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Parental and adolescents' perspectives on environmental predictors of active commuting to school – findings from the ARRIVE mixed-methods study

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Background: Active commuting to school (e.g., walking or cycling) can contribute to an increase in daily physical activity time of adolescents which is associated with positive health effects. However, it is known that the perceived barriers related to the physical and social environment hinder adolescents in participating in active commuting. To obtain more information about these barriers, and therefore be able to address them in the future, the present study aims to investigate how parents' and adolescents' perception of the physical and social environment is associated with (active) commuting to school.

Methods: The ARRIVE study consists of a quantitative online survey with parent-adolescent dyads ($N = 517$) followed by qualitative interviews with adolescents and parents ($N = 32$). The quantitative part examined adolescents' travel behaviour to and from school and its predictors. The qualitative part sought to explore the decision-making process in families regarding transport mode choice. To evaluate predictors of active commuting to and from school binary logistic regression analysis and qualitative content analysis were performed.

Results: In the quantitative part, we found that adolescents and parents perceive especially having much luggage to carry as crucial for adolescents' active travel. Besides this barrier on active commuting to and from school found in the questionnaires, parents and adolescents reported lack of social support, weather, convenience, lack of traffic safety and getting a lift as barriers in the interviews.

Conclusion: We found differences and similarities in the perceived barriers of active commuting regarding the physical and social environment between adolescents and parents. To encourage adolescents

to actively commute to school, the perception of the physical and social environment, especially from parents, be taken into account.

KEYWORDS

active commuting, travel behaviour, adolescents, parents, physical activity

Introduction

Physical activity (PA) contributes to several health benefits such as better cardiovascular fitness, helps to maintain a healthy body weight, and has positive effects on mental health (Gordon-Larsen et al., 2005; Jacob et al., 2021; Larouche et al., 2014). However, only 22.4% of girls and 29.4% of boys between the ages of 3 and 17 achieve the World Health Organization's (WHO) recommended amount of daily moderate-to-vigorous PA (MVPA) time of 60 min (Finger et al., 2018; WHO, 2022).

Using PA such as walking or cycling as a means of transport to school or other destinations in daily life, which is defined as active travel, is an important source of daily PA for young people (Larouche et al., 2014). Furthermore, people who follow an active lifestyle in childhood are more likely to maintain this active life in adulthood (Yang et al., 2014). In Germany, 50% of children under 9 years and 27% of adolescents aged 10–19 years cover their daily trips in the parental car (Reimers et al., 2021). Replacing passive transport modes (e.g., parental car, bus, or train) with active ones (e.g., walking, cycling, skateboarding, scootering, or inline skating) can contribute to an increase in daily PA in children and adolescents without requiring them to spend a large amount of additional leisure time on PA, as they have to cover several ways a day anyway (Chillon et al., 2010).

Travel behaviour, and thereby active travel, is influenced by several predictors and barriers, especially related to the physical and social environment (Panter et al., 2008; Sallis et al., 2006). *Physical environmental factors* relate to the environmental circumstances in which adolescents commute, and include aspects such as the infrastructure (e.g., walking and biking facilities), safety aspects (e.g., road safety, darkness, or heavy traffic) or distance (Aranda-Balboa et al., 2021; Forman et al., 2008; Molina-Garcia et al., 2016; Panter et al., 2008). *Social environmental factors* describe mostly planning and psychosocial aspects and involve themes such as mood and social support from others, for example walking together with parents or peers (Aranda-Balboa et al., 2021; Huertas-Delgado et al., 2019; Sallis et al., 2006).

A number of studies already addressed the topic of the physical and social environment related to travel behaviour in youth (Brindley et al., 2023; Buttazzoni et al., 2023; Klos et al., 2024). For example, a study on active travel to school shows that greater distance to school and the perceived importance of having other people to walk with is negatively associated with active travel to school while living closer to school, road safety and neighbourhood safety are positively associated with active school travel (Brindley et al., 2023). Adolescents perceive different barriers that hinder them in using active transport modes (Buttazzoni et al., 2023). These barriers include low motivation or a lack of support from the social environment (Buttazzoni et al., 2023). Further, another study shows that the

perception of the environment differs between various levels of urbanisation. For example, adolescents living in urban regions perceive higher availability of sports and recreational facilities, walking and cycling infrastructure as well as accessibility to shopping facilities and bus stops that can be reached by foot compared to adolescents living in rural areas. Additionally, adolescents living in rural areas feel safer from crime and perceive that there are fewer cars in their neighbourhood (Klos et al., 2024). In addition to the adolescents' perception of the environment, the parents' perspective also plays a role when deciding on transport modes (Westman et al., 2017).

Since parents are mostly responsible for their children and adolescents, they have an impact on their children's travel behaviour (Beck et al., 2023; Cheng et al., 2014; Garriguet et al., 2017; Jacobi et al., 2011). Parents of primary school children (grades 1–6) were found to be the main decision-makers on their children's transport mode (Forsberg et al., 2020). In contrast, adolescents often decide for themselves on their preferred transport mode (Tristram et al., 2023). However, mothers and fathers seem to affect decisions on travel behaviour through behaviour modelling, social support, or perceived barriers (Beets et al., 2010; Reimers et al., 2019). Similarly to adolescents, parental barriers to active travel relate to the physical and social environment (Ahlport et al., 2008; Aranda-Balboa et al., 2020). For example, the most common barriers stated by parents in a study with Spanish adolescents were distance to school and dangerous intersections (Huertas-Delgado et al., 2017). Further, adolescents' choice on using active transport modes to and from school seems to increase with strong family support (Loureiro et al., 2022).

Previous research further shows that parents and adolescents perceive physical and social environmental barriers to active travel differently (Wilson et al., 2018). Mothers and fathers primarily perceive distance as well as social interaction as barriers to the use of active transport modes while adolescents perceive poor aesthetic (e.g., no trees on the way) as an important barrier (Wilson et al., 2018). Further, children and adolescents state higher physical, motivational and social support barriers to the use of active transport modes to school than parents (Crawford et al., 2017). In another study, parents mention distance, a lack of traffic safety, high convenience as well as factors related to the physical environment, crime issues and bad weather (e.g., rain or snow) as barriers to active travel (Aranda-Balboa et al., 2021).

Still, most studies only refer to younger children by neglecting adolescents (Macdonald et al., 2019; Terron-Perez et al., 2018). Further, existing studies have either examined the association between barriers perceived by parents or adolescents and travel behaviour in adolescents (Aibar Solana et al., 2018; Huertas-Delgado et al., 2019). Linking the perspectives that parents and adolescents' have on the physical and social environment helps

to gain a deeper understanding of adolescents' transport mode choices, which is essential when it comes to encouraging young people to use more active transport modes instead of passive ones. Therefore, the present study aims to investigate how parents' and adolescents' perceptions of the physical and social environment are associated with (active) commuting to school in adolescents. Since physical environmental characteristics as well as (psycho-)social factors seem to be important predictors of active travel in children and adolescents (Hume et al., 2009), we hypothesize that the parental and adolescents' perception of physical and social environmental barriers are associated with transport mode choice in adolescents.

However, there are several studies that examine active travel to school from different perspectives. To the best of our knowledge, this study seems to be unique by using a mixed-methods approach in this field. Further, only few studies relate to adolescents while most research is focuses on younger children. Through the combination of the adolescents' and parental perspective, the mixed-methods design and the specific focus on adolescents, the present study adds a noteworthy contribution to the current literature on active travel to school.

Materials and methods

Study design

The analyses are based on the ARRIVE (Active tRavel behaviouR in the famIly enVironmEnt) study, a mixed-methods cross-sectional study from Germany. The study includes quantitative online surveys ($N = 517$) and qualitative semi-structured interviews ($N = 32$). We chose this design to gather quantitative data on predictors of active commuting to and from school in adolescents, and qualitative information about intra-familial dynamics and processes that impact the behaviour (Reimers et al., 2022).

The mixed-methods framework offers the opportunity to combine quantitative questionnaires and qualitative semi-structured interviews in a constructive way (Creswell and Clark, 2011). A mixed-methods approach further has been proven to be useful for ensuring content validity since the quantitative and qualitative method, and their results, inform each other (Newman et al., 2013). Since the ARRIVE study was planned in advance, i.e., the quantitative and qualitative part were considered and designed from study planning on, the present article is driven by a quantitatively concurrent design, also called 'QUAN + qual design' (Johnson and Christensen, 2014). By supplementing quantitative questionnaires ('QUAN') with qualitative semi-structured interviews ('qual'), both conducted as part of the ARRIVE study, a detailed understanding of the perceived physical and social environmental barriers by parents and adolescents can be achieved, which would not be possible by using only one of these methods.

The ARRIVE study received ethical approval from the ethics commission of the Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany (Reg. 249_21B) and was in accordance with the 1964 Declaration of Helsinki. All participants gave informed consent to participate in this study.

Quantitative study

Data collection

The quantitative part of the present study includes an online survey with parent-adolescent dyads ($N = 517$). In total, 1747 parents were invited to fill out the questionnaire of which 518 completed the survey. 168 parents were screend out due to the wrong age of the child. 178 parents cancelled answering and 883 were not available in the survey period. The response rate was 27.9%. Therefore, 518 parents and 518 adolescents completed the online questionnaire. One adolescents was excluded due to their reported diverse gender since $N = 1$ was too small to allow for a separate analysis. Data collection took place in June 2021. Adolescents and parents were recruited with regard to age, sex/gender, educational status (parents) or school type (adolescents) and place of residence (e.g., living in a rural or urban region). All participants were recruited by an existing nationwide online panel (forsa.omninet) which is representative for the German population. As forsa represents an independent private research institute that recruits participants throughout Germany, it is unlikely that participants e.g. live in the same neighbourhoods or that the recruited adolescents attend the same schools, for example. Nevertheless, we cannot completely exclude those kind of overlaps in our study but due to the low probability of their occurrence, these overlaps were not considered in our study.

Parents were recruited via telephone interviewing. After giving written informed consent via e-mail to participate in the study, they received an online link via e-mail which led to an online survey they were asked to answer. The survey was separated into two parts: First, parents were informed about the aims and content of the study and responded to the first section. After they had completed their part, adolescents received the second section of the questionnaire. Adolescents were informed about the study and gave their agreement to participate as well. It took participants about 15 min to complete the online survey. Study participants did not receive any financial rewards for participating. All data has been anonymised.

Measures

Detailed information on the questionnaire for the ARRIVE study can be found elsewhere (Reimers et al., 2022). First, parents were asked to answer questions about socio-demographic information (e.g., age and sex/gender) and predictors of their child's travel behaviour. Adolescents were then asked to answer questions about their travel behaviour and predictors. The current investigation focused on adolescents' travel behaviour and social and physical environmental barriers perceived by parents and adolescents.

Travel behaviour

To assess travel behaviour, we modified the "New Version of the Mode and Frequency of Commuting To and From School" questionnaire by Segura-Diaz et al. (2020). This questionnaire is a reliable and feasible tool to assess active travel in Spanish adolescents ($\kappa = 0.61-0.94$) (Segura-Diaz et al., 2020). We added further aspects from an existing German scale on active travel, and translated the questionnaire into German (Eggs et al., 2018). Adolescents were asked to report on their usually used transport

mode to and from school. They were able to answer the two questions (to school and from school) with “by foot”, “by bike”, “by e-bike”, “by car”, “by motorcycle”, “by bus”, “by train/metro” or “other transport mode”. We build a dichotomous variable to assess the ways travelled actively (“by foot”, “by bike”, “by e-bike”) and passively (“by car”, “by motorcycle”, “by bus”, “by train/metro”). For our analysis, we used the adolescents’ travel mode as the dependent variable which was coded binary with 1 (adolescents travelling actively to and from school) and 0 (adolescents travelling passively to and from school). Our sample included 21 adolescents who changed their transport mode from active on the way to school to passive on the way from school or *vice versa*. These adolescents were assigned to the group of active travellers since they also benefit from positive health effects of PA and contribute to the reduction of CO₂ emissions compared to adolescents travelling both ways passively.

Physical and social environment

For the analyses in the present study, we considered two subscales of the ARRIVE questionnaire which assess barriers perceived (1) by adolescents and (2) by parents regarding active commuting to and from school. For the parental questionnaire, we used a modified version of the “Parental Perception of Barriers Towards Active Commuting to School (PABACS)” scale (Huertas-Delgado et al., 2019). In 207 parents, the questionnaire showed good internal consistency ($\alpha = 0.86$), moderate reliability (ICC = 0.51–0.55) and moderate validity (Huertas-Delgado et al., 2019). For the adolescents’ questionnaire, we used a modified version of the “Barreras percibidas en el desplazamiento activo al centro educativo (BATACE)” scale (Molina-Garcia et al., 2016). The BATACE showed good test–retest reliability (ICC range: 0.68–0.77) and internal consistency ($\alpha = 0.59$ –0.76) in a sample of 465 adolescents (Molina-Garcia et al., 2016). The scale of adolescents consists of 18 items while the parental scale includes 24 items (Table 1). For example, adolescents were asked to answer questions such as “Walking or cycling is difficult for me if there are neither sidewalks nor cycle paths.” (Physical environment). Parents were asked “I would not allow my child to walk or cycle if there were no other children for my child to cycle with.” (Social environment). On a 4-point scale, adolescents and parents were able to decide on how much they agreed with the question (from 1 “do not agree at all” to 4 “agree at all”). The items of the two subscales (parents and adolescents) were summarised as barrier categories (metric variables) on the basis of previous literature (Huertas-Delgado et al., 2019; Molina-Garcia et al., 2016) and then clustered according to the physical and social environment. Regarding these barriers, the distance has a specific role since research shows that there is a difference between the actual and the perceived distance (Hernández and Witter, 2015). In our study, the actual distance was assessed in the parental questionnaire (“How far is your child’s school from your home?”) while the perceived distance was assessed in both the adolescents’ (“Walking or cycling is difficult for me when the distances are too far”) and the parental questionnaire (“I would not allow my child to walk or cycle if the distance was too far”). The categorisation of items and barriers as well as the clustering of barriers according to the physical and social environment can be seen in Table 1. To

evaluate the categorisation of the questionnaire items to the physical and social environmental barriers we calculated Cronbach’s alpha for each category (Table 1). We categorized Cronbach’s alpha as acceptable if it was >0.6 .

Analyses

For all analyses, the statistical software IBM SPSS Statistics for Windows version 29 (IBM Corporation, Armonk, NY, United States) was used. We conducted binary logistic regression analyses predicting travel behaviour to and from school in adolescents from parent- and adolescent-perceived physical and social environmental barriers to active travel. Regarding the regression, we used the adolescents’ travel mode, as described above, as the dependent variable. We inserted the independent variables in one block: Co-variables (age, sex/gender, distance and urbanisation), social environmental barriers (motivational barriers, lack of social support and convenience) and physical environmental barriers (built environment, lack of traffic safety, crime-related safety, weather, perceived distance and heavy luggage). The two variables sex/gender and urbanisation were categorical while the others were metric. In both categorical variables, the first category was used as reference in the regression (male for sex/gender and city for urbanisation). Effect sizes were categorised based on the Odds Ratio (OR) with OR = 1.5–2 indicating a small effect, OR = 3.0–3.5 indicating a medium effect and OR = 4.0–7.0 indicating a strong effect (Chen et al., 2010). Statistical significance was set to $p < 0.05$.

Qualitative study

Data collection

For the semi-structured interviews, a guideline was used to structure the adolescents’ as well as the parental interviews. This guideline focused on adolescents’ travel behaviour and potential influencing factors on it. More detailed information on the interview guideline can be found elsewhere (Reimers et al., 2022; Renninger et al., 2023).

The collection of qualitative data took place between September and November 2021. Adolescents and their parents ($N = 32$) were recruited as a convenient sample via social contacts of the researcher and with respect to socioeconomic status, migration background, sex/gender, and living area in Germany. To ensure diversity across school types or residential area, we recruited participants not only within the circle of one researcher but from several members of the research team who themselves lived in different cities and urbanization types. This enabled us to reduce the likelihood of the formation of nests within our sample. Additionally, theoretical sampling methods were used for recruitment (Nagl-Cupal, 2013). Before starting the interviews with participants, we conducted sample interviews to assess and refine the interview guideline and methodology, aiming to test the efficacy of the approach for interviewers. After recruiting families who gave their written consent via e-mail to participate in the study, they received a link via e-mail to an online meeting (zoom.us). Adolescents and their parents were informed about the study and allowed to refuse answering any question

TABLE 1 Categorisation of physical and social environmental barriers to active travel perceived by parents and adolescents.

Adolescents' items	Parental items
Walking or cycling is difficult for me if ...	I would not allow my child to walk or cycle if ...
Physical environmental barriers	
Built environment (Adolescents: Cronbach's $\alpha = 0.715$; Parents: Cronbach's $\alpha = 0.760$)	
- ... there are neither sidewalks nor cycle paths	- ... there were no sidewalks or they are in poor condition
- ... there is no place to park bikes/scooters etc. safely	- ... there were no cycle paths or they are in poor condition
- ... pedestrians occupy the cycle paths	- ... there was no place to park the bike
- ... there are one or more dangerous crossovers	- ... crossovers and road crossings were not safe
- ... there are too many hills	
Lack of traffic safety (Parents: Cronbach's $\alpha = 0.701$)	
- ... there is too much traffic	- ... the cars were going very fast
	- ... there were a lot of traffic on the way
	- ... there were no crossing guards or police officers at road crossings
Crime-related safety (Adolescents: Cronbach's $\alpha = 0.629$)	
- ... the routes are unsafe or dangerous due to crime (e.g., people who scare me, criminals, and rioting people)	- ... there were violence and/or crime in the area
- ... the paths are not well lit	
- ... there are dogs on the way that scare me	
Weather (Parents: Cronbach's $\alpha = 0.775$)	
- ... I get too hot and sweaty, or it always rains	- ... it was too hot/cold outside
	- ... it rained/snowed
Perceived distance	
- ... the distances are too far	- ... the distance was too far
Heavy luggage	
- ... I have a lot of things to carry	- ... if my child carries a lot of weight in the backpack and the backpack is too heavy
Social environmental barriers	
Motivational barriers (Adolescents: Cronbach's $\alpha = 0.616$; Parents: Cronbach's $\alpha = 0.757$)	
- ... I do not enjoy walking or cycling	- ... my child found it boring to walk
- ... the route is boring	- ... my child found it boring to cycle
Lack of social support (Adolescents: Cronbach's $\alpha = 0.595$; Parents: Cronbach's $\alpha = 0.887$)	
- ... other children are not walking or cycling	- ... there were no other children for my child to cycle with
- ... it is not <i>cool</i> to walk or cycle	- ... there were no other children for my child to walk with
	- ... there were no other adults cycling

(Continued on the following page)

TABLE 1 (Continued) Categorisation of physical and social environmental barriers to active travel perceived by parents and adolescents.

Adolescents' items	Parental items
	- ... there were no other adults walking
	- ... there were no other parents cycling together with my child
	- ... there were no other parents walking together with my child
Convenience (Adolescents: Cronbach's $\alpha = 0.453$; Parents: Cronbach's $\alpha = 0.633$)	
- ... it is easier to drive or to be taken	- ... it is more convenient to drive than to cycle
- ... too much advance planning is necessary	- ... it is more convenient to drive than to walk
	- ... my child was going to be away for a very long time
	- ... other activities/commitments made it difficult for my child to walk or cycle

during the interview. Mothers, fathers and adolescents were interviewed individually and there was no predetermined order. After answering all open-ended questions, the audio files of the interviews were saved and later transcribed verbatim by student assistants following the guideline according to [Dresing and Pehl \(2018\)](#). For the transcription of data, the software f4transcript (audiotranskription.de) was used. Additionally, participants were asked to complete a short questionnaire about their socio-demographic attributes, such as age, employment, and living area. All interviews lasted between 11 and 38 min due to the varying degrees of the participants' reports. Study participants did not receive any financial rewards for participating. All data has been anonymised.

Analyses

The interviews were coded independently by two researchers using the f4analysis software (audiotranskription.de). After that, the interview data were analysed deductively based on the categorization of physical and social environmental barriers ([Table 1](#)) using Mayring's Qualitative Content Analysis ([Mayring, 2015](#)). We chose this method to identify whether—and which physical and social environmental barriers regarding active travel were reflected in the interviews. The results of the qualitative analysis were discussed by two researcher and in order to check the accuracy of the obtained results.

Mixed-methods design

The "QUAN + qual design" was chosen for the present study ([Johnson and Christensen, 2014](#)). After collecting the data, quantitative and qualitative data were analysed independently, and brought together during the results phase which represents the "point of integration" ([Schoonenboom and Johnson, 2017](#)). We chose this mixed-methods design to extend the breadth and range of inquiry and seek corroboration of the findings.

Results

Quantitative part

Characteristics of study population

The study population of the quantitative part included 517 adolescents (13.1 ± 1.3 years), of whom 254 (49.8%) were female. Further, 517 parents (47.7 ± 5.3 years; 49.9% mothers) participated in the study. Most of the adolescents visited a secondary school (56.9%) and half of the parents had a high school degree (51.5%). Regarding the residential area, the majority of participants lived in rural areas or villages (30.8%). Overall, 47% of the adolescents travelled actively to school while 47% were active travelers on the way from school. [Supplemental Material Appendix S1](#) shows all sociodemographic data of participants in the quantitative part. Further, the following table shows the perception of barriers regarding adolescents' active commuting to and from school by adolescents and parents ([Table 2](#)). All variables are metric.

Association between the perceived barriers and travel behaviour in adolescents

A binary logistic regression was performed to assess the associations between active commuting in adolescents on the way to/from school and perceived barriers related to the physical and social environment ([Table 3](#)). The binary logistic regression model for adolescents was statistically significant, $\chi^2(16) = 239.43$, $p < 0.001$, resulting in a large amount of explained variance ([Backhaus et al., 2006](#)), as shown by Nagelkerke's $R^2 = 0.503$. Further, the model for parents was statistically significant $\chi^2(16) = 238.07$, $p < 0.001$, resulting in a large amount of explained variance ([Backhaus et al., 2006](#)), as shown by Nagelkerke's $R^2 = 0.501$.

Of the 13 variables entered into the regression model, few showed significances in relation to adolescents' active commuting to/from school: distance ($p < 0.001$) in the parental model, and heavy luggage in both models (adolescents $p = 0.019$; parents $p = 0.008$) as well as living in a rural area/village in both models

TABLE 2 Perception of barriers regarding adolescents' active commuting to and from school by adolescents and parents.

Barriers to active travel	Adolescents (<i>M</i> ; <i>SD</i>)	Parents (<i>M</i> ; <i>SD</i>)
Physical environmental barriers		
Built environment	2.53 ± 0.72	2.43 ± 0.74
Lack of traffic safety	2.58 ± 1.00	2.40 ± 0.74
Crime-related safety	2.56 ± 0.81	3.38 ± 0.84
Weather	2.75 ± 1.03	2.14 ± 0.86
Perceived distance	2.74 ± 1.08	2.38 ± 1.05
Heavy luggage	3.16 ± 0.87	2.59 ± 0.95
Social environmental barriers		
Motivational barriers	2.32 ± 0.90	1.34 ± 0.56
Lack of social support	1.91 ± 0.84	1.60 ± 0.61
Convenience	2.57 ± 0.83	2.08 ± 0.56

(adolescents $p < 0.001$; parents $p < 0.001$). All other variables reached no significances.

From the parental view, adolescents are more likely to travel actively to/from school if the distance is shorter OR = 0.763 (95%-CI [0.716, 0.813]). Further, adolescents are more likely to travel actively to/from school if parents consider the barrier of heavy luggage to be lower, OR = 0.662 (95%-CI [0.466, 0.934]). Last, adolescents are less likely to travel actively if they live in a rural area or village OR = 0.274 (95%-CI [0.146, 0.513]). From the adolescents view, adolescents are more likely to travel actively to/from school if they consider the barrier of heavy luggage to be lower, OR = 0.660 (95%-CI [0.489, 0.897]). Further, adolescents are less likely to travel actively if they live in a rural area or village OR = 0.267 (95%-CI [0.142, 0.500]). Overall, effect sizes according to OR were small. Correlations between predictor variables were low ($r < 0.50$), indicating that multicollinearity was not a confounding factor in the analysis in both parents and adolescents.

Mixed-method results (QUAN + qual)

Characteristics of study population of the qualitative part

The study population of the qualitative part included thirteen families, consisting either of mother, father and adolescent or, in cases of single-parent families, of one parent and his/her son or daughter. Due to one additional interview with an adolescent, altogether 13 adolescents (6 female; 7 male) aged between 11 and 14 years participated in the study. Because not all families could be surveyed with both mother and father, we interviewed seven fathers (44 ± 3.4 years) and twelve mothers (44 ± 3.3 years). Regarding the residential area, most families lived in a rural area or village. The sociodemographic data of participants in the qualitative part can be found in [Supplemental Material Appendix S2](#).

Following the mixed-methods design, qualitative findings are reported combined with the previously obtained quantitative results. To follow and focus on the mixed-methods design, we decided to examine if quantitative findings are reflected in the interviews, or where variations between the quantitative questionnaires and qualitative interviews can be identified.

Results of the quantitative and qualitative part

With regard to the quantitative study, our results show associations between distance, living in a rural area/village and heavy luggage on the one hand and travel behaviour on the way to and from school in adolescents on the other hand.

In the qualitative interviews, background information about the barriers distance and heavy luggage which were found in the questionnaires, and the reasons behind the perception of these barriers have been addressed. First, adolescents reported that if the distance is too long, they will not use walking or cycling as transport modes to and from school:

“Taking the car in the morning is difficult because my parents usually have to work. And walking would not work either because it's too far. Cycling would also be too far. That's why the bus is the only option.” (F3, boy, bus)

Then, adolescents reported that luggage plays a role in the decision for or against active commuting to school:

[...] and the books are relatively heavy and I think I would not be able to do it [walking or cycling], also in terms of my strength.” (F8, girl, car)

Additionally, we found in the interviews, other than in the questionnaires, that the weather, a lack of social support and convenience have an influence on adolescents' decision on their

TABLE 3 Associations between adolescents' and parent's perceived barriers on adolescents' active commuting for the way to and from school.

Barriers	Adolescents				Parents			
	Regression coefficient β	Odds Ratio	95% CI	<i>p</i> -value	Regression coefficient β	Odds Ratio	95% CI	<i>p</i> -value
Co-Variables								
Age	-0.007	0.993	0.834–1.181	0.934	-0.084	0.919	0.769–1.098	0.354
Sex/gender male	0.398	1.489	0.932–2.378	1.489	0.350	1.419	0.890–2.263	0.141
Sex/gender female	-0.398	0.672	0.421–1.072	0.096	-0.350	0.704	0.442–1.123	0.141
Distance	-0.274	0.760	0.712–0.812	0.760	-0.270	0.763	0.716–0.813	<0.001*
Urbanisation medium-sized town	0.128	1.137	0.581–2.224	0.708	0.155	1.167	0.595–2.292	0.653
Urbanisation small town	-0.011	0.989	0.532–1.839	0.973	-0.037	0.963	0.514–1.806	0.907
Urbanisation rural area/village	-1.322	0.267	0.142–0.500	<0.001*	-1.296	0.274	0.146–0.513	<0.001*
Social environment								
Motivational barriers	0.145	1.156	0.829–1.612	0.392	0.003	1.003	0.590–1.707	0.991
Lack of social support	-0.193	0.824	0.592–1.148	0.253	-0.309	0.734	0.417–1.292	0.284
Convenience	-0.329	0.720	0.498–1.042	0.081	0.075	1.078	0.581–2.000	0.812
Physical environment								
Built environment	0.207	1.230	0.724–2.091	0.444	-0.187	0.829	0.528–1.304	0.418
Lack of traffic safety	-0.194	0.823	0.600–1.129	0.228	0.350	1.419	0.920–2.188	0.113
Crime-related safety	0.144	1.155	0.765–1.743	0.493	-0.208	0.812	0.583–1.132	0.219
Weather	0.117	1.124	0.852–1.483	0.409	0.055	1.056	0.754–1.480	0.749
Perceived distance	-0.136	0.873	0.656–1.160	0.348	-0.142	0.868	0.665–1.134	0.299
Heavy luggage	-0.415	0.660	0.466–0.934	0.019*	-0.412	0.662	0.489–0.897	0.008*

Note: **p* < 0.05.

transport mode to and from school. First, adolescents reported that the weather has an influence on their travel behaviour:

“[...] and when it rained heavily, he [father] used to drive me.” (F2, boy, bus)

“[...] they [parents] always say that I should go with the car if it is raining. [One day] it was raining heavily and I said I can walk but my parents said I should go with the car.” (F13, boy, walking)

Further, perceiving a lower lack of social support promotes adolescents in using active transport modes:

“I would ride my bike if my friend would also take the bike because she lives nearby.” (F12, girl, tram)

Last, the results of the interviews indicate that convenience can affect adolescents' decision-making on transport mode choice which was not directly revealed in the questionnaires:

“[...] and then you do not feel like pedalling your legs for another half an hour, so as I said, it’s even more convenient to take the train.” (F12, girl, tram)

Besides these barriers to active commuting to and from school, we identified further barriers that were not captured by the quantitative questionnaires. Some adolescents reported that scarce time resources, especially in the morning, are a barrier to cycling to school:

“I can get up later if we drive, so we decided that I always get a ride in the morning.” (F8, girl, car)

In addition to the perception of barriers in adolescents, we further investigated barriers perceived by parents. The following aspects were captured by the parental perspective. With regard to the quantitative study, our results show associations between distance and heavy luggage with travel behaviour perceived by parents. In the qualitative interviews, we found further information on the barrier heavy luggage. For example, parents reported that if their adolescent has to carry a heavy school bag, they would give them a lift in the car:

“By bus? No. I drive him sometimes, rarely. For example, if he has to have all the books with him [...]” (F1, mother, car)

Besides the barriers stated above, we found that parents further reported in the interviews that the factors weather, lack of traffic safety, convenience and a lack of social support were crucial for choosing a transport mode. However, these barriers did not show up in the questionnaires. For example, parents perceive that bad weather hinders their child to use active transport modes to school:

I: “Has there ever been a day when you drove your daughter to school in the car?”

R: “Yes, but not often. Only if it rained heavily.” (F7, mother, walking)

Further, a mother described that she is concerned about the traffic safety on her child’s way to school:

I: “What was there to worry about?”

R: “There were no traffic lights there until five weeks ago. So you always had to be very careful when crossing the road.” (F3, mother, bus)

The following example shows that convenience has an influence on the preferred transport mode:

“Simply because you have the car and for convenience and because you are more flexible.” (F5, mother, car or bus)

Additionally, the following interview sequence indicates that a lack of social support resulted in the adolescent deciding to use passive transport modes to school:

“Because she does not want to ride her bike alone. She only wants to do that with a friend, and her friend does not want to because it’s too cold outside.” (F12, father, tram)

Last, we found barriers in the parental interviews that were not addressed in the questionnaires at all. These barriers were scarce time resources, darkness and giving the child a lift. For example, parents mentioned scarce time resources as having an influence on the transport mode choice:

“If I drive [adolescent] with the car in the morning, which is on my way to work anyway, then we simply save almost three quarters of an hour in the morning. [...] It’s the time factor, you can sleep longer in the morning.” (F8, mother, car)

Besides that, we found that parents perceive darkness as a barrier to active commuting to school:

“We do not have any cycle paths here. That mean she has to cycle on the road. Some of them are not lit. Of course, we have concerns when he drives in the dark that he will not be seen by the cars.” (F9, father, bus)

Last, in the following example, a father reported that he sometimes takes his son to school when he has to drive anyway:

I: “And then [adolescent] said that he also gets a ride from time to time?”

R: “In rare cases, when it is easier. If I have to go that way anyway, I can take him with me.” (F3, father, bus)

Discussion

The present study aimed to investigate how parents’ and adolescents’ perception of the physical and social environment is associated with (active) commuting to school in adolescents. To the best of our knowledge, this is the first study that takes a closer look on the perceived barriers to adolescents’ active commuting to and from school regarding the physical and social environment by combining the adolescents’ and parental perspective using a mixed-methods approach.

We propose that the parents’ and adolescents’ perception of physical and social environmental barriers is associated with transport mode choice in adolescents. This was confirmed by our results since we found various barriers to adolescents’ use of active transport modes to and from school related to the physical and social environment. Our results show that there are barriers to adolescents’ use of active transport modes to and from school that became apparent in both the quantitative questionnaires and qualitative interviews. We also found barriers that were not significant in the quantitative regression analysis and did appear in the qualitative interviews, or *vice versa*.

Our study highlights the importance of combining the perspectives of both adolescents and parents, as the results

reveal that there is different perception of the physical and social environment in terms of travel behaviour to and from school between adolescents and their parents. Regarding the perspective of adolescents, our results indicate that having much luggage to carry plays a role in adolescents' decision-making on transport mode choice to and from school. Further, our results only indicate a significant association between living in a rural area/village and transport mode choice in adolescents. Previous studies show that active travel in adolescents was highest in cities compared to areas, small-towns and medium-sized towns, especially for the way to shopping facilities (Marzi et al., 2023). Further, the increased distances adolescents from rural areas must cover to reach school may also have an impact on their decision-making on active commuting (Klos et al., 2024). Therefore, it should always be taken into account that the environment (e.g., rural or urban area) in which adolescents move as well as the multidimensionality of the perception of barriers play a role in adolescents' engagement in active travel, also regarding the way to and from school. Regarding the parental perspective, our results indicate that the distance, living in a rural area/village and having much luggage are factors that seem to influence how adolescents commute to and from school. This stays in line with further research showing that common barriers in active school transportation in a rural environment for children and adolescents aged 10 to 17 (from the parental and children's own perspective) are distance and heavy load to carry (Wex et al., 2023). In contrast to this, other research on primary and secondary school children's and their parent's perception on safe routes to school indicates that the perception of road safety is the key barrier when deciding on walking or cycling to school, rather than the distance to school (Swain et al., 2023). A possible explanation for the alongside of different relevancies of various barriers may be the living environment of adolescents and parents since a cross-continental comparison study shows that the perception of road safety varies between different continents (D'Haese et al., 2015).

When looking at the adolescents' and parental perspective, it is noticeable that having much luggage to carry, longer distances to school and living in a rural area are the main factors in adolescents and parents that hinder adolescents in active commuting to school. This raises the question of what it needs to promote adolescents in active commuting regarding these barriers. First, one option to reduce the heavy load that adolescents have to carry may be the increase of locker at school so that students can leave their books etc. in school while travelling home. Additionally, the digitalisation can contribute to a reduction of books and paper that makes the bag of students heavy. Second, when looking at the distance, there may be a chance in using e-bikes for adolescents. For example, the use of e-bikes could help adolescents to travel more actively to school because they can cover greater distances more quickly, sweat less or climb hills more easily (Nguyen et al., 2023). In addition to the use of e-bikes, which would enable adolescents to cover longer distances, the use of e-cargo bikes could make it further possible to transport heavier or more luggage. Therefore, the two perceived barriers of long distances and heavy luggage could be reduced by the promotion of using e-cargo bikes.

However, when considering the way to and from school, it becomes apparent that there is a coexistence of different perspectives, roles and responsibilities between adolescents and parents regarding the perception of physical and social environmental barriers. Further, they have different perspectives on transport behaviour, especially in terms of involvement on the decision for transport modes, which can have an impact on active commuting in adolescents. For example, we found that adolescents and parents perceive the distance, living in a rural area and heavy luggage as barriers. This became apparent in both the quantitative part and the interviews with adolescents. Regarding the interviews, most adolescents reported heavy luggage as a barrier for active commuting while parents reported that they perceive a lack of traffic safety as a main barrier. An explanation for this diverse perception of factors that hinder adolescents in active commuting to school could be based on interfamilial structures and decision-making processes on transport mode choices which are very complex (Niermann et al., 2018). For example, especially during adolescence young people strive for more self-determination and autonomy, and try to distance themselves from their parents (Sting, 2020). This increasing detachment of young people from their parents may be a reason for the different perception of barriers between adolescents and their parents, and the associated choice of various transport modes to and from school.

Additionally, we identified further barriers in the interviews (e.g., scarce time resources in adolescents and parents or giving the child a lift and darkness in parents) that were not observed in the questionnaires or that we did not inquire about. A possible explanation for finding additional barriers may be situated at the methodological level. During the interviews, the researcher got the chance to ask more specific and follow-up questions. Therefore, more detailed information on separate aspects could be provided. The deeper reflection in the interviews seems to make it possible for the participant to name aspects that they could not state spontaneously or that was not part of the questionnaire. The restrictive character of questionnaires narrows possible answer options (Patten, 2014). Since questionnaires aiming to capture mobility behaviour do not comprehensively survey all potential barriers to active travel, it seems beneficial to combine quantitative questionnaires and qualitative interviews to get a deeper understanding of the decision-making process on travel behaviour, and to also disclose the perceived barriers articulated by adolescents and parents themselves. These results may potentially lead to revisions or new developments of questionnaires on active travel barriers.

The outcomes of the present study can guide policymaker to design interventions that aim to promote active commuting to school in adolescents. These interventions should consider the perception of barriers by both parents and adolescents alike. In particular, distance seems to have an impact on whether adolescents use active transport modes or not (D'Haese et al., 2011; Duncan et al., 2016; Macdonald et al., 2019). Interventions that aim to promote active commuting to and from school in children and adolescents should focus especially on those who live within a distance of 3.0 km for cycling and 1.5 km for walking away from school (D'Haese et al., 2011). In addition to these aspects related

to the physical environment, interventions should also address the social and individual environment of adolescents, motivational aspects for example, that increase their engagement in active travel. For example, in an intervention where “gamification” on the way to school was used, the proportion of children and adolescents who walked or cycled to school increased due to the incentives on the way (Coombes and Jones, 2016). In summary, there is still potential for the promotion of active travel in adolescents regarding aspects encompassing the distance, or fast and safe cycling paths.

Last, regarding the methodological level, aspects that appeared in the quantitative and qualitative analysis confirm the benefit of the mixed-methods approach as the results of the quantitative questionnaires can be explored in more detail by the qualitative interviews. Further, the mixed-methods design made it possible to have a more comprehensive understanding of the perception of the physical and social environment and its role in the decision-making process on transport mode choice for the way to and from school in adolescents and parents.

Strengths and limitations

The major strength of this study is its mixed-methods design. With the help of quantitative methods, we were able to give a broad overview of the physical and social environmental barriers related to adolescents’ commuting to and from school. By using qualitative methods, it was feasible to get more information on the adolescents’ and parental perception of these barriers. Further, participants got the chance to deeper reflect their travel behaviour and name aspects that were not addressed in the questionnaires due to the standardized format and closed questions. Therefore, the mixed-methods approach allows additional insights to be gained from the interviews that may not have been covered by the questionnaires.

Nonetheless, the present study has some limitations. First, the perception of barriers regarding active travel consists of a complex network of several determinants, as seen in the “Conceptual framework for the environmental determinants of active travel in children” (Panter et al., 2008). The present study, however, only examines social and physical environmental barriers. According to the model, there are additional determinants of travel behaviour such as external factors (e.g., costs of travel or government policy). Thus, the present study does not fully capture the complexity of potentially relevant predictors. Second, the classification of barriers to the physical and social environment in the present study is based on previous research. However, it should be noted that there is no consistent understanding regarding this classification of possible barriers on choosing active transport modes in the literature. Therefore, other classifications can be found in previous research (Ahlport et al., 2008; Aibar Solana et al., 2018; Aranda-Balboa et al., 2020). Last, differences in the perception of barriers between adolescents and parents may also have been caused by mediation effects such as socialisation, or experiences had in the past (Hartmann et al., 2022). Especially during the quantitative analysis, we examined the association between perceived barriers regarding the physical and social

environment and the decision on transport mode. In our analyses, we cannot completely exclude the possibility that the assumed relationship may be disrupted by additional determinants. Another limitation may be the timing of the study, as it took place during the COVID-19 pandemic which could have an influence on travel behaviour in adolescents and thereby the responses in our study. For example, research on that shows that travel behaviour changed during COVID-19 while the pandemic encouraged use of active travel and provided a setting for positive experiences with active travel in adolescents (Levi and Baron-Epel, 2022).

Conclusion

Engaging in active travel can contribute to increase adolescents’ PA (Larouche et al., 2014). Knowing about perceived barriers that hinder young people to actively commute helps to better understand adolescents’ behavioural decisions, to improve active commuting and thereby daily PA. We found that for the way to and from school, parents perceived especially long distances and heavy luggage as well as opportunity of getting a lift, convenience and scarce time resources as hindering to adolescents’ active travel. However, adolescents perceived especially social (e.g., missing other children on the way) barriers, as well as physical (e.g., weather, distance and heavy luggage) barriers as potentially having an impact on their commuting behaviour. In order to encourage adolescents to use active transport modes for the way to and from school, especially over longer distances, the built environment should be designed in such a way that commuting is efficiently. Further, it seems that adolescents perceive especially lack of social support as barrier to active travel. This became especially apparent in the interviews. Having social support from friends or scout groups on their way, is especially important for boys when travelling actively (Leslie et al., 2010). More research is needed to get a deeper understanding of the role of peers in adolescents’ travel behaviour. Therefore, future interventions that aim to promote active travel should 1) consider the role of peers. Here, there seem to be a need to take a closer look on social norms, peer pressure, shared interests between peers or role models that may have an impact on the decision for or against active transport modes. Analysing different types of peer groups (e.g., friends, classmates, sport groups) could also help to shed light on travel behaviour in adolescents. Further, forthcoming interventions should 2) consider both the parental and adolescents’ perspective in general and examine the perceived barriers of the environment in detail. Last, it seems that current questionnaires (Aranda-Balboa et al., 2020; Forman et al., 2008) and theoretical models (Panter et al., 2008) do not yet encompass all factors and barriers that may have an impact on adolescents’ active travel behaviour. More research is needed to develop and validate measurement instruments that capture additional barriers to adolescents’ active travel. The more comprehensive the knowledge about barriers perceived by adolescents and parents regarding active travel, the more targeted future interventions aiming to promote adolescents’ active travel behaviour can be designed.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

CT: Conceptualization, Data curation, Formal Analysis, Writing—original draft. IM: Conceptualization, Data curation, Supervision, Writing—review and editing. FB: Formal Analysis, Methodology, Writing—review and editing. KD: Conceptualization, Methodology, Writing—review and editing. DR: Writing—review and editing. YD: Conceptualization, Project administration, Writing—review and editing. CK: Conceptualization, Project administration, Writing—review and editing. AR: Conceptualization, Methodology, Project administration, Supervision, Writing—review and editing.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fbuil.2024.1494837/full#supplementary-material>

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