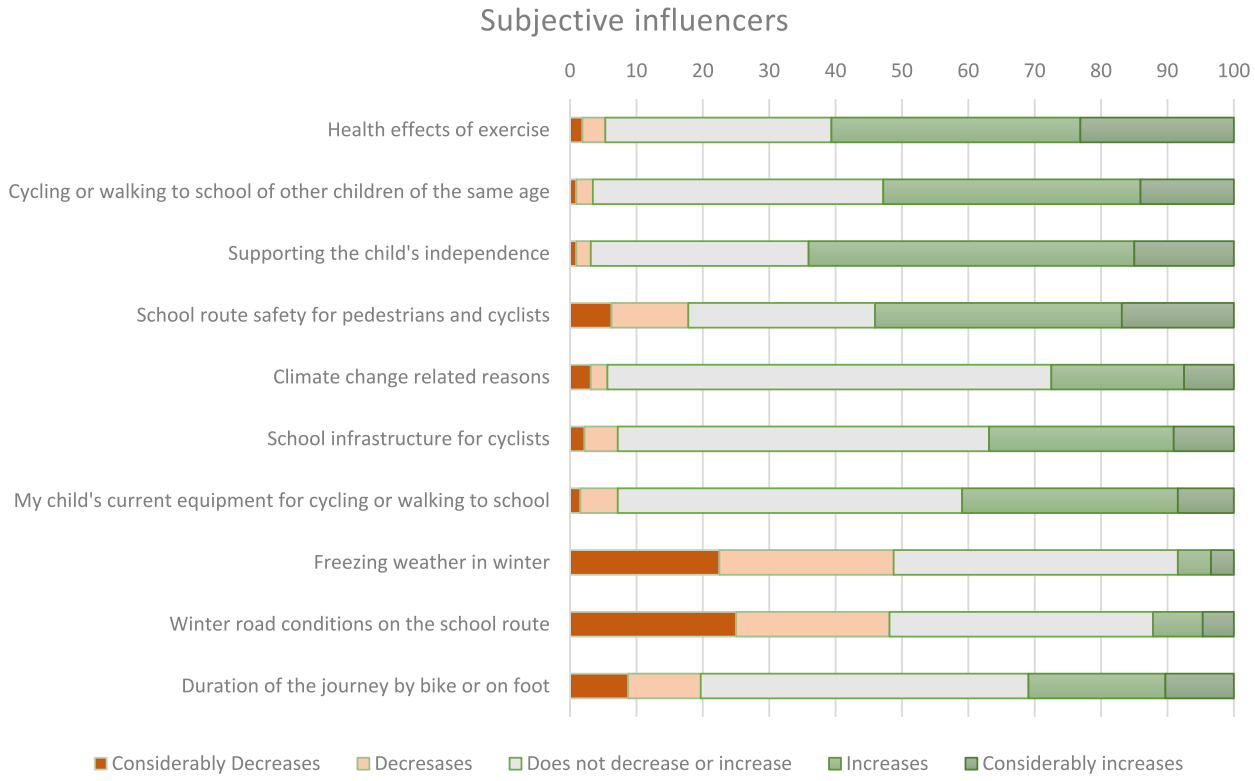

Fig. 1. Subjective influencers. Participants were asked: Do the following increase or decrease your willingness to encourage your child to cycle or walk to school? Answers were given on a Likert scale: 1) Significantly decreases, 2) Decreases, 3) Neither decrease or increase, 4) Increases, 5) Significantly increases. N = 320.

few times a week, and 5) Daily or almost daily. To focus our analyses, especially on the extreme ends of these responses, the answers were recoded into three categories of using active commuting: 1) Never (original response 1), 2) Sometimes (original responses 2–4), and 3) Always (original response 5). Our main interest was to compare the two extreme ends — those who usually commute to school actively and those who almost never do so — to get a clearer picture of which factors are connected to routine habits.

Based on previous studies, we analyzed 24 possible predictors for commute mode choice, including background and demographic variables, as well as factors related to commute behavior or pro-environmental behavior. Background variables included commuting distance, the financial situation of the parent who responded to the survey, living situation (1 or 2 parent household), parental education level (college/university degree: no/yes), the number of children in the family, city or countryside residence based on the postal code reported on the survey, and the grade the child was in (1st–9th grade).

Child's commute distance was assessed as follows: 1) Less than 500 m, 2) 500 m – 1 km, 3) 1–2 km, 4) 2–3 km, 5) 3–5 km, 6) 5–10 km, 7) 10–20 km, 8) Over 20 km. Parental financial situation was assessed by asking participants to describe their financial situation on a Likert scale: 1) Very poor, 2) Relatively poor, 3) Mediocre, 4) Relatively good, 5) Very good.

Parental active commuting was measured with the question, "*How do you usually travel to work or study – by…*walking/cycling in the summer?" with answer options on a Likert scale: 1) Never, 2) Less than once a week, 3) Approximately once a week, 4) A few times a week, 5) Daily or almost daily. The Likert scale responses were recoded into 3 categories for the purposes of this article: 1) The parent never goes to work using active commuting, 2) The parent sometimes goes to work using active commuting, 3) The parent always or almost always goes to work using active commuting. The answers for walking and summer cycling were combined to create an active commuting variable.

The descriptive social norm related to school commuting was assessed by asking the parents how often they think their child's classmates go to school by walking or cycling. Response options were: 1) Never, 2) Less than once a week, 3) About once a week, 4) A few times a week, 5) Daily or almost daily, 6) I don't know. The "I don't know" −answers (n = 96) were removed for the analyses.

Furthermore, we asked participants to rate whether 10 different subjective influencers were perceived as motivators or barriers for active commuting (see Fig. 1). The participants reported how each factor either *significantly decreases, decreases, doesn't decrease or increase, increases,* or *significantly increases* willingness to guide their child to walk or cycle to school. To calculate a ratio of motivational factors and barriers for each participant, we summed responses where the participant had selected either *significantly decreases* or *decreases* willingness as barriers and subtracted this from the sum of *significantly increases* or *increases* willingness responses, i.e., motivators. This ratio variable was used in the analysis alongside the 10 different subjective influencers.

In addition, since active modes of transport can be perceived as an environmental action, we explored a set of questions concerning environmental attitudes and climate change to see if such attitudes or climate change related feelings are connected to active commuting.

To assess the respondents' views about the importance of the environment and environmental protection we used a 12-item version of the original 24-item version of Environmental Attitudes Inventory (EAI-S) (Milfont & Duckitt, 2010). The EAI-S consists of questions concerning attitudes towards the environment, ranging from from regulation to personal engagement and conservation priorities. Respondents answered on a 7-point scale ranging from 1) completely agree to 7) completely disagree. The 12 items were summed to create an EAI variable in which a higher score indicated a more positive attitude towards the natural environment. This short version of the EAI consists of two factors, which had reasonable reliability in this data: Cronbach's alpha was 0.71 for the *preservation* factor and 0.69 for the *utilization* factor.

Climate change worry (CC worry) was assessed by asking the participants: "Are you worried about climate change?" The answer options were 1) Not at all worried, 2) Not too worried, 3) Somewhat worried, 4) Very worried, 5) Extremely worried.

Climate change information (CC information) was assessed by asking the participants: How much knowledge do you have about climate change? Answer options were indicated on a 5-point Likert scale 1) I have very good knowledge about climate change, 2) I have good knowledge about climate change, 3 I have mediocre knowledge about climate change, 4) I have poor knowledge about climate change, 5) I do not know what climate change is.

Climate change action possibilities (CC self-efficacy) were assessed by asking the participants how easy it is for them to take actions to mitigate climate change in their everyday lives. Response options were: 1) Very easy, 2) Easy, 3) Not easy nor difficult, 4) Difficult, 5) Very difficult.

2.3. Statistical analyses

Statistical analyses were conducted with IBM SPSS Statistics, version 27. The dataset had five variables with some missing values: CC-self efficacy, Parental active commute, Descriptive social norm, Number of children and City or countryside residence. Little's MCAR test was significant when examining all 25 variables (Chi-Square = 511.282, df = 323, $p < 0.001$) indicating the missing variables were not random. This is mainly explained by the "I don't know" answers being coded as missing, with the missing value analysis conducted with these recoded variables. There were 28 respondents who first reported number of children as 0, yet later nonetheless answered having school-aged children, and answered all child-related questions. Thus, the number of children had 28 missing values. In the living area variable, which was comprised of postal codes of the respondents, there were 7 missing values. In the question concerning the possibilities for climate action, there were 11 missing answers, since the survey directed past that question if the person stated they had not done any actions to reduce their own emissions. Collinearity diagnostics indicated no significant multicollinearity (All VIF < 2.9, Tolerance > 0.34).

Test of parallel lines was conducted for choosing ordinal or multinomial approach in the final model. Test indicated that the multinomial approach should be used. In the multinomial logistic regression analysis, the Always-group, which always goes to school

using active commuting, was used as the reference category. Explaining which factors separate the *Never*-group from the *Always*-group may be particularly useful in planning interventions to promote active commuting. However, the Never-group was also the smallest group and therefore not the best choice for the reference category.

Variable selection for the final model was conducted using two automated stepwise selections (i.e., forward and backward methods) and theoretical considerations. Since automated selection methods prioritize only model fit and prediction, we analyzed all 24 predictors, but included climate change-related variables and parental active work commuting as forced entry terms in the selection methods, to ensure that theoretically significant variables are included, and to preserve the theoretical integrity of the final model (Steyerberg & Vergouwe, 2014). Automated selection methods suggested nine predictors to the final model, in addition to the four forced entry items. The forward method suggested the following items to the model: School commute distance, Family situation, Social norm: active commute level of peers, Financial situation, Parental active commute, and the Subjective influencer: Duration of walking/cycling to school. The backward model suggested additionally also the following Subjective influencers: Health effects of exercise, Sub-zero temperatures, and Winter road conditions for the walking/biking paths. The interaction of CC variables (CC worry * CC information * CC self-efficacy) was also tested in the model. Theoretically, the combined effect of having CC information, worry, and self-efficacy should have a stronger effect on actual behavior, however the interaction did not reach statistical significance and was thus removed from the final model. The family situation variable was also removed from the final model due to abnormally large confidence intervals caused by small cell values (de Irala et al., 1997). The following variables were included in the final model to predict the level of active commuting: CC worry, CC information and CC self-efficacy, School commute distance, Social norm: active commute level of peers, Financial situation, Parental active commute, and the following Subjective influencers: Health effects of exercise, Sub-zero temperatures, Winter road conditions for the walking/biking paths, and Duration of walking/cycling to school.

We conducted two separate multinomial logistic regression analyses to examine the barriers and motivators for active commuting. A 99 % confidence interval was used due to the presence of multiple variables. P-values larger than 0.01 should be interpreted with caution but are reported for transparency. The first analysis was conducted with the Always-group as the reference category, as it is the largest group, resulting in more precise estimates and smaller confidence intervals compared to using the Never-group, the smallest group, as a reference category. An additional analysis was conducted with the Never-group as the reference category, since it makes the interpretation of the results easier from the motives' point of view and provides additional information about the Sometimes-group in relation to Never-group. Notably, the results between the Never- and Always-group are consistent regardless of which group is used as the reference.

This dual approach allows us to examine the results from both barrier and motivator perspectives. Understanding the factors associated with passive and active commuters is crucial for informing policies and interventions aimed at promoting active commuting. It helps identify specific barriers to address and encourage active travel habits.

3. Results

3.1. Descriptive statistics

There were 320 valid cases in the final multinomial logistic regression models. Of those, 59 % (n = 190) were categorized in the Always (commuting actively) group, 23 % (n = 73) in the Sometimes-group, and 18 % (n = 57) in the Never-group. Descriptive statistics are reported in Table 1. To demonstrate the Finnish baseline for active commuting with different commute distances, a cross-tabulation of the full sample of 490 cases is reported in Table 2. The most common distances for the Always-group were 500 m–1 km and 1–2 km (70 % of the respondents), for the Sometimes-group, they were 2–3 km and 3–5 km (51 % of the respondents) and for the Never-group, they were 5–10 km and 10–20 km (55 % of the respondents). After 2 km distance, "Always" was no longer the most frequent response, whereas after 5 km, "Never" became the most frequent response.

Table 1
Descriptive statistics, N = 320.

Predictors	Mean	SD	Range
CC information (1 = I have a very good knowledge, …, 5 = I do not know…)	2.07	0.86	1–5
CC worry (1 = I'm not worried at all, …, 5 = I'm extremely worried)	2.89	0.94	1–5
CC self-efficacy (to take action: 1 = Very easy, …, 5 = Very difficult)	2.80	0.81	1–5
Commute distance (1 < 500 m, …, 8 > 20 km)	3.34	1.86	1–8
Social norm (child's peers commute actively 1 = Never, …, 5 = Daily or almost daily)	4.27	1.22	1–5
Financial situation (1 = Very poor, …, 5 = Very good)	3.34	0.86	1–5
Parental active commute (0 = Never, 1 = Sometimes, 2 = Always)	0.66	0.74	0–2
[a] Subjective influencers (i.e. barriers or motivators)			
Health effects of exercise[a]	3.77	0.91	1–5
Freezing weather in winter[a]	2.41	1.00	1–5
Winter road conditions on the school route[a]	2.44	1.09	1–5
Duration of the journey by bike or on foot[a]	3.13	1.03	1–5

[a] Scale for the subjective influencers for active commuting was 1 = significantly decreases, 2 = decreases, 3 = doesn't decrease or increase, 4 = increases, 5 = significantly increases.

Table 2
Crosstabulation of school commute distance and the level of active commuting.

School commute distance (km)									
		<0.5	0.5–1	1–2	2–3	3–5	5–10	10–20	>20	Total
Level of active commuting	Never	3	3	3	4	15	22	26	11	87
	Sometimes	7	14	23	28	28	7	3	0	110
	Always	53	116	89	25	7	2	1	0	293
Total		63	133	115	57	50	31	30	11	490

The crosstabulation presents an overview of the prevalence of active commuting with different school commute distances in Finland, with the complete sample. N = 490.

3.2. Multinomial logistic regression

3.2.1. Model fit

Goodness-of-fit indicators of Cox and Snell = 0.660, Nagelkerke = 0.775 and McFadden = 0.566, indicate a relatively good fit of the final model to the data. The model's predictive accuracy was very good for the Always-group, with 96 % correct predictions. For the Sometimes-group, it was the lowest (66 %) and for the Never-group, it was relatively good 74 %, considering it was the smallest group. The overall percentage of correct predictions was 85 % indicating a relatively good model. However, the dominant class skews the prediction of the model to a higher end, and the result should be interpreted with caution.

3.2.2. Always as a reference category

3.2.2.1. Nevers vs. Always. When comparing the Always- and Never-groups, statistically significant associations were found regarding child's commute distance, peer social norm, financial situation, and subjective influencers of the health effects of exercise and below zero temperatures in the winter (Table 3).

To be precise, people were more likely to be in the Never-group if the school commute distance was longer *(OR = 6.28; p < 0.*001*)*.

Table 3
Multinomial logistic regression models.

Variable	**Model 1. Always as a reference group**				**Model 2. Never as a reference group**			
	Never vs. Always		Sometimes vs. Always		Always vs. Never		Sometimes vs. Never	
	B	OR, 99 % CI	B	OR, 99 % CI	B	OR, 99 % CI	B	OR, 99 % CI
CC information	−0.39	0.68, 0.28 – 1.64	−0.21	0.81, 0.41 – 1.61	0.39	1.48, 0.61 – 3.59	0.18	1.20, 0.62 – 2.31
CC worry	−0.46	0.63, 0.27 – 1.50	−0.09	0.91, 0.49 – 1.71	0.46	1.58, 0.67 – 3.75	0.37	1.44, 0.72 – 2.91
CC self efficacy	−0.40	0.67, 0.25 – 1.80	−0.15	0.86, 0.42 – 1.76	0.40	1.49, 0.56 – 4.01	0.25	1.28, 0.57 – 2.87
Commute distance	**1.84**	**6.28, 3.27 – 12.07*****	**0.95**	**2.58, 1.59 – 4.19*****	**−1.84**	**0.16, 0.08 – 0.31*****	**−0.89**	**0.41, 0.26 – 0.66*****
Social norm	**−2.15**	**0.12, 0.04 – 0.31*****	**−1.98**	**0.14, 0.06 – 0.33*****	**2.15**	**8.54, 3.26 – 22.37*****	0.16	1.18, 0.75 – 1.84
Financial situation	**−0.96**	**0.38, 0.15 – 0.95****	**−0.74**	**0.47, 0.23 – 0.97****	**0.96**	**2.62, 1.05 – 6.53****	0.22	1.24, 0.63 – 2.45
Parental active commute	**−1.21**	**0.30, 0.09 – 1.01***	−0.27	0.76, 0.33 – 1.73	**1.21**	**3.36, 0.99 – 11.42***	**0.94**	**2.56, 0.92 – 7.11***
Subjective influencers (i.e. barriers or motivators)								
Health effects	**−1.10**	**0.33, 0.13 – 0.86****	**−0.63**	**0.53, 0.26– 1.11***	**1.10**	**3.00, 1.17 – 7.73****	0.44	1.55, 0.59 – 4.04
Freezing weather	**−1.47**	**0.23, 0.06 – 0.82****	**−1.03**	**0.36, 0.14 – 0.93****	**1.47**	**4.35, 1.22 – 15.47****	−0.24	0.79, 0.30 – 2.11
Winter road conditions	**0.97**	**2.64, 0.76 – 9.14***	**0.73**	**2.08, 0.84 – 5.20***	**−0.97**	**0.38, 0.11 – 1.32***	0.02	1.02, 0.49 – 2.10
Duration of the journey	**−0.85**	**0.43, 0.15 – 1.20***	**−0.84**	**0.43, 0.18 – 1.02***	**0.85**	**2.34, 0.83 – 6.61***	0.44	1.55, 0.59 – 4.04
Constant	15.89		14.46		−15.89		−1.43	

Model 1. reference group: Always uses active commute.
Model 2. reference group: Never uses active commute.
*** p < 0.001, ** p < 0.01, *p < 0.05.

Responses to the measure of social norm (how often does your child's classmates go to school by walking or cycling) ranged from "Never" to "Daily or almost daily". Each incremental increase on this scale corresponded with reduced odds of being categorized in the Never-group ($OR = 0.12$; $p < 0.001$). Financial situation was reported on a scale from "Very poor" to "Very good", and one-point increase on that scale was associated with lower odds of belonging to the Never-group ($OR = 0.38$; $p < 0.01$).

The response scale for subjective influencer variables was from 1 = significantly decreases to 5 = significantly increases willingness to guide their child to walk or cycle to school. Moving up on that scale, i.e., being more motivated to encourage their children to engage in active commuting, was associated with lower odds of belonging to the Never-group, when assessing health effects of exercise ($OR = 0.33$; $p < 0.01$) and below zero temperatures in the winter ($OR = 0.23$; $p < 0.01$).

When comparing the Never-group with the Always-group, parental active commuting, as well as subjective influencers of winter road conditions and duration of the journey, failed to reach statistical significance at the level of 99 %, and thus, those results need to be interpreted with caution. The more actively the parent commuted to work, the less likely the child belonged to the Never- ($OR = 0.30$; $p = 0.011$). The result marginally failed to meet the requirement for the p-value limit.

The subjective influencer of winter road conditions was associated with higher odds of belonging to the Never-group ($OR = 2.64$; $p = 0.045$), when moving up on the response scale from barrier to motivator. On the contrary, moving up on the response scale from barrier to motivator with the duration of the journey, the odds were lower for the Never-group ($OR = 0.43$; $p = 0.034$).

3.2.2.2. Sometimes vs. Always. When comparing with the Always-group, belonging to the Sometimes-group was explained by commute distance, social norm, financial situation and the subjective influencer of below zero temperatures. Similarly to comparison between the Never and Always −groups, people were more likely to be in the Sometimes-group if the commute distance was longer ($OR = 2.58$; $p < 0.001$), and less likely if the social norm was more favorable for active commuting ($B = -1.98$; $p < 0.001$). The better the financial situation, the less likely it was to belong to the Sometimes-group ($OR = 0.48$; $p < 0.01$). The subjective influencer of below zero temperatures was also similarly associated with the Sometimes-group: the more motivating it was seen, the lower odds there were in belonging to the Sometimes-group ($OR = 0.36$; $p < 0.01$).

The subjective influencers of health effects of exercise, duration of the journey, and winter road conditions were significant only at the 95 % level, and therefore should be interpreted with caution. When health effects of exercise were perceived as more motivating, it was associated with lower odds of being in the Sometimes-group ($OR = 0.53$; $p = 0.026$). Similar direction was observed with the duration of the journey, where if it was seen as more motivating, it was less likely to belong to the Sometimes-group ($OR = 0.43$; $p = 0.012$). It was more likely to belong to the Sometimes-group if the winter road conditions were more motivating ($OR = 2.08$; $p = 0.039$) (Table 3).

3.2.3. Never as a reference category

The results of the comparison between the Never- and Always-groups remained consistent, even when the reference category was switched (Table 3). While the p-values were stable, the odds ratios exhibited a change in direction.

When comparing the Sometimes-group with the Never-group, only commute distance was a significant predictor ($OR = 0.41$; $p < 0.001$), indicating that a shorter commute distance was associated with belonging to the Sometimes-group compared to the Never-group. Parental active commuting was nearly a significant predictor ($OR = 2.56$; $p = 0.018$), indicating that the more parents commuted actively, the more likely their children were to be in the Sometimes-group compared to the Never-group.

4. Discussion

We investigated which parent-reported factors serve either as barriers or as motivators for active commuting to school in Finland. Longer commute distance and parental beliefs about the low social norm regarding active commuting were the strongest determinants for never or sometimes commuting actively in comparison to always commuting actively. Also, financial situation, how motivated people were from the health effects of exercise, and freezing temperatures were associated with the level of active commuting.

Social factors have previously been shown to affect the decision to commute by bicycle among adults and children (see review by Willis et al., 2015), and the same effect was found in the current study with children. Social support in the form of encouragement from parents or friends has been linked to greater likelihood of cycling (Willis et al., 2015). Active commuting is more likely also, if family or friends themselves use active transportation modes. In our study, children used active commuting modes less if their parents believed that the peers of their children also commuted less actively, and more if they believed the peers were more active, indicating a social norm. There was also some evidence of synchrony between parents' and children's commuting habits; the more the parent used active commuting the less likely the child was in a passive commuter group. However, because of multiple variables, the results should be interpreted somewhat conservatively. Nevertheless, this marginal result is worth reporting, considering the support from the recent report by Turunen et al. (2023) where 91 % of parents who commuted actively also reported that their child commutes actively. The most common reason for a child to commute to school by car was that the school was on the way to a parent's workplace (38 %). These results also indicate some synchrony between the parent's and child's commuting habits.

Thus, based on our study, and previous studies, and non-peer-reviewed reports, different social influences could be utilized more effectively to promote active commuting. For example, making the behavior more visible or utilizing role models and communication that encourages social conformity can be effective strategies. Increasing the visibility of active school commuting has been shown to change related social norm perceptions (Schuster et al., 2016), which in turn might alter the behaviors accordingly. The importance of parent-perceived social norm aligns with findings from other parts of the world, such as Israel (Levi, 2024), Spain (Forsberg, 2024),

and Australia (Saleme & Pang, 2022; Pang et al., 2017). Levi (2024) highlights how family norms and parental support positively influence adolescent active transportation and physical activity. Similarly, Forsberg's (2024) study in Spain demonstrates that perceptions of social norms of active commuting as more common among parents increase the odds of their adolescents using active commuting strategies. Additionally, perceptions of risk mediate this relationship, suggesting that parents whose social norms support active school commutes will feel safer, which helps overcome safety concerns (Pang et al., 2017). These findings suggest that intervention programs aiming to boost adolescent active transportation and physical activity should focus on enhancing parental support by promoting positive social norms.

Characteristics of the journey were associated with active commuting. When the commute distance was shorter, the odds of never using active commuting decreased and always using active commuting increased. This is consistent with results from previous studies indicating that shorter commute distance increases the likelihood of active commuting (Aranda-Balboa, Huertas-Delgado, Herrador-Colmenero, Cardon, & Chillón, 2020; González et al., 2020b; Saleme & Pang, 2022; Yeung, Wearing, & Hills, 2008). Commute distance is the one factor that seems to correlate with the level of active commuting in most countries. Another significant contextual factor was related to weather: if parents considered the sub-zero degrees more as barriers than motivators, their children were more likely to never commute actively. Given that the perception of an acceptable commute distance varies between countries (Larouche et al., 2015) and acceptable cycling temperature is lower in more Northern areas in Finland (Perälä, 2003) it might be possible to increase active commuting by modifying how distance and temperature are perceived.

Interestingly, parental environmental attitudes, climate worry, perceived possibilities for climate action, and the level of information about climate change were not associated with active commuting of their children. This observation suggests that promoting sustainable behavior may require alternative or additional framing. In the report by Turunen et al. (2023) 24 %–28 % of parents of school-aged children reported that one of the reasons their child uses active commuting is because it is an environmentally friendly option. The percentages are similar to those in our study; climate change was considered a motivator for active commuting by 28 % of parents in our sample. However, when we analyzed the association of climate attitudes with commuting behavior, such attitudes did not seem to have a significant effect. Either these environmental factors do not have an effect on commute mode habits, or some other factors overshadow the effect. It is also possible that environmental attitudes and knowledge about climate change might have a more direct impact on parents' own commute habits, but the effect simply did not carry over to their children. This, however, needs further research about the effects of these factors to commute habits of adults.

If parents perceived health effects as more motivating, their child was less likely to belong to the group that never commuted actively, and more likely to be in the group that commuted always actively. These results can be interpreted in several ways. It might suggest that health benefits could be something worth highlighting when promoting active commuting to children, since the health benefits of active commuting may not be clear to all parents. Alternatively, the parents of children who never commute actively may not be heavily motivated by health reasons, perceive some health threats in active commuting, or their children may have health problems that prevent active commuting.

In our study, the majority (61 %) of parents indicated health effects of active commuting as a motivating factor, in line with a report by Turunen et al. (2023). Thus, it seems that health motivates active commuting, but it is unclear how highlighting health benefits would translate into actual behavior in groups not motivated by health benefits. In an adult population, it has been suggested that highlighting health effects might not be as effective as highlighting short travel times and convenience, for example (Jones & Ogilvie, 2012). Nonetheless, adults may have different motivational factors for their own commuting compared to their children's commuting.

A study using a game to address parental concerns and promote active school commuting showed that challenging beliefs about risks increased parental awareness and support for active transport (Lindqvist et al., 2023). This suggests an opportunity to educate and influence parents not currently motivated by health benefits. By addressing perceived health threats and providing clear information on health benefits, parental attitudes can shift, potentially increasing active commuting among children.

A better financial situation was somewhat counter-intuitively associated with lower odds of being in the Never- or Sometimes-groups, compared to Always-group. In theory, active commuting should be the most affordable way to travel, so those with a better financial situation might be expected to use more expensive commute options more often than those with a poorer financial situation. However, a similar trend was also observed in Sweden, where adolescents from higher socio-economic status (SES) neighborhoods were 80 % more likely to use active commuting compared to adolescents from lower SES neighborhoods (Buli et al., 2022). Furthermore, a nationally representative study from Germany demonstrated that children from low SES background were less likely to cycle to school than their higher SES peers (Reimers, Marzi, Schmidt, Niessner, Oriwol, Worth & Woll, 2021). One possible explanation for the connection between a better financial situation and lower odds of being in the more passive commuter groups is the poorer accessibility to active commuting gear in lower socio-economic status groups.

Examining the Sometimes-group provides valuable insights into the factors influencing varying levels of activity in commuting. When comparing the Never-group with the Sometimes-group, only shorter commute distance and more active parental commuting were associated with higher odds of being in the Sometimes-group. When comparing the Sometimes-group to the Always-group, several factors were associated with higher odds of being in the Always-group rather than the Sometimes-group, including a more positive social norm, a better financial situation, and shorter commute distances.

These findings suggest that fewer factors differentiate those who are completely passive commuters from those who are only sometimes active, whereas more factors contribute to the likelihood of becoming a consistently active commuter. It is intuitive that longer commute distances lead to more passive commuting. However, it is noteworthy that the other significant factor distinguishing the Never- and Sometimes-groups was parental active commuting, highlighting the role of parents as behavioral role models for active commuting behavior. Additionally, the transition from irregularly active commuting to consistently active commuting is influenced by a broader range of factors, where the social norm is an especially strong predictor.

4.1. Strengths and limitations

We were the first to analyze how parental barriers and motivators are associated with active school commuting in Finland. The study also contributes to the research on the effects of environmental attitudes on pro-environmental actions. While prior research has studied motivators and barriers for active school commuting in different countries, it is important to note that countries with a high prevalence of active commuting display considerable diversity in both environmental and socio-cultural aspects, as highlighted by the Global Matrix 3.0 study (González et al., 2020a). Our research contributes to a more profound understanding of the determinants of active school commuting in a high-prevalence country with a cold climate. By adding to the existing literature, we help identify context-specific factors, which in turn allow for better differentiation between universal and unique influences on active commuting behaviors.

The sample consisting of participants from various regions of the country can be considered a strength of this study. The original sample was representative of the Finnish population regarding gender, age, and living area. We utilized a subsample targeting only people with school-aged children. In future studies, it would be beneficial to collect a representative sample specifically of families with school-aged children. However, the sample still covers several geographical areas and thus makes the results more generalizable compared to a sample from one or a few locations, which would be more affected by specific, local conditions.

Another strength of this study is the comprehensive approach that considered a large pool of possible predictors. This approach allowed us to identify which variables are the most important among several aspects. However, this exploratory approach also comes with limitations: the risk of type II error is a known issue in exploratory analyses.

The study was cross-sectional and relied solely on self-reported, subjective measures. This study design has both limitations and strengths. It provides insights into what people are thinking about the conditions, how they are perceiving them and how they are connected to their experienced behavior. However, objective measures of commute behavior could have offered more robust results regarding the association between subjective factors and actual behavior. Since this was a cross-sectional study and people's commute mode choices vary from week to week, we used a Likert scale to obtain an overall understanding of the most common commute patterns. We re-coded the scale into three categories, which led to a loss of detail. However, this trade-off is justified by the improved interpretability and clarity of the results. Future studies would benefit from incorporating objective measures, particularly longitudinal data, to mitigate the effects of socially desirable responses and common method bias, thereby providing more accurate and robust measures of commuting behavior.

One limitation of this study is its focus on parental factors influencing school commuting, potentially neglecting how children's own opinions might affect their commute choices. Research from the US and Spain has shown that children's and parents' perceptions of barriers to active commuting can differ significantly (Aranda-Balboa et al., 2021; Pfledderer et al., 2021). Parents tend to express greater concerns about factors such as distance, traffic safety, convenience, the built environment, safety related to crime, and weather conditions, while children and adolescents are more likely to emphasize physical, motivational, and social support barriers (Aranda-Balboa et al., 2021). Thus, even if parental concerns are addressed, children might still be demotivated from engaging in active commuting, though a child's enthusiasm could serve as a counterbalance to parental concerns (Rutberg & Lindqvist, 2019). Exploring the interactions between children's and parents' attitudes in different cultural settings would provide valuable insights for future research.

The choice of commute mode is influenced by a range of factors, and while our study aimed to provide a comprehensive view, we were unable to address all relevant aspects. Specifically, we did not ask separate questions for different active commuting modes, such as cycling versus skateboarding, nor did we explore how commuting habits might vary across different seasons. Future research could benefit from a deeper examination of the Sometimes-group, which is very diverse and includes individuals who either rarely or often engage in active commuting but do not have a consistent habit. There may be specific predictors for different types of irregular active commuters. For instance, some in the occasional active commuting group might only engage in active commuting during favorable weather conditions, when they are in a good mood, or if their parents are not commuting to work.

5. Conclusions

In conclusion, our study provides insights into the parental factors that influence their children's school commuting. Commute distance, social norms, weather conditions, health motivation, and financial situation were found to be the most significant determinants. However, concerns about climate change or pro-environmental attitudes did not impact active commuting.

These findings offer practical implications for policymakers and educators who seek to promote active school commuting. They contribute to the existing literature, by adding to existing literature about the determinants of active commuting in different contexts. We recommend focusing on shaping social norms, addressing weather-related barriers, and highlighting health benefits to encourage active commuting among children. Additionally, our study indicates that parental active commuting habits may affect their children's commuting behaviors, suggesting that interventions aimed at adults could also benefit their children. Future research should also consider how to address parental perceptions of acceptable commute distances. Environmental reasons should not be the primary motivator, as there is no evidence that they influence commute mode choice in this target group.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to cross-validate human-made grammar checks and improve some sentence structures. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for

the content of the publication.

CRediT authorship contribution statement

Marianna C. Melin: Writing – review & editing, Writing – original draft, Formal analysis. **Jarno Tuominen:** Supervision. **Paula Salo:** Supervision, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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