BMJ Open

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| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-056383 |
| Article Type: | Protocol |
| Date Submitted by the Author: | 16-Aug-2021 |
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| Keywords: | SPORTS MEDICINE, SOCIAL MEDICINE, PUBLIC HEALTH |
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# Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study

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Submitted to: *BMJ open (Protocol)*

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## Abstract:

**Introduction**: Active travel is an important source of physical activity and is a primary contributor to overall health among adolescents. To understand and promote active travel behavior in adolescents, developing a more robust understanding of the predictors of active travel and its associated decision-making processes are needed. Situated within a theoretical socio-ecological framework for adolescent travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making processes of both adolescents and parents.

**Methods and analysis**: Our mixed-methods approach will feature online surveys and semi-structured interviews. The online questionnaire, developed in accordance with a theoretical framework of adolescent active travel, will examine adolescent travel behavior with respect to four different destinations while controlling for multiple relevant individual, social, and physical environment factors. To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered by a representative sample of adolescents (11-15 years old) and their parents from Germany.

Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework of adolescent active travel, will seek to explore the decision-making process of families regarding travel mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To investigate travel decision-making processes, adolescents and their parents will be invited to talk about trips they undertook using both active and passive transport modes during the last week. Thematic analyses will be conducted to highlight the central concerns, priorities, and values of participants' decision-making processes.

**Ethics and dissemination**: This study has received ethical approval from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly available to relevant health, policy, and research stakeholders and groups.

## Strength and limitations of this study

Bullet points:

- The ARRIVE study includes a large representative sample of parents and adolescents from diverse neighborhoods and regions and different socio-economic backgrounds from Germany.
- Situated within a theoretical socio-ecological framework, multiple theoretically relevant predictors of adolescent active travel behavior and different modes of transport to four distinct destinations will be assessed.
- Reliable and valid tools in the form of online surveys, which were developed based on the central tenets of a theoretical socio-ecological framework of adolescent active travel, will be used to assess adolescent active travel behavior and its predictors.

- Semi-structured interviews will seek to generate a novel and nuanced understanding of the familial decision-making processes regarding transport mode choices from parental and adolescent perspectives.
- Limitations include the cross-sectional design, self-report survey data, and a lack of objectively measured physical environment characteristics.

**Keywords (3-10):**

Active commuting, active transport, fathers, mothers, family, mixed-methods, framework, interview, online questionnaire

## Introduction

Regular physical activity is an important source of overall health, can decrease the risk of non-communicable diseases, and is linked to improved mental health (1). Long-term health benefits of physical activity are well documented for children, adolescents (2, 3), and adults (4). However, concerning low levels of physical activity among children, adolescent (5), and adults (6) in countries across the globe demands urgent action. The World Health Organization (WHO) has observed that current efforts to reduce global inactivity rates have been largely ineffective, and that more innovative and comprehensive approaches to promote physical activity are needed (7).

Active travel, or any form of human-powered transportation (e.g., walking, biking), as a daily routine (e.g., trips to/from school) is a low-cost and widely accessible source of physical activity (8). Longitudinal data supports that nine- to 18-year-old active commuters have higher levels of physical activity during young adulthood and can maintain these behaviors for up to 12 years (9). Active travel can also improve the emotional health of both adolescents and adults by increasing levels of happiness and relaxation (10). Furthermore, trips made by bike or by foot are a sustainable means of daily transport; have little-to-no $CO_2$ emissions; and are more affordable, reliable, cleaner, and less congested than trips made by car (11).

Despite these many potential benefits of active commuting, percentages of active commuters have declined in most countries (12-16). In Germany, like in many other countries, for example, only a

significant minority of adolescents currently walk or cycle to school (12, 17-19). Recent nationwide data from the German MoMo Study showed that 17.7% of adolescent girls and 20.2% of adolescent boys regularly walk to school and 21.5% of girls and 25.2% of boys take their bike, respectively (12).

To better understand adolescent travel mode decisions and travel behavior, and to enable the development of evidence-based intervention programs that promote active travel in adolescents, a more comprehensive analysis of the predictors of adolescent active travel and decision-making processes that generates new insights and helps to illuminate new paths for programming is warranted. At present, cross-sectional (20-23) and longitudinal (19, 24, 25) research has identified various individual- and neighborhood-level factors related to adolescent active travel. However, while these studies and extant theoretical socio-ecological models (26) and active travel frameworks (27-30) have outlined that adolescent active travel is a multi-level phenomenon, little is known about the influence of family-based predictors of adolescent active travel behavior, the decision-making processes within the family, and especially about adolescent travel behavior to non-school destinations.

One comparatively understudied influence of potential consequence regarding adolescent active travel behavior is family environment predictors. Although existing research confirms the importance of parental controls with respect to adolescent transport mode choice (31-33), comprehensive studies of family environment predictors of adolescent active commuting remain rather limited (34). Safety aspects in terms of traffic safety and a child's own ability to travel safely and independently strongly influence parental decision making on transport mode (31, 32, 35). Additionally, some parents prefer car usage to spend time with their children (35). Other relevant factors, which influence parental decision on travel behavior may include weather conditions (32), social norms and convenience (31, 35), and parenting practices (32). Regarding the role of distance to school with respect to parental decision making, existing evidence is more inconclusive: while one Swedish study (35) revealed that parents chauffeured their children to school regardless of distance, another from Canada (31) found that transport mode choice was influenced by perceptions of travel time and distance to school.

Presently, a large body of literature has highlighted the relevance of active travel as one domain of physical activity in adolescents, and the necessity to consider multiple socio-ecological levels of

influence regarding active travel. However, a number of research gaps regarding the predictors of and decision-making associated with active travel in adolescents still exist.

While existing literature has focused significantly on active travel to/ from school, only a few studies have considered other highly frequented destinations. Trips to leisure facilities, shops, or the homes of friends and relatives often represent as much or a greater proportion of all trips traveled by adolescents than school commutes. For example, in Germany, adolescents 10-19 years old accumulate on average 2.8 trips taking 72 minutes and having a total distance of 29 kilometers per day (36). Of these trips, school commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5% are related to shopping and everyday activities, and around 4% are made while accompanying adults/parents to other locations. As it seems that there is a dearth of knowledge pertaining to how this variety of daily trips to destinations other than school may contribute to adolescent health, study into this topic represents an important opportunity as it may offer new insights into adolescent active travel in reference to a more extensive set of predictors and social contexts, and ultimately help to promote more active lifestyles.

The dynamics and impacts of parental and adolescent decision-making processes on adolescent active travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the perceived social and physical environment facilitators and barriers to active travel among parents may vary across diverse cohorts from various geographical regions and degrees of urbanization (37, 38). Furthermore, while many previous studies have focused on children, few have addressed active travel behavior in adolescents (37). Moreover, previous studies have not considered adolescent active travel behavior in the context of the differing perspectives and attitudes of multiple family members (39, 40) resulting in most existing studies focusing exclusively on either youth or parental perspectives and neglecting the interrelation of both perspectives (41, 42). Such a precedent is an important oversight given that in their comparative study of children and parental barriers on active commuting to school, Aranda-Balboa et al. (43) found that there are significant differences between adolescents' and parents' perspectives in terms of perceived social and environmental determinants of active travel exist. Moreover, while other evidence has posited that child gender plays a significant role with regard to

physical activity and travel behavior (44-46), it has been observed that parental perspectives of this issue have been largely limited to the views of mothers (e.g., (32, 47)).

Additionally, only a few qualitative studies exist that provide a deeper understanding of the interrelationships and familial decision-making processes on active travel behavior in adolescents (31, 32, 35). The inclusion of qualitative methods in the study of this issue can be beneficial as they may help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus on the experiences, meanings, and perspectives of the participants (48).

To better understand and promote adolescent active travel there are a few important research opportunities to address, namely: family context predictors of adolescent active travel, the value and impact of non-school commuting trips, and the influence of the decision-making processes of adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the famIly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of adolescent active travel behavior through conducting a theoretically-informed, multi-component, and mixed-methods investigation of German adolescents and parents.

## Methods and analysis

### Study design

The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both studies will collect data from multiple groups, specifically adolescents between 11-15 years old and their parents. Data collection for both studies will take place between June and October 2021.

### Theoretical framework

We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (30) (see Figure 1). This framework serves as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents' active travel based on the social-ecological model (21, 34). The framework considers physical (e.g., neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both parents and youth (e.g., sociodemographic and psychosocial variables, attitudes). In the ARRIVE study, we used these conceptual categories to identify relevant predictors of interest—e.g., personal characteristics, attitudes, parental and adolescent perceptions of physical and social environment barriers—that we will examine in our statistical models in order to explore how they impact the main outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (49-51).

*Figure 1. Theoretical Framework for the ARRIVE study*

**Quantitative study**

*Aims*

The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (30). To systematically evaluate this theoretical model, our specific aims are threefold. First, we will seek to identify predictors of adolescent travel behavior with respect to four different destinations in order to discern whether the predictive strength of these correlates varies between trip destinations. Second, we will aim to develop a more comprehensive understanding of adolescent transport mode choice in the family context by comparing parent and adolescent perspectives regarding transport mode choice. Third, we will investigate the moderating effects of several theoretically relevant socio-demographic characteristics (e.g., sex/gender, migration background, and residential area) on adolescent travel behavior.

*Sampling strategy*

The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided by Forsa, a leading organization for public opinion polls. The recruitment for the survey will be conducted entirely offline via telephone interviews, so as to ensure that those lacking internet access are proportionately represented in the study. The panel is representative of the German population regarding age, gender, education and place of residence. Based on this panel, a sample of adults living together with adolescents aged 11- 15 years old will be recruited. The sample will include roughly the same number of mothers and fathers. After giving informed consent to be contacted for the survey, participants will receive an invitation e-mail with a link to the questionnaire.

Equivalent samples of parents (N = 500) and adolescents (N=500) will complete the survey. As previous regression models suggest that individual and environmental predictors tend to explain approximately 8-40% of the total explained variance in active travel (18, 52, 53), a conservative value of 10% was assumed to calculate effect size $f^2$. The G*power a priori sample size calculation conducted at a power of 0.8 and a significance level of 0.05 for a maximum of 25 potential correlates suggested a minimum sample size of 226. To get deeper insights into gender differences, we plan to stratify our sample by gender. Consequently, to allow for this stratification, we increased the sample size by roughly 50% resulting in final sample estimates of around 500 parents and 500 adolescents.

*Data collection*

Participants will be able to answer the online questionnaire using one of a tablet, smartphone, or computer. The questionnaire includes two parts: a parent-focused section, and an adolescent-focused section. After answering their portion of the questionnaire, parents will be asked to provide the link to their child or, if there is more than one child in this age group in the family, to one randomly selected child. To this end, parents will be instructed to select the child whose first name appears first in the alphabet to fill out the adolescent portion of the survey. The survey is anticipated to take about 15 minutes to complete for adolescents and parents together.

*Measures*

To cover all relevant constructs, an online questionnaire has been developed based on already existing scales (that were partly translated into German), modified scales, and additional single item questions. The selection of scales and questions were derived from the central tenets of the theoretical framework; all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. A detailed description of all measures applied in the online questionnaire for parents and adolescents is provided in Table 1.

*Table 1. Overview on Instrument used in the Parental and Adolescent Questionnaire*

*Data analysis*

Data analysis will include descriptive statistics, an examination of normally distributed data, and examinations of the homogeneity of variance. To prove internal consistencies of the adapted scales, Cronbach's alpha will be calculated. Differences between groups (e.g., age, gender) will be calculated using t-tests and analysis of variance for continuous variables, and chi-squares for categorical variables. Outcome measures will consist of a categorical variable representing the different transport modes (e.g., walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode) for each destination, and an overall score of active transport trips made. Multinomial (different transport modes) and binary (active vs. passive travel) logistic regression models controlling for multiple relevant sociodemographic variables will be used to identify predictors of adolescent active travel. Structural equation model including moderation and mediation analyses will be used to evaluate the multi-step pathways outlined in the theoretical framework. With regard to the relationship between parental and adolescent travel behavior, correlation analyses will be conducted. To compare parental and adolescents' perspective on barriers of active travel, binary logistic regression models will be performed. Analyses will be conducted with R, Matlab, and SPSS.

**Qualitative study**

*Aims*

The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box). Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated by the adolescents and parents themselves. To complement our online survey which aims to examine if and how various socio-demographic and socio-environmental factors predict adolescent travel behavior, this qualitative investigation seeks to understand the experiences of adolescent travel behavior by precisely exploring what and why certain influences centrally impact parental and adolescent decision-making processes regarding transport mode choice.

*Sampling strategy*

Participants for the qualitative survey will be recruited using theoretical sampling methods (54). Therefore, the sample will not be defined by the onset of the study, but will be selected against the background of theoretical problems outlined earlier and in accordance with our proposed analysis processes. Our sampling methods will thus initially be based on ensuring the samples contain diversity with respect to socio-economic status, migration status, gender, and environmental conditions (e.g., urban and rural living locations). When possible, we will interview both parents to capture the perspectives of fathers and mothers. We anticipate that the final sample will consist of 10-15 adolescents and 15-20 parents.

*Data collection*

Interviews will be conducted with adolescent and parent participants separately. Prior to the data collection process all interviewers received formal training from an interview expert. Sample interviews were conducted to ensure the appropriateness of the interview guides.

Interviews are anticipated to take around 30 minutes to complete. However, because deviations are possible, for each participant an appointment time of 60 minutes will be made. After giving informed consent and agreeing on an appointment, each participant will receive an individual link for an online meeting to conduct the interview. Participants will be able to complete their interview from any desired

place so long as they have a stable internet connection and quiet surrounding. Before the start of the recording, the objective and the interview procedure will be explained and participants will be reassured of the voluntary nature of their involvement and their right to refuse to answer any questions. After clarifying any questions that participants may have, the audio recording device will be turned on and the interview will begin. At the end of the interview, the audio recording will stop.

*Interview Guideline*

The focus of the interviews for both groups of participants will be the travel behavior of adolescents and the associated decision-making process. During the interviews, adolescents and their parents will be encouraged to relive their travel experiences and their decision-making processes regarding mode choice in relation to four different situations. In order to generate a thorough understanding of the differences in decision-making processes when considering the choice of active vs. passive transport to the distinct locations, different interview paths will be followed to ensure that the interview inquires about four (two active, two passive trips) different travel type-location examples (see Figure 2). At the start of each interview parents and adolescents will be instructed to first talk about a recent trip the latter made during one of the days prior to the interview. This first trip may be undertaken by either an active or passive means. Next, and to facilitate a comparison of factors affecting adolescent travel mode decision-making processes, participants will be asked to remember a trip to the same destination that they made using another transport mode (passive/active). To generate additional depth regarding understanding the potential variety of relevant factors influencing participants' decision-making processes, this procedure will be repeated for another destination that the adolescent traveled to in the previous week.

*Figure 2. Structure of the interview guide – decision-tree*

When discussing each of the four distinct trips, participants will be asked to describe their experiences of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks: the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation on the journey itself (i.e., social and environmental factors). To garner further information pertaining to

the various circumstances which might affect the travel planning process, adolescents and parents will also be asked about a hypothetical commute to school, and specifically what factors (e.g., concerns, priorities) they would foremost consider when planning the trip. Interviews will close with adolescents and parents being asked which transport mode they would prefer and why. More detailed information regarding both interview guides are enclosed in the supplementary materials.

*Table 2. Topics addressed in the adolescents and parental interview*

| | Situation | Topic | Examples |
|---|---|---|---|
| **Active/Passive Transport Mode to Destination** | situation at home | General aspects | e.g., weather, stress, behavior, particularities |
| | | decision-making process | e.g., own behavior, parental behavior, decision on mode choice, rules, motivation |
| | situation on the route | Physical environment | e.g., distance, characteristics of way, like/dislike |
| | | Social environment | e.g., friends, siblings, companionship |
| **Hypothetical way to school** | situation at home | relevant factors | e.g., weather, school situation, daily schedule |
| | | decision-making process | e.g., parental influence, motivation, attitudes |

*Data analysis*

All audio recordings will be saved, treated as strictly confidential material, and eventually transcribed verbatim. With regard to the research questions, analysis will be conducted using thematic analysis (55) or content analysis (56). We will use theoretical sampling methods that begin based on the central tenets of the theoretical framework mentioned earlier (e.g., multiple groups, diverse socio-demographics) and will develop in accordance with our iterative data collection and analysis process.

## Ethics and dissemination

The ARRIVE study is designed in accordance with the ethical principles for research involving human subjects of the Declaration of Helsinki. Ethical approval for the study and its procedures were received from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg (Reg. 249_21 B). Participation in both parts of the study is voluntary. Informed assent will be obtained from all adolescents and informed consent will be obtained from all parents that participate in this study. With

regard to the quantitative survey, no personally identifiable information will be included in the data set and transferred from forsa to the study team. In the interviews, participants will not be addressed by name, nor will any personal identifying information be requested. All data will be stored on central servers of the Technical University of Munich/Germany and the University of Erlangen-Nuremberg/Germany.

The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly journals with international audiences, and will be presented at academic conferences. Additionally, the results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made publicly available for interested individuals, families, teachers, and caregivers via a project website and public knowledge translation activities (e.g., public talks, community information sessions).

**Patient and public involvement statement**

No medical patients and/or members of the public were involved in setting the research question nor they were involved in developing plans for design (or implementation) of this study protocol.

**Discussion**

Increasing physical activity in adolescents is an immediate and serious challenge for modern societies, but one that if effectively addressed can contribute to preventing a number of chronic and non-communicable diseases (7). The ARRIVE study aims to contribute to this prevention work by providing a comprehensive multi-component and multi-group analysis of the socio-ecological determinants of adolescent active travel behavior. Quantitative analyses of several theoretically relevant predictors of adolescent active travel are intended to provide the necessary empirical evidence to illustrate the influence of family context influences and non-school commutes on travel behaviors. Qualitative semi-structured interviews are anticipated to provide deeper insights into the decision making-processes of both adolescents and parents regarding travel mode behaviors. Together, the findings from both components of the ARRIVE study should be of value to both practitioners and researchers as they will offer a comprehensive evaluation of a more diverse set of trips, family predictors, and decision-making

processes associated with adolescent active travel, as well as provide empirical evidence to support public health active travel interventions for targeted adolescent groups and families.

## Authors' contributions

All authors made substantial contribution to the concept and design of the ARRIVE study. AKR and IM prepared the first draft of the protocol article and finalized the manuscript. All authors contributed to the preparation of the manuscript, provided edits to the manuscript and read and approved the final manuscript.

## Competing interests

The authors declare that they have no competing interests.

## Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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**Table 1: Overview on Instrument used in the Parental and Adolescent Questionnaire**

| Construct | Instrument | Description | Reliability and Validity |
|---|---|---|---|
| **Parent questionnaire** | | | |
| Parents' and child's socio-demographics | Demographic Standards (57) | Parent indicate their age, gender, migration background, education, employment and how many children under 18 are living in household. For their child, they indicate age, gender and school typ. | - |
| BMI (child and parent) | Self-reported and proxy-reported weight and height | Parent report their weight and height as well as their children's weight and height. | |
| Current situation in school due to COVID-19 | Single-item question | Due to COVID-19 pandemic, an additional question is used to indicate the current schooling situation: normal, home schooling, or alternate lessons. | - |
| urbanization | BIK regions (58) | Parents indicate the degree of urbanization in dependence of inhabitants in their hometown. | - |
| Home environment | MiD (59) | Parents indicate car availability and bike availability (parent and child) and if they hold a driver license. | - |
| Distance to school | Single-item question | Parent indicate the distance to their child's school from home in kilometers. | - |
| Aerobic PA guideline compliance | European Health Interview Survey – Physical Activity Questionnaire (EHIS-PAQ) (Finger et al., 2015) | Six items are used to indicate parental aerobic PA guideline compliance (at least 150min aerobic PA per week) | The EHIS-PAQ is a reliable and valid tool to assess domain-specific PA as shown by adults from Germany (ICC range = 0.43-0.73) (60). |
| Joint physical activity with child | Modified item from the MoMo-AFB (61) | Parents indicate on how many days in a normal week they are more than 60min physically active with their child. | - |
| Active travel | MiD (59) | To assess active travel in parents, they indicate transport mode, distance, and accompaniment of child to 4 different destinations (work, friends'/relatives' home, shopping, and leisure time activities). | - |
| Perceived social and physical environment | Modified version of the Parental Perception of Barriers Towards Active Commuting to School (PABACS) (62) | A 24-item scale is used to assess parental barriers towards active travel including general aspects, barriers for walking and barriers for cycling. | In 207 parents, the questionnaire showed good internal consistency (Cronbach's alpha $\alpha = 0.86$), moderate reliability (ICC range: 0.51-0.55) and moderate validity (62). |

| | | | |
|---|---|---|---|
| Parents' self-efficacy | Modified version of the Parents' Self-efficacy Scale (63) | A 13-item scale is used to assess parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy. | Crobach's α for the three first-order factors parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy were 0.95, 0.86, and 0.76, respectively (63). |
| Environmental self-identity | Environmental self-identity scale (64) | Parents indicate their agreement to three items on environmental friendliness. | The scale showed good internal consistency (Cronbach's Alpha α = 0.870; average corrected item-total correlations = 0.755) (64). |
| Health consciousness | Health consciousness scale (65) | Parents indicate their agreement to five items related to health practices on a 5-point-likert scale. | The scale showed good internal consistency (Cronbach's alpha α = 0.72) (65). |
| **Adolescent questionnaire** | | | |
| WHO PA guideline compliance | MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo-AFB) (61) | Children indicate on how many days in a normal week they are physically active for 60min or more. | In 9-17-year-olds, the MoMo-AFB showed good test-retest reliability (ICC=0.68) and validity (Spearman r = 0.29) (66). |
| Active travel | MiD (59) and New Version of Mode and Frequency of Commuting To and From School (67) | Children indicate transport mode, accompaniment, and distance (in min and km) to school, to friends/relatives, to shopping opportunities and to leisure time activities. | The questionnaire is a reliable and feasible tool to assess active travel in adolescents (κ = 0.61-0.94) (67). |
| Perceived social and physical environment | Modified Version of the Barreras percibidas en el desplazamiento activo al centro educativo (BATACE) (68) | An 18-item scale is used to assess perceived barriers to active travel including environmental and safety factors as well as planning and psychosocial barriers. | The BATACE showed good test-retest reliability (ICC range: 0.68-0.77) and internal consistency (Cronbach's alpha α = 0.59-0.76) in a sample of 465 adolescents (68). |
| Perceived parental autonomy support for AT | Modified Version of the Perceived Autonomy Support Scale for Active Commuting to and from School (PASS-ACS) (69) | A 4-item scale assesses perceived parental support for active travel. | The PASS-ACS is a valid and reliable (Cronbach's alpha α = 0.85; ICC = 0.88) tool to assess adolescents' perceived support for active travel (69). |
| Basic Psychological Need Satisfaction | Modified Version of the Basic Psychological Need Satisfaction in Active Commuting to and from School (BPNS-ACS) (70) | A 12-item scale is used to assess adolescents' autonomy, competence, and relatedness need satisfaction with regard to active travel behavior. | In 675 students (10-18 years), the BPNS-ACS showed acceptable internal consistency (autonomy satisfaction α = 0.81, competence satisfaction α = 0.92, and relatedness satisfaction α = 0.82) and predictive validity (total variance explained: 24%) (70). |
| Motivation for active travel | Modified version of the Behavioural Regulation in Active Commuting to and from School (BR-ACS) Questionnaire (71) | A 23-item scale is used to assess motivational regulation in active travel including intrinsic motivation, integrated, identified, introjected and external regulation, and amotivation. | In 404 secondary students, the BR-ACS showed adequate internal consistency (Cronbach's alpha range α = 0.70-0.91) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (71). |

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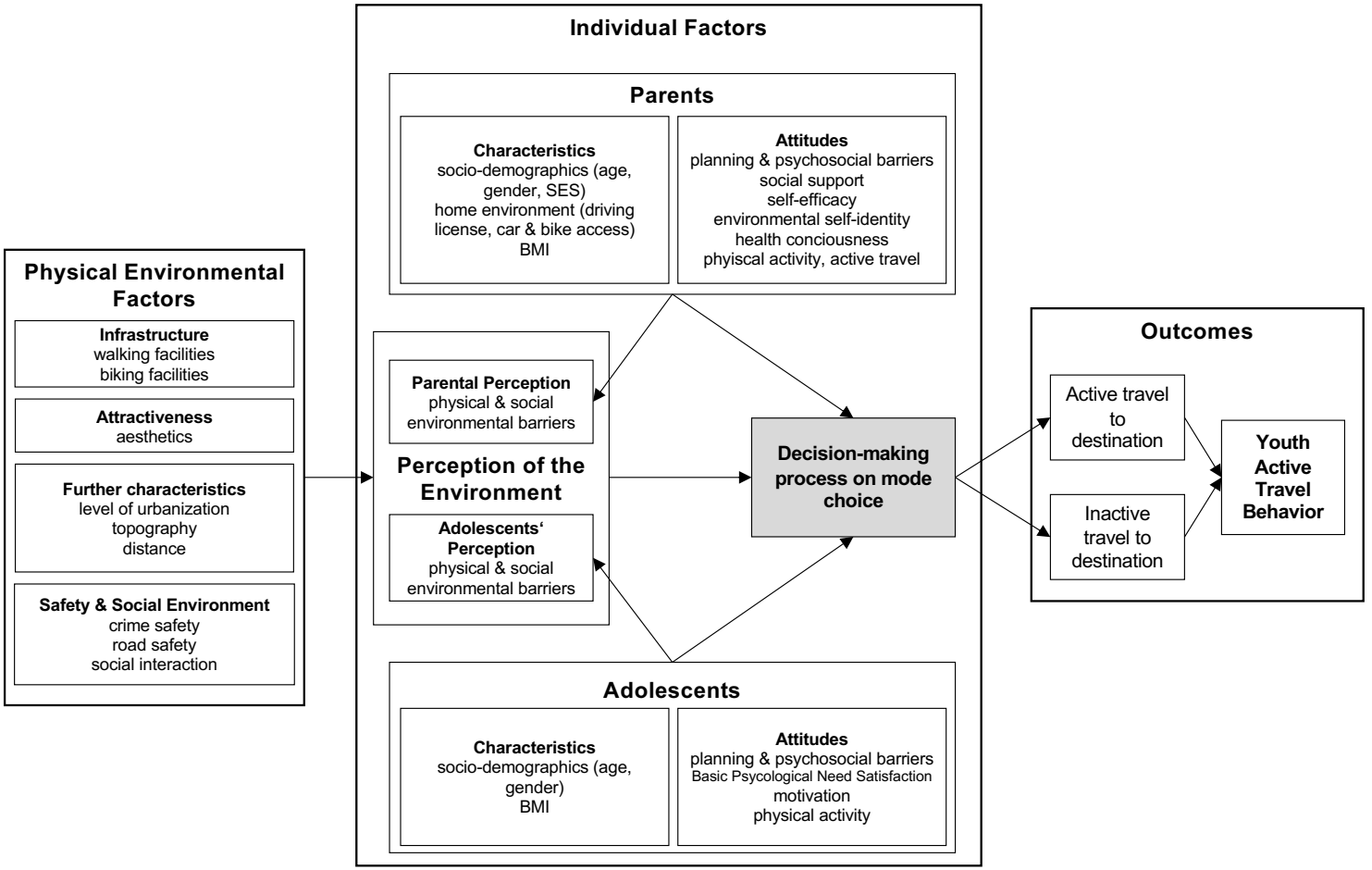
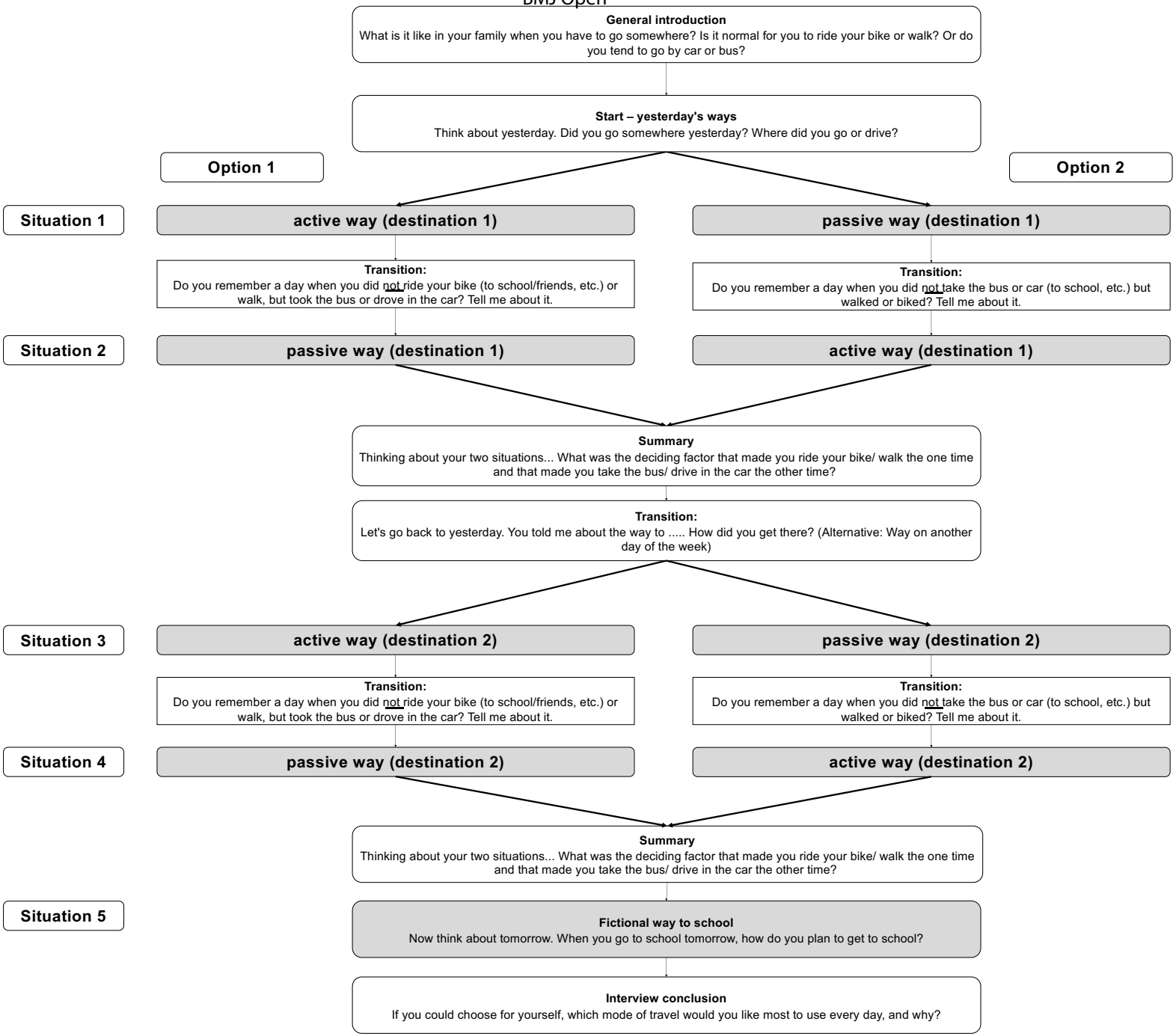

Individual Factors
Parents
Characteristics
socio-demographics (age, gender, SES)
home environment (driving license, car & bike access)
BMI
Attitudes
planning & psychosocial barriers
social support
self-efficacy
environmental self-identity
health conciousness
phyiscal activity, active travel
Physical Environmental Factors
Infrastructure
walking facilities
biking facilities
Attractiveness
aesthetics
Further characteristics
level of urbanization
topography
distance
Safety & Social Environment
crime safety
road safety
social interaction
Parental Perception
physical & social environmental barriers
Perception of the Environment
Adolescents' Perception
physical & social environmental barriers
Decision-making process on mode choice
Outcomes
Active travel to destination
Inactive travel to destination
Youth Active Travel Behavior
Adolescents
Characteristics
socio-demographics (age, gender)
BMI
Attitudes
planning & psychosocial barriers
Basic Psycological Need Satisfaction
motivation
physical activity


General introduction
What is it like in your family when you have to go somewhere? Is it normal for you to ride your bike or walk? Or do you tend to go by car or bus?
Start – yesterday's ways
Think about yesterday. Did you go somewhere yesterday? Where did you go or drive?
Option 1
Option 2
Situation 1
active way (destination 1)
passive way (destination 1)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 2
passive way (destination 1)
active way (destination 1)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Transition:
Let's go back to yesterday. You told me about the way to ..... How did you get there? (Alternative: Way on another day of the week)
Situation 3
active way (destination 2)
passive way (destination 2)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 4
passive way (destination 2)
active way (destination 2)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Situation 5
Fictional way to school
Now think about tomorrow. When you go to school tomorrow, how do you plan to get to school?
Interview conclusion
If you could choose for yourself, which mode of travel would you like most to use every day, and why?

# Supplementary material

## A. Interview guideline - parents

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way - decision making process | Think again carefully about the situation before your child left with [mode of travel]. Can you describe the situation at home? | Stress | Can you describe the situation at home in detail? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | Can you describe what you did before your child left home? | How did you feel about it? / How did it make you feel? |
| | Can you describe how the decision was made/how it came about that your child chose [mode of travel]? | Behavior family | How did you behave? How did your child / siblings behave? | How did you feel about it? |
| | | Decision | Who decided that your child used [mode of travel]?<br>Can you describe the extent to which you influenced this decision? | Can you describe what was running through your mind when you made the decision? |
| | | Rules | Are there any rules in the family regarding [mode of travel]? | Can you describe why these rules exist / are important to you? |
| | | Persuasion/reason | Can you remember a specific reason why your child used [mode of travel]? | Is there a personal persuasion behind them? |
| | | Motivation | To what extent did you motivate your child to use [mode of travel]? | |
| Way – physical environment | Do you know where your child drove/walked along? | Parental perspective | How do you feel about the way?<br>Is there anything on the way that worries you? | How do you deal with it? |

| | | | | |
|---|---|---|---|---|
| | Can you describe the way as precisely as possible so that I can get an idea? | Child's perspective<br><br>Behavior child – way | How do you think your child likes the way?<br><br>Can you describe what your child has done/experienced along the way? | How do you feel about it? |
| Way – social environment | Did someone accompany your child? | Friends company<br><br>Parents company | How does it happen?<br><br>What do you do on the way together? Can you describe why you accompany your child? | What do you say to that?<br><br>How is this for you - to use [mode of travel] with your child? |
| **Interview guide for situations 5** | | | | |
| Fictional way to school | Now please think about tomorrow, when your child goes to school. How do you plan (together with your child) the way to school? Or does your child plan the way to school alone? | Relevant factors<br><br>Decision | What factors are you or your child considering for planning tomorrow? What are you thinking about it?<br><br>To what extent do you involve your child? | What would change your decision? Are you satisfied with the decision? How do you evaluate this decision? |

## B. Interview guideline - youth

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way – decision making process | Think again exactly about the situation before you [mode of travel]. Can you describe how it came about that you [mode of travel]? | Stress | What was the situation like? Was it stressful? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | What did you do before you left the house? | |
| | Tell me about how all went with your parents. | Behavior family | How did you behave? How did your mom/dad/siblings behave? | How did you feel at that time? What was running through your mind? |
| | | Decision | Who decided that you [mode of travel]?/ How did you decide to [mode of travel]? | How do you feel about that? That you can decide alone / That your parents decide for you? How did you come to your decision to [mode of travel]? |
| | | Rules | Are there any rules in your family? | Do you know why your parents make the decision the way they do? |
| | | Persuasion/reason | Was there anything in particular that convinced you to [mode of travel]? | |
| | | Motivation | What did motivate you? | |
| Way – physical environment | Think about where you drove/walked along. Can you describe the way exactly so that I can get an idea of it? | Distance | How long did you spend on the way? How far is the way? | How do you feel about the way? |
| | | Behavior | How did you drive/walk? Do you do anything special on the way? | How did you feel while [mode of travel]? How was [mode of travel] for you? |
| | | Way - characteristics | How did you like the way? What do you like about the way? What do you not like about it? | |

| | | | | |
|---|---|---|---|---|
| | | | What did you like about [mode of travel]? | |
| Way – social environment | Did anyone accompany you on the way? Can you describe the situation on the way in detail? | Company | Can you tell me about how you rode together?<br>Can you tell me what you did along the way?<br><br>Do you meet other people along the way? | What was it like between you?<br>Was there anything that you particularly liked?<br>Was there anything you did not like so much? |
| **Interview guide for situation 5** | | | | |
| Fictional way to school | Now think about tomorrow. Can you describe to me how you decide how to get to school? How do you plan the way to school? | Relevant factors<br><br>Decision | Which factors do you take into account in the planning?<br>What are you considering?<br>Do you check with your parents?<br>Whom do you involve in the decision?<br>How do you come to the decision? | What would change your decision?<br>Are you satisfied with the decision?<br>How do you evaluate this decision? |

# Note from the Editors: Instructions for reviewers of study protocols

Since launching in 2011, BMJ Open has published study protocols for planned or ongoing research studies. If data collection is complete, we will not consider the manuscript.

Publishing study protocols enables researchers and funding bodies to stay up to date in their fields by providing exposure to research activity that may not otherwise be widely publicised. This can help prevent unnecessary duplication of work and will hopefully enable collaboration. Publishing protocols in full also makes available more information than is currently required by trial registries and increases transparency, making it easier for others (editors, reviewers and readers) to see and understand any deviations from the protocol that occur during the conduct of the study.

The scientific integrity and the credibility of the study data depend substantially on the study design and methodology, which is why the study protocol requires a thorough peer-review.

*BMJ Open* will consider for publication protocols for any study design, including observational studies and systematic reviews.

Some things to keep in mind when reviewing the study protocol:

- Protocol papers should report planned or ongoing studies. The dates of the study should be included in the manuscript.
- Unfortunately we are unable to customize the reviewer report form for study protocols. As such, some of the items (i.e., those pertaining to results) on the form should be scores as Not Applicable (N/A).
- While some baseline data can be presented, there should be no results or conclusions present in the study protocol.
- For studies that are ongoing, it is generally the case that very few changes can be made to the methodology. As such, requests for revisions are generally clarifications for the rationale or details relating to the methods. If there is a major flaw in the study that would prevent a sound interpretation of the data, we would expect the study protocol to be rejected.

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# Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study



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|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-056383.R1 |
| Article Type: | Protocol |
| Date Submitted by the Author: | 14-Dec-2021 |
| Complete List of Authors: | Reimers, Anne; Friedrich-Alexander-Universitat Erlangen-Nurnberg, Department of Sport Science and Sport<br>Marzi, Isabel; Friedrich-Alexander University Erlangen-Nuremberg, Department of Sport Sciene and Sport<br>Beck, Franziska; Friedrich-Alexander-Universitat Erlangen-Nurnberg, Sport Science and Sport<br>Engels, Eliane ; Friedrich-Alexander-Universitat Erlangen-Nurnberg<br>Renninger, Denise; Technical University of Munich<br>Buttazzoni, Adrian; University of Waterloo<br>Krieger, Claus; Universität Hamburg<br>Demetriou, Yolanda; Technical University of Munich |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Sports and exercise medicine |
| Keywords: | SPORTS MEDICINE, SOCIAL MEDICINE, PUBLIC HEALTH |
| | |

# Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study

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Submitted to: *BMJ open (Protocol)*

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## Abstract:

**Introduction**: Active travel is an important source of physical activity and a primary contributor to overall health among adolescents. To understand and promote active travel behavior in adolescents, developing a more robust understanding of the predictors of active travel and its associated decision-making processes is needed. Situated within a theoretical socio-ecological framework for adolescent travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making processes of both adolescents and parents.

**Methods and analysis**: Our mixed-methods approach will feature online surveys and semi-structured interviews. The online questionnaire, developed in accordance with a theoretical framework of adolescent active travel, will examine adolescent travel behavior with respect to four different destinations while controlling for multiple relevant individual, social, and physical environment factors. To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered by a representative sample of German adolescents (11–15 years old) and their parents.

Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework of adolescent active travel, will seek to explore the decision-making process of families regarding travel mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To investigate travel decision-making processes, adolescents and their parents will be invited to talk about trips they undertook using both active and passive transport modes during the last week. Thematic analyses will be conducted to highlight the central concerns, priorities, and values of participants' decision-making processes.

**Ethics and dissemination**: This study has received ethical approval from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly available to relevant health, policy, and research stakeholders and groups.

## Strength and limitations of this study

Bullet points:

- The quantitative part of the ARRIVE study includes a large representative sample of German parents and adolescents from diverse neighborhoods and regions and different socio-economic backgrounds. However, the sample might not be representative of typical German travel behaviors as they result from many additional factors like urban infrastructure accessibility, family work arrangements, and other socio-demographic factors (e.g., vehicle ownership) that we aren't able to control for in this study.
- Situated within a theoretical socio-ecological framework, multiple theoretically relevant predictors of adolescent active travel behavior and different modes of transport to four distinct destinations will be assessed.
- Reliable and valid tools in the form of online surveys, which were developed based on the central tenets of a theoretical socio-ecological framework of adolescent active travel, will be used to assess adolescent active travel behavior and its predictors.
- Semi-structured interviews will seek to generate a novel and nuanced understanding of the familial decision-making processes regarding transport mode choices from both parental and adolescent perspectives.
- Limitations include the cross-sectional design, self-report survey data, and a lack of objectively measured physical environment characteristics.

**Keywords (3–10):**

Active commuting, active transport, fathers, mothers, family, mixed-methods, framework, interview, online questionnaire

## Introduction

Regular physical activity is an important source of overall health, can decrease the risk of non-communicable diseases, and is linked to improved mental health (1). Long-term health benefits of physical activity are well documented for children, adolescents (2, 3), and adults (4). However, concerning low levels of physical activity among children, adolescent (5), and adults (6) in countries across the globe demands urgent action. The World Health Organization (WHO) has observed that current efforts to reduce global inactivity rates have been largely ineffective, and that more innovative and comprehensive approaches to promote physical activity are needed (7).

Active travel, that is any form of human-powered transportation (e.g., walking, biking), as a daily routine (e.g., trips to/from school) is a low-cost and widely accessible source of physical activity (8). But despite many potential benefits of active commuting, percentages of active commuters have declined in most countries (9-13). In Germany, like in many other countries, for example, only a significant minority of adolescents currently walk or cycle to school (9, 14-16). Recent nationwide data from the German MoMo Study showed that 17.7% of adolescent girls and 20.2% of adolescent boys regularly walk to school, while 21.5% of girls and 25.2% of boys cycle to school (9).

To better understand adolescent travel mode decisions and travel behavior, as well as to enable the development of evidence-based intervention programs that promote active travel in adolescents, a more comprehensive analysis of the predictors of adolescent active travel and decision-making processes is warranted. At present, cross-sectional (17-20) and longitudinal (16, 21, 22) research has identified various individual- and neighborhood-level factors related to adolescent active travel. However, while these studies and extant theoretical socio-ecological models (23) and active travel frameworks (24-27) have outlined that adolescent active travel is a multi-level phenomenon, little is known about the influence of family-level predictors of adolescent active travel behavior, the decision-making processes within the family, and especially about adolescent travel behavior to non-school destinations.

One comparatively understudied influence of potential consequence regarding adolescent active travel behavior is family environment predictors (e.g., parental support, role modelling, availability of a bicycle). Although recent study confirms the importance of parental controls with respect to adolescent transport mode choice (28-30), comprehensive studies of family environment predictors of adolescent

active commuting remain rather limited (31). To date, studies have largely focused on examining only singular elements of the family-level. For example, recent works have found safety aspects in terms of traffic safety and a child's own ability to travel safely and independently strongly influence parental decision making on transport mode (28, 29, 32), and that some parents prefer car usage to spend time with their children (32). Other noted relevant factors in this regard include social norms and convenience (28, 32), and parenting practices (29) as significant individual predictors. In other cases, however, family environment influences are ambiguous. When examining the role of distance to school and its interaction with family-level factors, existing evidence is inconclusive: while one Swedish study (32) revealed that parents chauffeured their teenagers to school regardless of distance, another from Canada (28) found that transport mode choice was influenced by perceptions of travel time and distance to school. Ultimately, given this combination of a lack of comprehensive investigations and uncertainty in other areas, there is a need to more comprehensively (e.g., examine the interaction of parent and adolescent perceptions) consider family environment influences of adolescent active travel.

Similarly, while existing literature has focused significantly on active travel to/ from school, only a few studies have considered other highly frequented destinations. Trips to leisure facilities, shops, or the homes of friends and relatives often represent as much or a greater proportion of all trips traveled by adolescents than school commutes. For example, in Germany, adolescents accumulate on average 2.8 trips taking 72 minutes and having a total distance of 29 kilometers per day (33). Of these trips, school commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5% are related to shopping and everyday activities, and around 4% are made while accompanying adults/parents to other locations. Despite these documented trends, there is a relative dearth of knowledge pertaining to how this variety of daily trips to destinations other than school may contribute to adolescent health representing another important avenue for future study.

The dynamics and impacts of parental and adolescent decision-making processes on adolescent active travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the perceived social and physical environment facilitators and barriers to active travel among parents may vary across diverse cohorts from various geographical regions and degrees of urbanization (34, 35). Furthermore, while many previous studies have focused on children, few have addressed active travel

behavior in adolescents (34). Moreover, previous studies have not considered adolescent active travel behavior in the context of the differing perspectives and attitudes of multiple family members (36, 37) resulting in most existing studies focusing exclusively on either youth or parental perspectives and neglecting the interrelation of both perspectives (38, 39). Such a precedent is an important oversight given that in their comparative study of children and adolescents as well as parental barriers on active commuting to school, Aranda-Balboa et al. (40) found that there are significant differences between adolescents' and parents' perspectives in terms of perceived social and environmental determinants of active travel.

To better understand and promote adolescent active travel there are a few important research opportunities to address, namely: family environment predictors of adolescent active travel, the value and impact of non-school commuting trips, and the influence of the decision-making processes of adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the famIly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of adolescent active travel behavior through conducting a theoretically-informed, multi-component, and mixed-methods investigation of German adolescents and parents.

## Methods and analysis

### Study design

The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both studies will collect data from multiple groups, specifically adolescents between 11–15 years old and their parents. Data collection for both studies will take place between June and December 2021.

### Theoretical framework

We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (27) (see Figure 1). This framework serves as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents' active travel based on the social-ecological model (18, 31). The framework considers physical (e.g., neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both parents and youth (e.g., sociodemographic and psychosocial variables, attitudes). In the ARRIVE study, we used these conceptual categories to identify relevant predictors of interest—e.g., personal characteristics, attitudes, parental and adolescent perceptions of physical and social environment barriers—that will be examined in our statistical models in order to explore how they impact the main outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (41-43).

*Figure 1. Theoretical Framework for the ARRIVE study*

**Quantitative study**

*Aims*

The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (27). To systematically evaluate this theoretical model, our specific aims are threefold. First, we will seek to identify predictors of adolescent travel behavior with respect to four different destinations in order to discern whether the predictive strength of these correlates varies between trip destinations. Second, we will aim to develop a more comprehensive understanding of adolescent transport mode choice in the family context by comparing parent and adolescent perspectives regarding transport mode choice. Third, we will investigate the moderating effects of several theoretically relevant socio-demographic characteristics (e.g., sex/gender, migration background, and degree of urbanization) on adolescent travel behavior.

*Sampling strategy*

The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided by Forsa, a leading organization for public opinion polls. The recruitment for the survey will be conducted entirely offline via telephone interviews, so as to ensure that those lacking internet access are proportionately represented in the study. The panel contains people living in Germany and is representative of the German population regarding age, sex/gender, education and place of residence. Based on this panel, a sample of adults living together with adolescents aged 11–15 years old will be recruited. The sample will include roughly the same number of mothers and fathers. After giving informed consent to be contacted for the survey, participants will receive an invitation e-mail with a link to the questionnaire.

As suggested by Bujang et al. (44) for observational studies with large population sizes a minimum sample size of 500 is necessary to derive logistic regression analyses. By using real patient data, it was shown that a minimum sample size of 500 "is able to produce statistics that are nearly representative of the true values in the target population" (44). Thus, equivalent samples of parents (N = 500) and adolescents (N=500) will complete the survey.

*Data collection*

Participants will be able to answer the online questionnaire using one of a tablet, smartphone, or computer. The questionnaire includes two parts: a parent-focused section, and an adolescent-focused section. After answering their portion of the questionnaire, parents will be asked to provide the link to their adolescent or, if there is more than one adolescent in this age group in the family, to one randomly selected adolescent. To this end, parents who have multiple potential participants in their family will be instructed to select the adolescent whose first letter of their first name appears the earliest in the alphabet to fill out the adolescent portion of the survey. The survey is anticipated to take about 15 minutes to complete for adolescents and parents together.

*Measures*

To cover all relevant constructs, an online questionnaire has been developed based on already existing scales (that were partly translated into German), modified scales, and additional single item questions.

The selection of scales and questions were derived from the central tenets of the theoretical framework; all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. Based on a literature search on activity settings of adolescents, four destinations adolescents frequently visit and which are the most popular places for adolescents in the walkable neighborhood have been selected to assess travel behavior in youth (41, 42, 45, 46). A detailed description of all measures applied in the online questionnaire for parents and adolescents is provided in Table 1.

*Table 1. Overview on Instrument used in the Parental and Adolescent Questionnaire*

*Data analysis*

Descriptive analysis

Data analysis will include descriptive statistics, an examination of normally distributed data, and examinations of the homogeneity of variance. Descriptive statistics will include means (M) and standard deviations (SD) for continuous variables, and frequencies (%) for categorical variables (e.g., boys and girls and mothers and fathers). Frequency distribution of transport mode for each destination will be calculated separately for boys and girls. To examine internal consistencies of the adapted scales, Cronbach's alpha will be calculated with the respective values indicating excellent > 0.9, good > 0.8, acceptable > 0.7, questionable > 0.6, poor >0.5, and unacceptable < 0.5 fit (47).

Outcome measures will consist of a categorical variable representing the different transport modes (e.g., walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode) for each destination, and an overall score of active transport including all destinations. This overall score will be calculated based on the proportion of active trips in relation to all reported trips resulting in a interval scaled variable with values between 0 (all trips *passive*) to 1 (all trips *active*).

Differences in transport mode choice and predictor variables between different groups (e.g., age, sex/gender) will be calculated using t-tests and analysis of variance for continuous variables, and chi-squares for categorical variables. For example, differences in transport mode choice between boys and girls and adolescents living in different regions with different degrees of urbanization (cities, medium-sized towns, small towns, rural areas) will be calculated using Pearson-Chi2-test and post-hoc analysis

(48) as well as the comparison of transport mode across destinations according to parental sex/gender (mothers and fathers). To identify differences in travel distance between transport modes one-way analysis of variance will be calculated.

Aim 1: Identifying predictors of adolescent travel behavior

Multinomial (different transport modes) and binary (active vs. passive travel) logistic regression models controlling for multiple relevant socio-demographic variables will be used to identify predictors of adolescent active travel. Due to the heterogeneity of outcome measures, separate logistic regression analyses will be conducted for each destination using the dichotomous variables of transport mode choice as dependent variable, the individual, social and physical environmental variables as predictors, and socio-demographic factors (e.g., age, education) as confounders. Adjusted odds ratio (aOR) and 95%-confidence intervals will be reported. For some analyses, the overall score of active travel will be used as categorical, dependent variable, for example, to assess the effect of the motivational regulations on active travel behavior in adolescents. The regression analysis will either be performed for the whole sample or due to theoretical assumptions separately for male and female adolescents to account for sex/gender differences. To assess associations between travel behavior in adolescents and their parents, separate sex/gender analyses with parent-adolescent-dyads (mother-daughter, mother-son, father-daughter, and father-son) will be conducted by binary logistic regressions.

Aim 2: Comparing parental and adolescents' perspectives on transport mode choice

To investigate parental and adolescents' perspectives on social and physical barriers of active travel, several multiple regression models will be performed. The overall score for transport mode in adolescents will be set as the dependent variable and each barrier as an independent variable. Thus, for each comparable barrier a separate multiple regression will be implemented.

Aim 3: Investigating moderating effects of relevant socio-demographic characteristics

To assess whether the association between the social and physical environment and adolescents' travel behavior are moderated by socio-demographic characteristics (e.g., sex/gender, degree of urbanization),

we will run 1) logistic regression models controlling for socio-demographic variables, and 2) logistic regression analyses including interactions effects.

If appropriate, further exploratory analysis based on the theoretical framework will be conducted within the ARRIVE project. For all analysis, a level of $\alpha = 0.05$ will be set as a threshold to determine statistical significance. Analyses will be conducted with R, Matlab, and SPSS.

**Qualitative study**

*Aims*

The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box). Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated by the adolescents and parents themselves. To complement our online survey which aims to examine if and how various socio-demographic and socio-environmental factors predict adolescent travel behavior, this qualitative investigation seeks to understand the experiences of adolescent travel behavior by precisely exploring what and why certain influences centrally impact parental and adolescent decision-making processes regarding transport mode choice. Specifically, the qualitative investigation will focus on the following research questions:

- What physical environment and individual factors influence transport mode choice in adolescents?
- How do adolescents experience the decision-making process on transport mode choice?
- How do parents experience the decision-making process on transport mode choice in adolescents?
- Are there any differences in adolescents' and parental perspectives on transport mode choice?

*Sampling strategy*

In addition to the online sample, we will also be recruiting another set of adolescents and their parents to take part in the qualitative investigation. These participants will be recruited using theoretical sampling methods (49). Therefore, the sample will not be defined by the onset of the study, but will be selected against the background of theoretical problems outlined earlier and in accordance with our proposed analysis processes. Our sampling methods will thus initially be based on ensuring the samples contain diversity with respect to socio-economic status, migration status, sex/gender, and environmental conditions (e.g., urban and rural living locations). When possible, we will interview both parents to capture the perspectives of fathers and mothers. We anticipate that the final sample will consist of 10–15 adolescents and 15–20 parents.

*Data collection*

Interviews will be conducted with adolescent and parent participants separately. Prior to the data collection process all interviewers received formal training from an interview expert. Sample interviews were conducted to ensure the appropriateness of the interview guides.

Interviews are anticipated to take around 30 minutes to complete. However, because deviations are possible, for each participant an appointment time of 60 minutes will be made. After giving informed consent and agreeing on an appointment, each participant will receive an individual link for an online meeting to conduct the interview. Participants will be able to complete their interview from any desired place so long as they have a stable internet connection and quiet surrounding. Before the start of the recording, the objective and the interview procedure will be explained and participants will be reassured of the voluntary nature of their involvement and their right to refuse to answer any questions. After clarifying any questions that participants may have, the audio recording device will be turned on and the interview will begin. At the end of the interview, the audio recording will stop.

*Interview Guideline*

The focus of the interviews for both groups of participants will be the travel behavior of adolescents and the associated decision-making process. During the interviews, adolescents and their parents will be encouraged to recount their travel experiences and their decision-making processes regarding mode

choice in relation to four different situations. In order to generate a thorough understanding of the differences in decision-making processes when considering the choice of active vs. passive transport to the distinct locations, different interview paths will be followed to ensure that the interview inquires about four (two active, two passive trips) different travel type-location examples (see Figure 2). At the start of each interview parents and adolescents will be instructed to first talk about a recent trip the latter made during one of the days prior to the interview. This first trip may be undertaken by either an active or passive means. Next, and to facilitate a comparison of factors affecting adolescent travel mode decision-making processes, participants will be asked to remember a trip to the same destination that they made using another transport mode (passive/active). To generate additional depth regarding understanding the potential variety of relevant factors influencing participants' decision-making processes, this procedure will be repeated for another destination that the adolescent traveled to in the previous week. In the event that an adolescent participant reports that they never changed transport mode to the two selected destinations, the interviewer will ask about any trips made with the opposite (passive/active) transport mode to explore how their habits and perceptions might be changed.

*Figure 2. Structure of the interview guide – decision-tree*

When discussing each of the four distinct trips, participants will be asked to describe their experiences of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks: the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation on the journey itself (i.e., social and environmental factors). To garner further information pertaining to the various circumstances which might affect the travel planning process, adolescents and parents will also be asked about a hypothetical commute to school, and specifically what factors (e.g., concerns, priorities) they would foremost consider when planning the trip. Interviews will close with adolescents and parents being asked which transport mode they would prefer and why. More detailed information regarding both interview guides is enclosed in the supplementary materials.

*Table 2. Topics addressed in the adolescents and parental interview*

| | Situation | Topic | Examples |
|---|---|---|---|
| **Active/Passive Transport Mode to Destination** | Situation at home | General aspects | e.g., weather, stress, behavior, particularities |
| | | Decision-making process | e.g., own behavior, parental behavior, decision on mode choice, rules, motivation |
| | Situation on the route | Physical environment | e.g., distance, characteristics of way, like/dislike |
| | | Social environment | e.g., friends, siblings, companionship |
| **Hypothetical way to school** | Situation at home | Relevant factors | e.g., weather, school situation, daily schedule |
| | | Decision-making process | e.g., parental influence, motivation, attitudes |

*Data analysis*

All audio recordings will be saved, treated as strictly confidential material, and eventually transcribed verbatim. With regard to answering the four research questions noted earlier, analysis will be conducted using thematic analysis (50) or content analysis (51). In the first step, two researchers will independently analyze interview transcripts by the means of a deductive-inductive process. Deductive themes are defined prior to analysis according to the presented framework (Figure 1) and in this study will include physical environment factors (e.g., attractiveness, infrastructure, social environment), parent characteristics and attitudes (e.g., SES, social support), adolescent characteristics and attitudes (e.g., age, motivation), and environmental perceptions (e.g., parental perceptions of barriers/enablers, adolescent perceptions of barriers/enablers). To allow for more in-depth insights in the decision-making process, researchers will then code transcripts inductively to identify emerging ideas and concepts that may not align well with the original deductive categories. Subsequently, emerging differences and commonalities from the deductive-inductive analysis will be discussed together to develop consensus. In cases where a consensus may not be reached, a third researcher will join the discussion.

## Ethics and dissemination

The ARRIVE study is designed in accordance with the ethical principles for research involving human subjects of the Declaration of Helsinki. Ethical approval for the study and its procedures were received from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg (Reg. 249_21

B). Participation in both parts of the study is voluntary. Participants will not receive any reimbursement or compensation for participating in one part of the study. Informed assent will be obtained from all adolescents and informed consent will be obtained from all parents that participate in this study. With regard to the quantitative survey, no personally identifiable information will be included in the data set and transferred from forsa to the study team. In the interviews, participants will not be addressed by name, nor will any personal identifying information be requested. All data will be stored on central servers of the Technical University of Munich/Germany and the University of Erlangen-Nuremberg/Germany.

The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly journals with international audiences, and will be presented at academic conferences. Additionally, the results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made publicly available for interested individuals, families, teachers, and caregivers via a project website and public knowledge translation activities (e.g., public talks, community information sessions).

**Patient and public involvement statement**

No medical patients and/or members of the public were involved in setting the research question nor they were involved in developing plans for design (or implementation) of this study protocol.

**Discussion**

Increasing physical activity in adolescents is an immediate and serious challenge for modern societies, but one that if effectively addressed can contribute to preventing a number of chronic and non-communicable diseases (7). Recent recommendations by the European Society of Cardiology (ESC) suggest approaches targeting optimizing lifestyle activities to change physical activity behaviors and reduce sedentary time as important preventive measures in this regard (52). Better understanding the decision-making processes of both adolescents and parents regarding multiple forms of, and influences on, daily adolescent active travel behavior can be an effective strategy in supporting these desired lifestyle activity alterations.

Until now, only a few qualitative studies exist that provide a deeper understanding of the interrelationships and familial decision-making processes on active travel behavior in adolescents (28, 29, 32). The inclusion of qualitative methods in the study of this issue can be beneficial as they may help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus on the experiences, meanings, and perspectives of the participants (53). Additionally, previous evidence has posited that child or adolescent sex/gender plays a significant role with regard to physical activity and travel behavior (54-56), it has been observed that parental perspectives of this issue have been largely limited to the views of mothers (e.g., (29, 57)).

The ARRIVE study aims to address these research gaps, by providing a comprehensive multi-component and multi-group analysis of the socio-ecological determinants of adolescent active travel behavior and its associated decision-making processes. Quantitative analyses of several theoretically relevant predictors of adolescent active travel are intended to provide the necessary empirical evidence to illustrate the relationships of the family environment with non-school commutes and travel behaviors. Qualitative semi-structured interviews are anticipated to provide deeper insights into the decision making-processes of both adolescents and parents regarding travel mode behaviors. Together, the findings from both components of the ARRIVE study should be of value to both practitioners and researchers as they will offer a comprehensive evaluation of a more diverse set of trips, family predictors, and decision-making processes associated with adolescent active travel, as well as provide empirical evidence to support public health active travel interventions for targeted adolescent groups and families.

To build on the expected findings of the ARRIVE study in future research, targeted active travel interventions, especially those featuring gamification elements (58), could be a starting point for larger-scale prevention efforts aimed to reduce non-communicable diseases and to improve public health. For example, longitudinal data supports that nine to 18-year-old active commuters have higher levels of physical activity during young adulthood and can maintain these behaviors for up to 12 years (59), thus targeted and gamified early-years interventions may be prudent prevention strategies. Other potential benefits of regular active travel, or targeted interventions, include the improved emotional health and happiness of both adolescents and adults (60), improvements in cardiovascular health (e.g., exercise

capacity, maximal power, blood pressure and blood parameters) in adults (61-63) and adolescents (64, 65), and cleaner and less congested neigbourhoods (66, 67)—all points which future intervention studies could also evaluate alongside the findings (e.g., articulated decision-making processes) of our ARRIVE study.

## Authors' contributions

AKR, IM, FB, EE, DR, CK and YD made substantial contribution to the concept and design of the ARRIVE study. AKR and IM prepared the first draft of the protocol article and finalized the manuscript. FB, EE, DR, AB, CK and YD made substantial contributions to the manuscript, provided edits to the manuscript and read and approved the final manuscript.

## Competing interests

The authors declare that they have no competing interests.

## Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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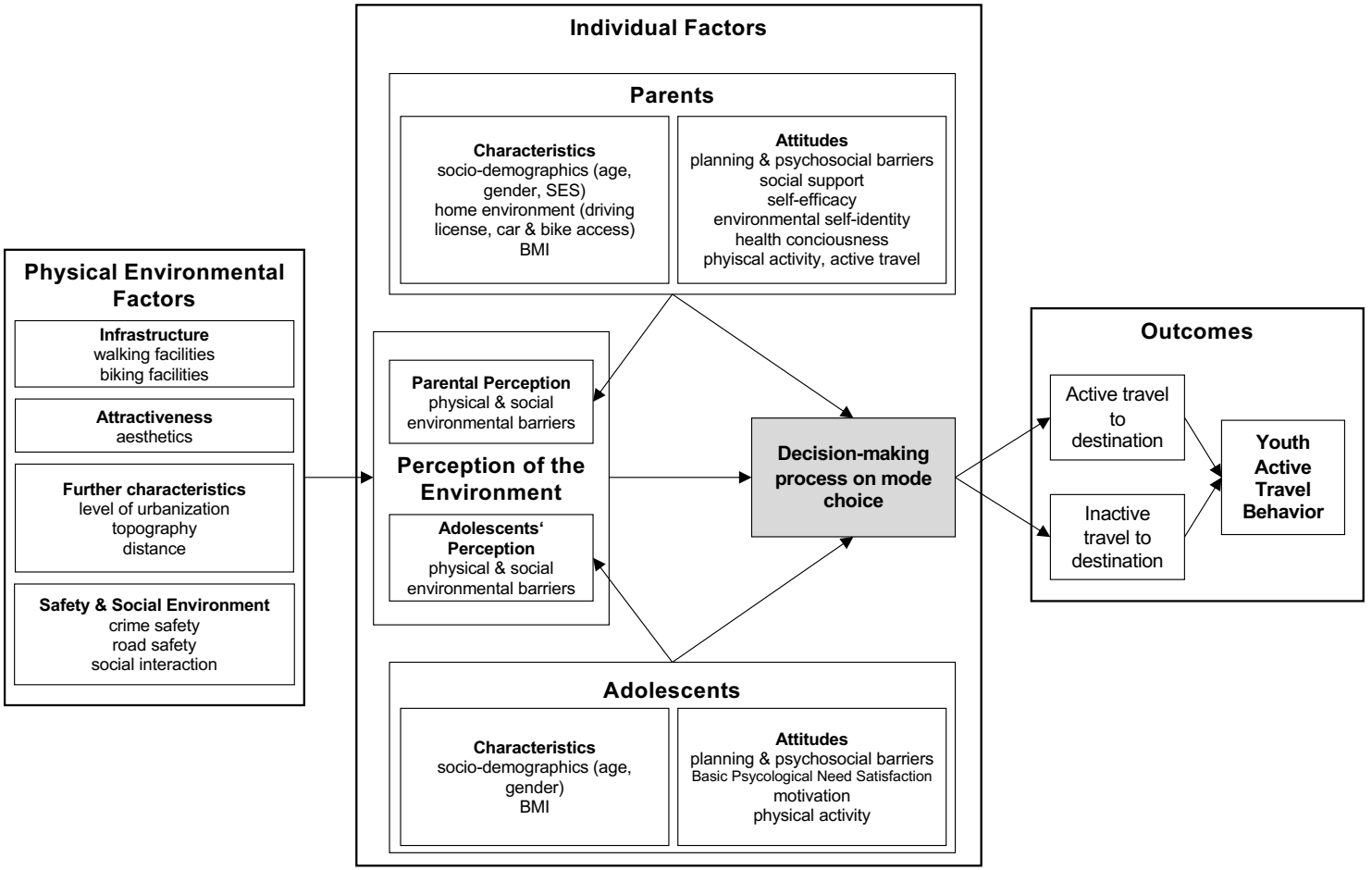
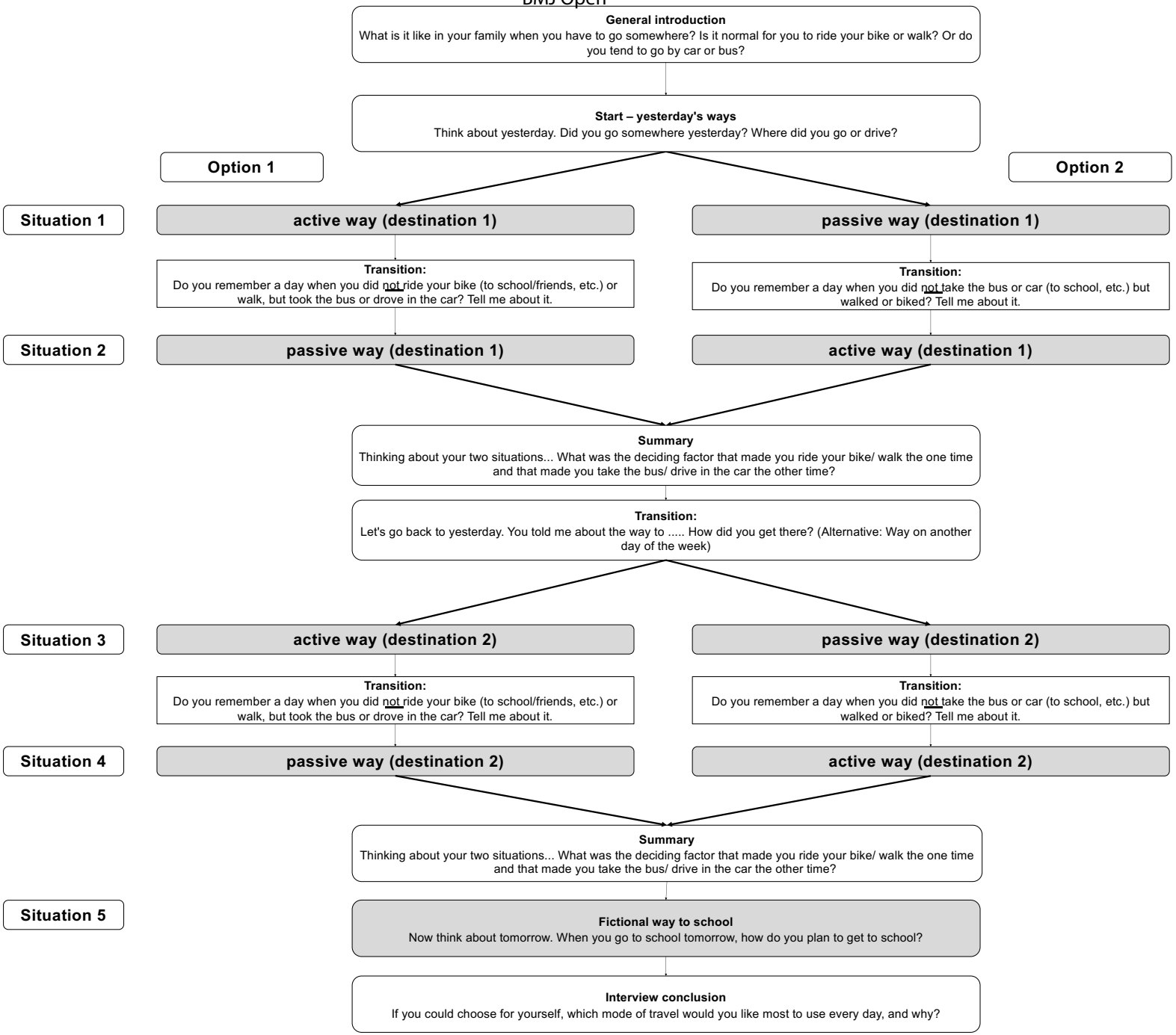
**Table 1: Overview on Instrument used in the Parental and Adolescent Questionnaire**

| Construct | Instrument | Description | Reliability and Validity |
|---|---|---|---|
| **Parent questionnaire** | | | |
| Parents' and child's socio-demographics | Demographic Standards (68) | Parent indicate their age, gender, migration background, education, employment and how many children under 18 are living in household. For their child, they indicate age, gender and school typ. | - |
| BMI (child and parent) | Self-reported and proxy-reported weight and height | Parent report their weight and height as well as their children's weight and height. | |
| Current situation in school due to COVID-19 | Single-item question | Due to COVID-19 pandemic, an additional question is used to indicate the current schooling situation: normal, home schooling, or alternate lessons. | - |
| Degree of urbanization | BIK regions (69) | Parents indicate the degree of urbanization in dependence of inhabitants in their hometown (>100,000 inhabitants: city; 20,000–99,999 inhabitants: medium-sized town; 5,000–19,999 inhabitants: small town; <5,000 inhabitants: rural). | - |
| Home environment | MiD (45) | Parents indicate car availability and bike availability (parent and child) and if they hold a driver license. | - |
| Distance to school | Single-item question | Parent indicate the distance to their child's school from home in kilometers. | - |
| Aerobic PA guideline compliance | European Health Interview Survey – Physical Activity Questionnaire (EHIS-PAQ) (Finger et al., 2015) | Six items are used to indicate parental aerobic PA guideline compliance (at least 150min aerobic PA per week) | The EHIS-PAQ is a reliable and valid tool to assess domain-specific PA as shown by adults from Germany (ICC range = 0.43-0.73) (70). |
| Joint physical activity with child | Modified item from the MoMo-AFB (71) | Parents indicate on how many days in a normal week they are more than 60min physically active with their child. | - |
| Active travel | MiD (45) | To assess active travel in parents, they indicate transport mode, distance, and accompaniment of child to 4 different destinations (work, friends'/relatives' home, shopping, and leisure time activities). | - |
| Perceived social and physical environment | Modified version of the Parental Perception of Barriers Towards Active Commuting to School (PABACS) (72) | A 24-item scale is used to assess parental barriers towards active travel including general aspects, barriers for walking and barriers for cycling. | In 207 parents, the questionnaire showed good internal consistency (Cronbach's alpha $\alpha = 0.86$), moderate reliability (ICC range: 0.51-0.55) and moderate validity (72). |

| | | | |
|---|---|---|---|
| Parents' self-efficacy | Modified version of the Parents' Self-efficacy Scale (73) | A 13-item scale is used to assess parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy. | Crobach's α for the three first-order factors parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy were 0.95, 0.86, and 0.76, respectively (73). |
| Environmental self-identity | Environmental self-identity scale (74) | Parents indicate their agreement to three items on environmental friendliness. | The scale showed good internal consistency (Cronbach's Alpha α = 0.870; average corrected item-total correlations = 0.755) (74). |
| Health consciousness | Health consciousness scale (75) | Parents indicate their agreement to five items related to health practices on a 5-point-likert scale. | The scale showed good internal consistency (Cronbach's alpha α = 0.72) (75). |
| **Adolescent questionnaire** | | | |
| WHO PA guideline compliance | MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo-AFB) (71) | Adolescents indicate on how many days in a normal week they are physically active for 60min or more. | In 9-17-year-olds, the MoMo-AFB showed good test-retest reliability (ICC=0.68) and validity (Spearman r = 0.29) (76). |
| Active travel | MiD (45) and New Version of Mode and Frequency of Commuting To and From School (77) | Adolescents indicate transport mode, accompaniment, and distance (in min and km) to school, to friends/relatives, to shopping opportunities and to leisure time activities. | The questionnaire is a reliable and feasible tool to assess active travel in adolescents (κ = 0.61-0.94) (77). |
| Perceived social and physical environment | Modified Version of the Barreras percibidas en el desplazamiento activo al centro educativo (BATACE) (78) | An 18-item scale is used to assess perceived barriers to active travel including environmental and safety factors as well as planning and psychosocial barriers. | The BATACE showed good test-retest reliability (ICC range: 0.68-0.77) and internal consistency (Cronbach's alpha α = 0.59-0.76) in a sample of 465 adolescents (78). |
| Perceived parental autonomy support for AT | Modified Version of the Perceived Autonomy Support Scale for Active Commuting to and from School (PASS-ACS) (79) | A 4-item scale assesses perceived parental support for active travel. | The PASS-ACS is a valid and reliable (Cronbach's alpha α = 0.85; ICC = 0.88) tool to assess adolescents' perceived support for active travel (79). |
| Basic Psychological Need Satisfaction | Modified Version of the Basic Psychological Need Satisfaction in Active Commuting to and from School (BPNS-ACS) (80) | A 12-item scale is used to assess adolescents' autonomy, competence, and relatedness need satisfaction with regard to active travel behavior. | In 675 students (10-18 years), the BPNS-ACS showed acceptable internal consistency (autonomy satisfaction α = 0.81, competence satisfaction α = 0.92, and relatedness satisfaction α = 0.82) and predictive validity (total variance explained: 24%) (80). |
| Motivation for active travel | Modified version of the Behavioral Regulation in Active Commuting to and from School (BR-ACS) Questionnaire (81) | A 23-item scale is used to assess motivational regulation in active travel including intrinsic motivation, integrated, identified, introjected and external regulation, and amotivation. | In 404 secondary students, the BR-ACS showed adequate internal consistency (Cronbach's alpha range α = 0.70-0.91) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (81). |


Individual Factors
Parents
Characteristics
socio-demographics (age, gender, SES)
home environment (driving license, car & bike access)
BMI
Attitudes
planning & psychosocial barriers
social support
self-efficacy
environmental self-identity
health conciousness
phyiscal activity, active travel
Physical Environmental Factors
Infrastructure
walking facilities
biking facilities
Attractiveness
aesthetics
Further characteristics
level of urbanization
topography
distance
Safety & Social Environment
crime safety
road safety
social interaction
Parental Perception
physical & social environmental barriers
Perception of the Environment
Adolescents' Perception
physical & social environmental barriers
Decision-making process on mode choice
Outcomes
Active travel to destination
Inactive travel to destination
Youth Active Travel Behavior
Adolescents
Characteristics
socio-demographics (age, gender)
BMI
Attitudes
planning & psychosocial barriers
Basic Psycological Need Satisfaction
motivation
physical activity


General introduction
What is it like in your family when you have to go somewhere? Is it normal for you to ride your bike or walk? Or do you tend to go by car or bus?
Start – yesterday's ways
Think about yesterday. Did you go somewhere yesterday? Where did you go or drive?
Option 1
Option 2
Situation 1
active way (destination 1)
passive way (destination 1)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 2
passive way (destination 1)
active way (destination 1)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Transition:
Let's go back to yesterday. You told me about the way to ..... How did you get there? (Alternative: Way on another day of the week)
Situation 3
active way (destination 2)
passive way (destination 2)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 4
passive way (destination 2)
active way (destination 2)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Situation 5
Fictional way to school
Now think about tomorrow. When you go to school tomorrow, how do you plan to get to school?
Interview conclusion
If you could choose for yourself, which mode of travel would you like most to use every day, and why?

# Supplementary material

## A. Interview guideline - parents

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way - decision making process | Think again carefully about the situation before your child left with [mode of travel]. Can you describe the situation at home? | Stress | Can you describe the situation at home in detail? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | Can you describe what you did before your child left home? | How did you feel about it? / How did it make you feel? |
| | Can you describe how the decision was made/how it came about that your child chose [mode of travel]? | Behavior family | How did you behave? How did your child / siblings behave? | How did you feel about it? |
| | | Decision | Who decided that your child used [mode of travel]?<br>Can you describe the extent to which you influenced this decision? | Can you describe what was running through your mind when you made the decision? |
| | | Rules | Are there any rules in the family regarding [mode of travel]? | Can you describe why these rules exist / are important to you? |
| | | Persuasion/reason | Can you remember a specific reason why your child used [mode of travel]? | Is there a personal persuasion behind them? |
| | | Motivation | To what extent did you motivate your child to use [mode of travel]? | |
| Way – physical environment | Do you know where your child drove/walked along? | Parental perspective | How do you feel about the way?<br>Is there anything on the way that worries you? | How do you deal with it? |

| | | | | |
|---|---|---|---|---|
| | Can you describe the way as precisely as possible so that I can get an idea? | Child's perspective<br><br>Behavior child – way | How do you think your child likes the way?<br><br>Can you describe what your child has done/experienced along the way? | How do you feel about it? |
| Way – social environment | Did someone accompany your child? | Friends company<br><br>Parents company | How does it happen?<br><br>What do you do on the way together? Can you describe why you accompany your child? | What do you say to that?<br><br>How is this for you - to use [mode of travel] with your child? |
| **Interview guide for situations 5** | | | | |
| Fictional way to school | Now please think about tomorrow, when your child goes to school. How do you plan (together with your child) the way to school? Or does your child plan the way to school alone? | Relevant factors<br><br>Decision | What factors are you or your child considering for planning tomorrow? What are you thinking about it?<br><br>To what extent do you involve your child? | What would change your decision? Are you satisfied with the decision? How do you evaluate this decision? |

## B. Interview guideline - youth

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way – decision making process | Think again exactly about the situation before you [mode of travel]. Can you describe how it came about that you [mode of travel]? | Stress | What was the situation like? Was it stressful? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | What did you do before you left the house? | |
| | Tell me about how all went with your parents. | Behavior family | How did you behave? How did your mom/dad/siblings behave? | How did you feel at that time? What was running through your mind? |
| | | Decision | Who decided that you [mode of travel]?/ How did you decide to [mode of travel]? | How do you feel about that? That you can decide alone / That your parents decide for you? How did you come to your decision to [mode of travel]? |
| | | Rules | Are there any rules in your family? | Do you know why your parents make the decision the way they do? |
| | | Persuasion/reason | Was there anything in particular that convinced you to [mode of travel]? | |
| | | Motivation | What did motivate you? | |
| Way – physical environment | Think about where you drove/walked along. Can you describe the way exactly so that I can get an idea of it? | Distance | How long did you spend on the way? How far is the way? | How do you feel about the way? |
| | | Behavior | How did you drive/walk? Do you do anything special on the way? | How did you feel while [mode of travel]? How was [mode of travel] for you? |
| | | Way - characteristics | How did you like the way? What do you like about the way? What do you not like about it? | |

| | | | | |
|---|---|---|---|---|
| | | | What did you like about [mode of travel]? | |
| Way – social environment | Did anyone accompany you on the way? Can you describe the situation on the way in detail? | Company | Can you tell me about how you rode together?<br>Can you tell me what you did along the way?<br><br>Do you meet other people along the way? | What was it like between you?<br>Was there anything that you particularly liked?<br>Was there anything you did not like so much? |
| **Interview guide for situation 5** | | | | |
| Fictional way to school | Now think about tomorrow. Can you describe to me how you decide how to get to school? How do you plan the way to school? | Relevant factors<br><br>Decision | Which factors do you take into account in the planning?<br>What are you considering?<br>Do you check with your parents?<br>Whom do you involve in the decision?<br>How do you come to the decision? | What would change your decision?<br>Are you satisfied with the decision?<br>How do you evaluate this decision? |

BMJ Open

# Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study



| | |
|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-056383.R2 |
| Article Type: | Protocol |
| Date Submitted by the Author: | 12-Jan-2022 |
| Complete List of Authors: | Reimers, Anne; Friedrich-Alexander-Universitat Erlangen-Nurnberg, Department of Sport Science and Sport<br>Marzi, Isabel; Friedrich-Alexander University Erlangen-Nuremberg, Department of Sport Sciene and Sport<br>Beck, Franziska; Friedrich-Alexander-Universitat Erlangen-Nurnberg, Sport Science and Sport<br>Engels, Eliane ; Friedrich-Alexander-Universitat Erlangen-Nurnberg<br>Renninger, Denise; Technical University of Munich<br>Buttazzoni, Adrian; University of Waterloo<br>Krieger, Claus; Universität Hamburg<br>Demetriou, Yolanda; Technical University of Munich |
| Primary Subject Heading: | Public health |
| Secondary Subject Heading: | Sports and exercise medicine |
| Keywords: | SPORTS MEDICINE, SOCIAL MEDICINE, PUBLIC HEALTH |
| | |

# Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study

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Submitted to: *BMJ open (Protocol)*

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## Abstract:

**Introduction**: Active travel is an important source of physical activity and a primary contributor to overall health among adolescents. To understand and promote active travel behavior in adolescents, developing a more robust understanding of the predictors of active travel and its associated decision-making processes is needed. Situated within a theoretical socio-ecological framework for adolescent travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making processes of both adolescents and parents.

**Methods and analysis**: Our mixed-methods approach will feature online surveys and semi-structured interviews. The online questionnaire, developed in accordance with a theoretical framework of adolescent active travel, will examine adolescent travel behavior with respect to four different destinations while controlling for multiple relevant individual, social, and physical environment factors. To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered by a representative sample of German adolescents (11–15 years old) and their parents.

Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework of adolescent active travel, will seek to explore the decision-making process of families regarding travel mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To investigate travel decision-making processes, adolescents and their parents will be invited to talk about trips they undertook using both active and passive transport modes during the last week. Thematic analyses will be conducted to highlight the central concerns, priorities, and values of participants' decision-making processes.

**Ethics and dissemination**: This study has received ethical approval from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly available to relevant health, policy, and research stakeholders and groups.

## Strength and limitations of this study

Bullet points:

- The quantitative part of the ARRIVE study includes a large representative sample of German parents and adolescents from diverse neighborhoods and regions and different socio-economic backgrounds. However, the sample might not be representative of typical German travel behaviors as they result from many additional factors like urban infrastructure accessibility, family work arrangements, and other socio-demographic factors (e.g., vehicle ownership) that we aren't able to control for in this study.
- Situated within a theoretical socio-ecological framework, multiple theoretically relevant predictors of adolescent active travel behavior and different modes of transport to four distinct destinations will be assessed.
- Reliable and valid tools in the form of online surveys, which were developed based on the central tenets of a theoretical socio-ecological framework of adolescent active travel, will be used to assess adolescent active travel behavior and its predictors.
- Semi-structured interviews will seek to generate a novel and nuanced understanding of the familial decision-making processes regarding transport mode choices from both parental and adolescent perspectives.
- Limitations include the cross-sectional design, self-report survey data, and a lack of objectively measured physical environment characteristics.

**Keywords (3–10):**

Active commuting, active transport, fathers, mothers, family, mixed-methods, framework, interview, online questionnaire

## Introduction

Regular physical activity is an important source of overall health, can decrease the risk of non-communicable diseases, and is linked to improved mental health (1). Long-term health benefits of physical activity are well documented for children, adolescents (2, 3), and adults (4). However, concerning low levels of physical activity among children, adolescent (5), and adults (6) in countries across the globe demands urgent action. The World Health Organization (WHO) has observed that current efforts to reduce global inactivity rates have been largely ineffective, and that more innovative and comprehensive approaches to promote physical activity are needed (7).

Active travel, that is any form of human-powered transportation (e.g., walking, biking), as a daily routine (e.g., trips to/from school) is a low-cost and widely accessible source of physical activity (8). But despite many potential benefits of active commuting, percentages of active commuters have declined in most countries (9-13). In Germany, like in many other countries, for example, only a significant minority of adolescents currently walk or cycle to school (9, 14-16). Recent nationwide data from the German MoMo Study showed that 17.7% of adolescent girls and 20.2% of adolescent boys regularly walk to school, while 21.5% of girls and 25.2% of boys cycle to school (9).

To better understand adolescent travel mode decisions and travel behavior, as well as to enable the development of evidence-based intervention programs that promote active travel in adolescents, a more comprehensive analysis of the predictors of adolescent active travel and decision-making processes is warranted. At present, cross-sectional (17-20) and longitudinal (16, 21, 22) research has identified various individual- and neighborhood-level factors related to adolescent active travel. However, while these studies and extant theoretical socio-ecological models (23) and active travel frameworks (24-27) have outlined that adolescent active travel is a multi-level phenomenon, little is known about the influence of family-level predictors of adolescent active travel behavior, the decision-making processes within the family, and especially about adolescent travel behavior to non-school destinations.

One comparatively understudied influence of potential consequence regarding adolescent active travel behavior is family environment predictors (e.g., parental support, role modelling, availability of a bicycle). Although recent study confirms the importance of parental controls with respect to adolescent transport mode choice (28-30), comprehensive studies of family environment predictors of adolescent

active commuting remain rather limited (31). To date, studies have largely focused on examining only singular elements of the family-level. For example, recent works have found safety aspects in terms of traffic safety and a child's own ability to travel safely and independently strongly influence parental decision making on transport mode (28, 29, 32), and that some parents prefer car usage to spend time with their children (32). Other noted relevant factors in this regard include social norms and convenience (28, 32), and parenting practices (29) as significant individual predictors. In other cases, however, family environment influences are ambiguous. When examining the role of distance to school and its interaction with family-level factors, existing evidence is inconclusive: while one Swedish study (32) revealed that parents chauffeured their teenagers to school regardless of distance, another from Canada (28) found that transport mode choice was influenced by perceptions of travel time and distance to school. Ultimately, given this combination of a lack of comprehensive investigations and uncertainty in other areas, there is a need to more comprehensively (e.g., examine the interaction of parent and adolescent perceptions) consider family environment influences of adolescent active travel.

Similarly, while existing literature has focused significantly on active travel to/ from school, only a few studies have considered other highly frequented destinations. Trips to leisure facilities, shops, or the homes of friends and relatives often represent as much or a greater proportion of all trips traveled by adolescents than school commutes. For example, in Germany, adolescents accumulate on average 2.8 trips taking 72 minutes and having a total distance of 29 kilometers per day (33). Of these trips, school commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5% are related to shopping and everyday activities, and around 4% are made while accompanying adults/parents to other locations. Despite these documented trends, there is a relative dearth of knowledge pertaining to how this variety of daily trips to destinations other than school may contribute to adolescent health representing another important avenue for future study.

The dynamics and impacts of parental and adolescent decision-making processes on adolescent active travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the perceived social and physical environment facilitators and barriers to active travel among parents may vary across diverse cohorts from various geographical regions and degrees of urbanization (34, 35). Furthermore, while many previous studies have focused on children, few have addressed active travel

behavior in adolescents (34). Moreover, previous studies have not considered adolescent active travel behavior in the context of the differing perspectives and attitudes of multiple family members (36, 37) resulting in most existing studies focusing exclusively on either youth or parental perspectives and neglecting the interrelation of both perspectives (38, 39). Such a precedent is an important oversight given that in their comparative study of children and adolescents as well as parental barriers on active commuting to school, Aranda-Balboa et al. (40) found that there are significant differences between adolescents' and parents' perspectives in terms of perceived social and environmental determinants of active travel.

To better understand and promote adolescent active travel there are a few important research opportunities to address, namely: family environment predictors of adolescent active travel, the value and impact of non-school commuting trips, and the influence of the decision-making processes of adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the famIly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of adolescent active travel behavior through conducting a theoretically-informed, multi-component, and mixed-methods investigation of German adolescents and parents.

## Methods and analysis

### Study design

The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both studies will collect data from multiple groups, specifically adolescents between 11–15 years old and their parents. Data collection for both studies will take place between June and December 2021.

### Theoretical framework

We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (27) (see Figure 1). This framework serves as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents' active travel based on the social-ecological model (18, 31). The framework considers physical (e.g., neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both parents and youth (e.g., socio-demographic and psychosocial variables, attitudes). In the ARRIVE study, we used these conceptual categories to identify relevant predictors of interest—e.g., personal characteristics, attitudes, parental and adolescent perceptions of physical and social environment barriers—that will be examined in our statistical models in order to explore how they impact the main outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (41-43).

*Figure 1. Theoretical Framework for the ARRIVE study*

**Quantitative study**

*Aims*

The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants of Active Travel in Children" (27). In a first step, we will comprehensively describe travel behavior in adolescents from Germany in dependence of destination and adolescents' socio-demographic characteristics. To systematically evaluate this theoretical model, our specific aims are threefold. First, we will seek to identify predictors of adolescent travel behavior with respect to four different destinations in order to discern whether the predictive strength of these correlates varies between trip destinations. Second, we will aim to develop a more comprehensive understanding of adolescent transport mode choice in the family context by comparing parent and adolescent perspectives regarding transport mode choice. Third, we will investigate the moderating effects of several theoretically relevant socio-demographic characteristics (e.g., sex/gender, migration background, and degree of urbanization) on adolescent travel behavior.

*Sampling strategy*

The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided by Forsa, a leading organization for public opinion polls. The recruitment for the survey will be conducted entirely offline via telephone interviews, so as to ensure that those lacking internet access are proportionately represented in the study. The panel contains people living in Germany and is representative of the German population regarding age, sex/gender, education and place of residence. Based on this panel, a sample of adults living together with adolescents aged 11–15 years old will be recruited. The sample will include roughly the same number of mothers and fathers. After giving informed consent to be contacted for the survey, participants will receive an invitation e-mail with a link to the questionnaire.

As suggested by Bujang et al. (44) for observational studies with large population sizes a minimum sample size of 500 is necessary to derive logistic regression analyses. By using real patient data, it was shown that a minimum sample size of 500 "is able to produce statistics that are nearly representative of the true values in the target population" (44). Thus, equivalent samples of parents (N = 500) and adolescents (N=500) will complete the survey.

*Data collection*

Participants will be able to answer the online questionnaire using one of a tablet, smartphone, or computer. The questionnaire includes two parts: a parent-focused section, and an adolescent-focused section. After answering their portion of the questionnaire, parents will be asked to provide the link to their adolescent or, if there is more than one adolescent in this age group in the family, to one randomly selected adolescent. To this end, parents who have multiple potential participants in their family will be instructed to select the adolescent whose first letter of their first name appears the earliest in the alphabet to fill out the adolescent portion of the survey. The survey is anticipated to take about 15 minutes to complete for adolescents and parents together.

*Measures*

To cover all relevant constructs, an online questionnaire has been developed based on already existing scales (that were partly translated into German), modified scales, and additional single item questions. The selection of scales and questions were derived from the central tenets of the theoretical framework; all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. Based on a literature search on activity settings of adolescents, four destinations adolescents frequently visit and which are the most popular places for adolescents in the walkable neighborhood have been selected to assess travel behavior in youth (41, 42, 45, 46). A detailed description of all measures applied in the online questionnaire for parents and adolescents is provided in Table 1.

*Data analysis*

Descriptive analysis

Data analysis will include descriptive statistics, an examination of normally distributed data, and examinations of the homogeneity of variance. Descriptive statistics will include means (M) and standard deviations (SD) for continuous variables, and frequencies (%) for categorical variables (e.g., boys and girls and mothers and fathers). Frequency distribution of transport mode for each destination will be calculated separately for boys and girls. To examine internal consistencies of the adapted scales, Cronbach's alpha will be calculated with the respective values indicating excellent > 0.9, good > 0.8, acceptable > 0.7, questionable > 0.6, poor >0.5, and unacceptable < 0.5 fit (47).

Outcome measures will consist of a categorical variable representing the different transport modes (e.g., walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode) for each destination, and an overall score of active transport including all destinations. This overall score will be calculated based on the proportion of active trips in relation to all reported trips resulting in an interval scaled variable with values between 0 (all trips *passive*) to 1 (all trips *active*).

232 **Table 1: Overview on Instrument used in the Parental and Adolescent Questionnaire**

| Construct | Instrument | Description | Reliability and Validity |
|---|---|---|---|
| **Parent questionnaire** | | | |
| Parents' and child's socio-demographics | Demographic Standards (48) | Parent indicate their age, gender, migration background, education, employment and how many children under 18 are living in household. For their child, they indicate age, gender and school typ. | - |
| Body Mass Index (BMI; child and parent) | Self-reported and proxy-reported weight and height | Parent report their weight and height as well as their children's weight and height. | |
| Current situation in school due to COVID-19 | Single-item question | Due to COVID-19 pandemic, an additional question is used to indicate the current schooling situation: normal, home schooling, or alternate lessons. | - |
| Degree of urbanization | BIK regions (49) | Parents indicate the degree of urbanization in dependence of inhabitants in their hometown (>100,000 inhabitants: city; 20,000–99,999 inhabitants: medium-sized town; 5,000–19,999 inhabitants: small town; <5,000 inhabitants: rural). | - |
| Home environment | Mobilität in Deutschland (MiD) (45) | Parents indicate car availability and bike availability (parent and child) and if they hold a driver license. | - |
| Distance to school | Single-item question | Parent indicate the distance to their child's school from home in kilometers. | - |
| Aerobic PA guideline compliance | European Health Interview Survey – Physical Activity Questionnaire (EHIS-PAQ) (Finger et al., 2015) | Six items are used to indicate parental aerobic PA guideline compliance (at least 150min aerobic PA per week) | The EHIS-PAQ is a reliable and valid tool to assess domain-specific PA as shown by adults from Germany (ICC = 0.43-0.73) (50). |
| Joint physical activity with child | Modified item from the MoMo-Physical-Activity-Questionnaire (MoMo-AFB) (51) | Parents indicate on how many days in a normal week they are more than 60min physically active with their child. | - |
| Active travel | Mobilität in Deutschland (MiD) (45) | To assess active travel in parents, they indicate transport mode, distance, and accompaniment of child to four different destinations (work, friends'/relatives' home, shopping, and leisure time activities). | - |
| Perceived social and physical environment | Modified version of the Parental Perception of Barriers Towards Active Commuting to School (PABACS) (52) | A 24-item scale is used to assess parental barriers towards active travel including general aspects, barriers for walking and barriers for cycling. | In 207 parents, the questionnaire showed good internal consistency (α = 0.86), moderate reliability (ICC = 0.51-0.55) and moderate validity (52). |

| | | | |
|---|---|---|---|
| Parents' self-efficacy | Modified version of the Parents' Self-efficacy Scale (53) | A 13-item scale is used to assess parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy. | Cronbach's α for the three first-order factors parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy were 0.95, 0.86, and 0.76, respectively (53). |
| Environmental self-identity | Environmental Self-identity Scale (54) | Parents indicate their agreement to three items on environmental friendliness. | The scale showed good internal consistency (α = 0.870; average corrected item-total correlations = 0.755) (54). |
| Health consciousness | Health Consciousness Scale (55) | Parents indicate their agreement to five items related to health practices on a 5-point-likert scale. | The scale showed good internal consistency (α = 0.72) (55). |
| **Adolescent questionnaire** | | | |
| WHO PA guideline compliance | MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo-AFB) (51) | Adolescents indicate on how many days in a normal week they are physically active for 60min or more. | In 9-17-year-olds, the MoMo-AFB showed good test-retest reliability (ICC=0.68) and validity (Spearman r = 0.29) (56). |
| Active travel | MiD (45) and New Version of Mode and Frequency of Commuting To and From School (57) | Adolescents indicate transport mode, accompaniment, and distance (in min and km) to school, to friends/relatives, to shopping opportunities and to leisure time activities. | The questionnaire is a reliable and feasible tool to assess active travel in adolescents (κ = 0.61-0.94) (57). |
| Perceived social and physical environment | Modified Version of the Barreras percibidas en el desplazamiento activo al centro educativo (BATACE) (58) | An 18-item scale is used to assess perceived barriers to active travel including environmental and safety factors as well as planning and psychosocial barriers. | The BATACE showed good test-retest reliability (ICC range: 0.68-0.77) and internal consistency (α = 0.59-0.76) in a sample of 465 adolescents (58). |
| Perceived parental autonomy support for active travel | Modified Version of the Perceived Autonomy Support Scale for Active Commuting to and from School (PASS-ACS) (59) | A 4-item scale assesses perceived parental support for active travel. | The PASS-ACS is a valid and reliable (α = 0.85; ICC = 0.88) tool to assess adolescents' perceived support for active travel (59). |
| Basic Psychological Need Satisfaction | Modified Version of the Basic Psychological Need Satisfaction in Active Commuting to and from School (BPNS-ACS) (60) | A 12-item scale is used to assess adolescents' autonomy, competence, and relatedness need satisfaction with regard to active travel behavior. | In 675 students (10-18 years), the BPNS-ACS showed acceptable internal consistency (autonomy satisfaction α = 0.81, competence satisfaction α = 0.92, and relatedness satisfaction α = 0.82) and predictive validity (total variance explained: 24%) (60). |
| Motivation for active travel | Modified version of the Behavioral Regulation in Active Commuting to and from School (BR-ACS) Questionnaire (61) | A 23-item scale is used to assess motivational regulation in active travel including intrinsic motivation, integrated, identified, introjected and external regulation, and amotivation. | In 404 secondary students, the BR-ACS showed adequate internal consistency (α = 0.70-0.91) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (61). |

*Notes: Cronbach's alpha= α; ICC= intraclass correlation coefficient; κ = Cohen's Kappa; min= minutes; PA= physical activity*

Aim 1: Description of travel behavior in adolescents from Germany

Differences in transport mode choice and predictor variables between different groups (e.g., age, sex/gender) will be calculated using t-tests and analysis of variance for continuous variables, and chi-squares for categorical variables. For example, differences in transport mode choice between boys and girls and adolescents living in different regions with different degrees of urbanization (cities, medium-sized towns, small towns, rural areas) will be calculated using Pearson-Chi2-test and post-hoc analysis (62) as well as the comparison of transport mode across destinations according to parental sex/gender (mothers and fathers). To identify differences in travel distance between transport modes one-way analysis of variance will be calculated.

Aim 2: Identifying predictors of adolescent travel behavior

Multinomial (different transport modes) and binary (active vs. passive travel) logistic regression models controlling for multiple relevant socio-demographic variables will be used to identify predictors of adolescent active travel. Due to the heterogeneity of outcome measures, separate logistic regression analyses will be conducted for each destination using the dichotomous variables of transport mode choice as dependent variable, the individual, social and physical environmental variables as predictors. In all analyses, socio-demographic factors (e.g., age, education) will be included as confounders. Adjusted odds ratio (aOR) and 95%-confidence intervals will be reported. For some analyses, the overall score of active travel will be used as categorical, dependent variable, for example, to assess the effect of the motivational regulations on active travel behavior in adolescents. The regression analysis will either be performed for the whole sample or due to theoretical assumptions separately for male and female adolescents to account for sex/gender differences. To assess associations between travel behavior in adolescents and their parents, separate sex/gender analyses with parent-adolescent-dyads (mother-daughter, mother-son, father-daughter, and father-son) will be conducted by binary logistic regressions, with adolescents' travel behavior as the outcome and parental travel modes as the predictors.

Aim 3: Comparing parental and adolescents' perspectives on transport mode choice

To investigate parental and adolescents' perspectives on social and physical barriers of active travel, several multiple regression models will be performed. The overall score for transport mode in adolescents will be set as the dependent variable and each barrier as an independent variable. Thus, for each comparable barrier a separate multiple regression will be implemented.

Aim 4: Investigating moderating effects of relevant socio-demographic characteristics

To assess whether the association between the social and physical environment and adolescents' travel behavior are moderated by socio-demographic characteristics (e.g., sex/gender, degree of urbanization), we will run 1) logistic regression models controlling for socio-demographic variables, and 2) logistic regression analyses including interactions effects.

If appropriate, further exploratory analysis based on the theoretical framework will be conducted within the ARRIVE project. For all analysis, a level of $\alpha = 0.05$ will be set as a threshold to determine statistical significance. Analyses will be conducted with R, Matlab, and SPSS.

**Qualitative study**

*Aims*

The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box). Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated by the adolescents and parents themselves. To complement our online survey which aims to examine if and how various socio-demographic and socio-environmental factors predict adolescent travel behavior, this qualitative investigation seeks to understand the experiences of adolescent travel behavior by precisely exploring what and why certain influences centrally impact parental and adolescent decision-making processes regarding transport mode choice. Specifically, the qualitative investigation will focus on the following research questions:

- What physical environment and individual factors influence transport mode choice in adolescents?
- How do adolescents experience the decision-making process on transport mode choice?
- How do parents experience the decision-making process on transport mode choice in adolescents?
- Are there any differences in adolescents' and parental perspectives on transport mode choice?

*Sampling strategy*

In addition to the online sample, we will also be recruiting another set of adolescents and their parents to take part in the qualitative investigation. These participants will be recruited using theoretical sampling methods (63). Therefore, the sample will not be defined by the onset of the study, but will be selected against the background of theoretical problems outlined earlier and in accordance with our proposed analysis processes. Our sampling methods will thus initially be based on ensuring the samples contain diversity with respect to socio-economic status, migration status, sex/gender, and environmental conditions (e.g., urban and rural living locations). When possible, we will interview both parents to capture the perspectives of fathers and mothers. We anticipate that the final sample will consist of 10–15 adolescents and 15–20 parents.

*Data collection*

Interviews will be conducted with adolescent and parent participants separately. Prior to the data collection process all interviewers received formal training from an interview expert. Sample interviews were conducted to ensure the appropriateness of the interview guides.

Interviews are anticipated to take around 30 minutes to complete. However, because deviations are possible, for each participant an appointment time of 60 minutes will be made. After giving informed consent and agreeing on an appointment, each participant will receive an individual link for an online meeting to conduct the interview. Participants will be able to complete their interview from any desired place so long as they have a stable internet connection and quiet surrounding. Before the start of the recording, the objective and the interview procedure will be explained and participants will be reassured

of the voluntary nature of their involvement and their right to refuse to answer any questions. After clarifying any questions that participants may have, the audio recording device will be turned on and the interview will begin. At the end of the interview, the audio recording will stop.

*Interview Guideline*

The focus of the interviews for both groups of participants will be the travel behavior of adolescents and the associated decision-making process. During the interviews, adolescents and their parents will be encouraged to recount their travel experiences and their decision-making processes regarding mode choice in relation to four different situations. In order to generate a thorough understanding of the differences in decision-making processes when considering the choice of active vs. passive transport to the distinct locations, different interview paths will be followed to ensure that the interview inquires about four (two active, two passive trips) different travel type-location examples (see Figure 2). At the start of each interview parents and adolescents will be instructed to first talk about a recent trip the latter made during one of the days prior to the interview. This first trip may be undertaken by either an active or passive means. Next, and to facilitate a comparison of factors affecting adolescent travel mode decision-making processes, participants will be asked to remember a trip to the same destination that they made using another transport mode (passive/active). To generate additional depth regarding understanding the potential variety of relevant factors influencing participants' decision-making processes, this procedure will be repeated for another destination that the adolescent traveled to in the previous week. In the event that an adolescent participant reports that they never changed transport mode to the two selected destinations, the interviewer will ask about any trips made with the opposite (passive/active) transport mode to explore how their habits and perceptions might be changed.

*Figure 2. Structure of the interview guide – decision-tree*

When discussing each of the four distinct trips, participants will be asked to describe their experiences of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks: the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation

on the journey itself (i.e., social and environmental factors). To garner further information pertaining to the various circumstances which might affect the travel planning process, adolescents and parents will also be asked about a hypothetical commute to school, and specifically what factors (e.g., concerns, priorities) they would foremost consider when planning the trip. Interviews will close with adolescents and parents being asked which transport mode they would prefer and why. More detailed information regarding both interview guides is enclosed in the supplementary materials.

*Table 2. Topics addressed in the adolescents and parental interview*

| | Situation | Topic | Examples |
|---|---|---|---|
| **Active/Passive Transport Mode to Destination** | Situation at home | General aspects | e.g., weather, stress, behavior, particularities |
| | | Decision-making process | e.g., own behavior, parental behavior, decision on mode choice, rules, motivation |
| | Situation on the route | Physical environment | e.g., distance, characteristics of way, like/dislike |
| | | Social environment | e.g., friends, siblings, companionship |
| **Hypothetical way to school** | Situation at home | Relevant factors | e.g., weather, school situation, daily schedule |
| | | Decision-making process | e.g., parental influence, motivation, attitudes |

*Data analysis*

All audio recordings will be saved, treated as strictly confidential material, and eventually transcribed verbatim. With regard to answering the four research questions noted earlier, analysis will be conducted using thematic analysis (64) or content analysis (65). In the first step, two researchers will independently analyze interview transcripts by the means of a deductive-inductive process. Deductive themes are defined prior to analysis according to the presented framework (Figure 1) and in this study will include physical environment factors (e.g., attractiveness, infrastructure, social environment), parent characteristics and attitudes (e.g., SES, social support), adolescent characteristics and attitudes (e.g., age, motivation), and environmental perceptions (e.g., parental perceptions of barriers/enablers, adolescent perceptions of barriers/enablers). To allow for more in-depth insights in the decision-making process, researchers will then code transcripts inductively to identify emerging ideas and concepts that

may not align well with the original deductive categories. Subsequently, emerging differences and commonalities from the deductive-inductive analysis will be discussed together to develop consensus. In cases where a consensus may not be reached, a third researcher will join the discussion.

## Ethics and dissemination

The ARRIVE study is designed in accordance with the ethical principles for research involving human subjects of the Declaration of Helsinki. Ethical approval for the study and its procedures were received from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg (Reg. 249_21 B). Participation in both parts of the study is voluntary. Participants will not receive any reimbursement or compensation for participating in one part of the study. Informed assent will be obtained from all adolescents and informed consent will be obtained from all parents that participate in this study. With regard to the quantitative survey, no personally identifiable information will be included in the data set and transferred from forsa to the study team. In the interviews, participants will not be addressed by name, nor will any personal identifying information be requested. All data will be stored on central servers of the Technical University of Munich/Germany and the University of Erlangen-Nuremberg/Germany.

The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly journals with international audiences, and will be presented at academic conferences. Additionally, the results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made publicly available for interested individuals, families, teachers, and caregivers via a project website and public knowledge translation activities (e.g., public talks, community information sessions).

## Patient and public involvement statement

No medical patients and/or members of the public were involved in setting the research question nor they were involved in developing plans for design (or implementation) of this study protocol.

## Discussion

Increasing physical activity in adolescents is an immediate and serious challenge for modern societies, but one that if effectively addressed can contribute to preventing a number of chronic and non-communicable diseases (7). Recent recommendations by the European Society of Cardiology (ESC) suggest approaches targeting optimizing lifestyle activities to change physical activity behaviors and reduce sedentary time as important preventive measures in this regard (66). Better understanding the decision-making processes of both adolescents and parents regarding multiple forms of, and influences on, daily adolescent active travel behavior can be an effective strategy in supporting these desired lifestyle activity alterations.

Until now, only a few qualitative studies exist that provide a deeper understanding of the interrelationships and familial decision-making processes on active travel behavior in adolescents (28, 29, 32). The inclusion of qualitative methods in the study of this issue can be beneficial as they may help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus on the experiences, meanings, and perspectives of the participants (67). Additionally, previous evidence has posited that child or adolescent sex/gender plays a significant role with regard to physical activity and travel behavior (68-70), it has been observed that parental perspectives of this issue have been largely limited to the views of mothers (e.g., (29, 71)).

The ARRIVE study aims to address these research gaps, by providing a comprehensive multi-component and multi-group analysis of the socio-ecological determinants of adolescent active travel behavior and its associated decision-making processes. Quantitative analyses of several theoretically relevant predictors of adolescent active travel are intended to provide the necessary empirical evidence to illustrate the relationships of the family environment with non-school commutes and travel behaviors. Qualitative semi-structured interviews are anticipated to provide deeper insights into the decision making-processes of both adolescents and parents regarding travel mode behaviors. Together, the findings from both components of the ARRIVE study should be of value to both practitioners and researchers as they will offer a comprehensive evaluation of a more diverse set of trips, family predictors, and decision-making processes associated with adolescent active travel, as well as provide empirical evidence to support public health active travel interventions for targeted adolescent groups and families.

To build on the expected findings of the ARRIVE study in future research, targeted active travel interventions, especially those featuring gamification elements (72), could be a starting point for larger-scale prevention efforts aimed to reduce non-communicable diseases and to improve public health. For example, longitudinal data supports that nine to 18-year-old active commuters have higher levels of physical activity during young adulthood and can maintain these behaviors for up to 12 years (73), thus targeted and gamified early-years interventions may be prudent prevention strategies. Other potential benefits of regular active travel, or targeted interventions, include the improved emotional health and happiness of both adolescents and adults (74), improvements in cardiovascular health (e.g., exercise capacity, maximal power, blood pressure and blood parameters) in adults (75-77) and adolescents (78, 79), and cleaner and less congested neigbourhoods (80, 81)—all points which future intervention studies could also evaluate alongside the findings (e.g., articulated decision-making processes) of our ARRIVE study.

## Authors' contributions

AKR, IM, FB, EE, DR, CK and YD made substantial contribution to the concept and design of the ARRIVE study. AKR and IM prepared the first draft of the protocol article and finalized the manuscript. FB, EE, DR, AB, CK and YD made substantial contributions to the manuscript, provided edits to the manuscript and read and approved the final manuscript.

## Competing interests

The authors declare that they have no competing interests.

## Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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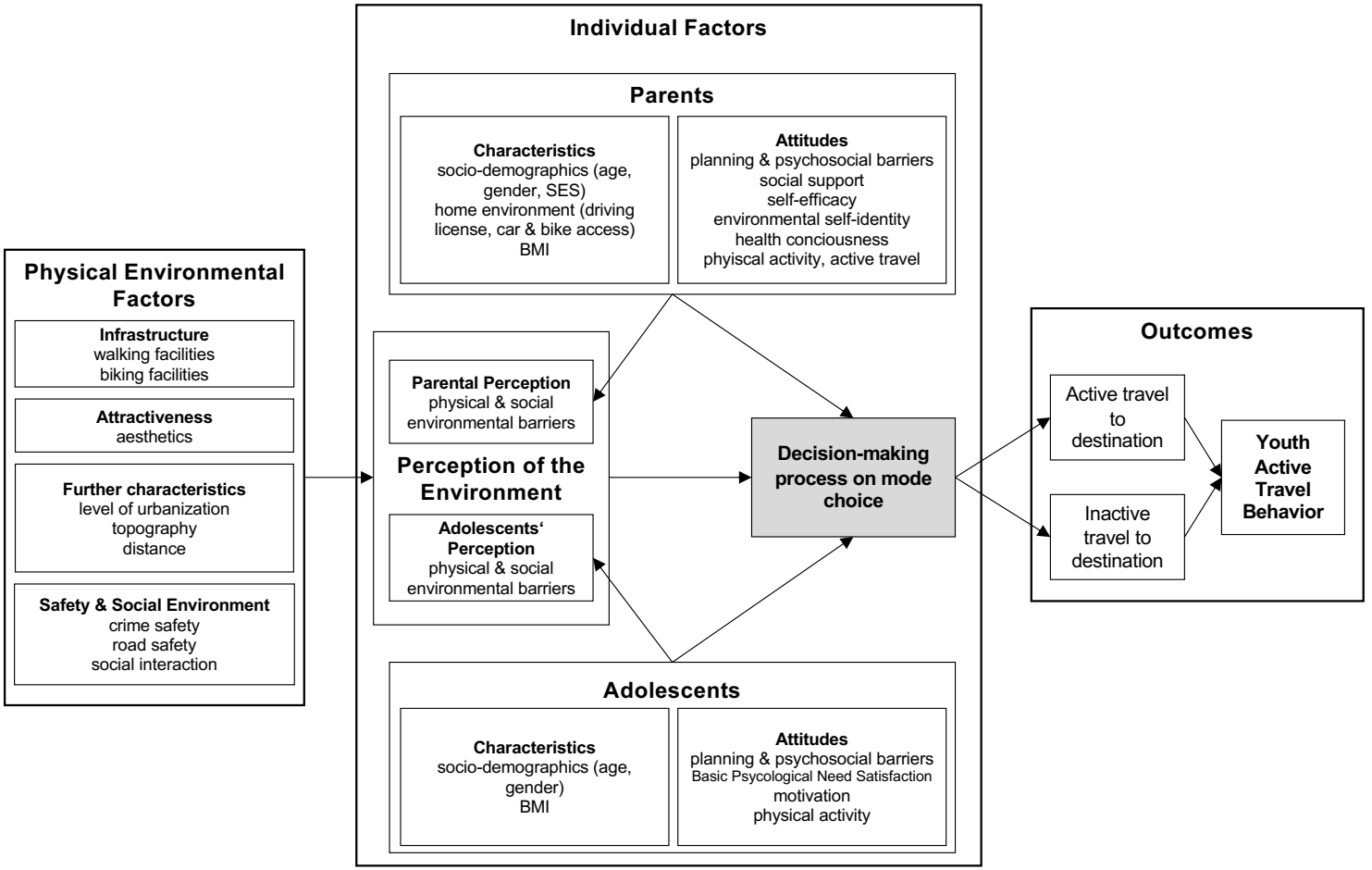
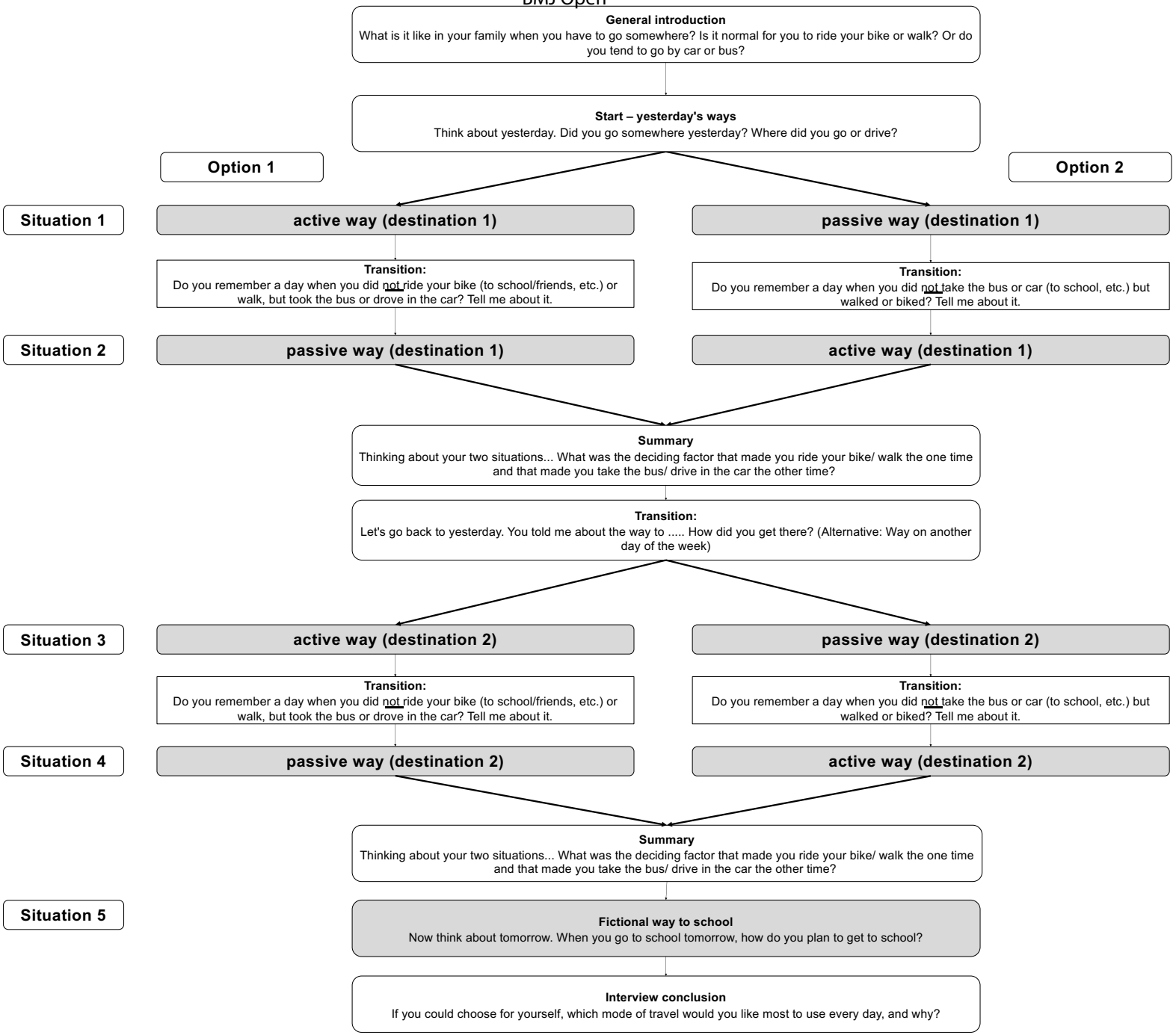

Individual Factors
Parents
Characteristics
socio-demographics (age, gender, SES)
home environment (driving license, car & bike access)
BMI
Attitudes
planning & psychosocial barriers
social support
self-efficacy
environmental self-identity
health conciousness
phyiscal activity, active travel
Physical Environmental Factors
Infrastructure
walking facilities
biking facilities
Attractiveness
aesthetics
Further characteristics
level of urbanization
topography
distance
Safety & Social Environment
crime safety
road safety
social interaction
Parental Perception
physical & social environmental barriers
Perception of the Environment
Adolescents' Perception
physical & social environmental barriers
Decision-making process on mode choice
Outcomes
Active travel to destination
Inactive travel to destination
Youth Active Travel Behavior
Adolescents
Characteristics
socio-demographics (age, gender)
BMI
Attitudes
planning & psychosocial barriers
Basic Psycological Need Satisfaction
motivation
physical activity


General introduction
What is it like in your family when you have to go somewhere? Is it normal for you to ride your bike or walk? Or do you tend to go by car or bus?
Start – yesterday's ways
Think about yesterday. Did you go somewhere yesterday? Where did you go or drive?
Option 1
Option 2
Situation 1
active way (destination 1)
passive way (destination 1)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 2
passive way (destination 1)
active way (destination 1)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Transition:
Let's go back to yesterday. You told me about the way to ..... How did you get there? (Alternative: Way on another day of the week)
Situation 3
active way (destination 2)
passive way (destination 2)
Transition:
Do you remember a day when you did not ride your bike (to school/friends, etc.) or walk, but took the bus or drove in the car? Tell me about it.
Transition:
Do you remember a day when you did not take the bus or car (to school, etc.) but walked or biked? Tell me about it.
Situation 4
passive way (destination 2)
active way (destination 2)
Summary
Thinking about your two situations... What was the deciding factor that made you ride your bike/ walk the one time and that made you take the bus/ drive in the car the other time?
Situation 5
Fictional way to school
Now think about tomorrow. When you go to school tomorrow, how do you plan to get to school?
Interview conclusion
If you could choose for yourself, which mode of travel would you like most to use every day, and why?

# Supplementary material

## A. Interview guideline - parents

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way - decision making process | Think again carefully about the situation before your child left with [mode of travel]. Can you describe the situation at home? | Stress | Can you describe the situation at home in detail? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | Can you describe what you did before your child left home? | How did you feel about it? / How did it make you feel? |
| | Can you describe how the decision was made/how it came about that your child chose [mode of travel]? | Behavior family | How did you behave? How did your child / siblings behave? | How did you feel about it? |
| | | Decision | Who decided that your child used [mode of travel]?<br>Can you describe the extent to which you influenced this decision? | Can you describe what was running through your mind when you made the decision? |
| | | Rules | Are there any rules in the family regarding [mode of travel]? | Can you describe why these rules exist / are important to you? |
| | | Persuasion/reason | Can you remember a specific reason why your child used [mode of travel]? | Is there a personal persuasion behind them? |
| | | Motivation | To what extent did you motivate your child to use [mode of travel]? | |
| Way – physical environment | Do you know where your child drove/walked along? | Parental perspective | How do you feel about the way?<br>Is there anything on the way that worries you? | How do you deal with it? |

| | | | | |
|---|---|---|---|---|
| | Can you describe the way as precisely as possible so that I can get an idea? | Child's perspective<br><br>Behavior child – way | How do you think your child likes the way?<br><br>Can you describe what your child has done/experienced along the way? | How do you feel about it? |
| Way – social environment | Did someone accompany your child? | Friends company<br><br>Parents company | How does it happen?<br><br>What do you do on the way together? Can you describe why you accompany your child? | What do you say to that?<br><br>How is this for you - to use [mode of travel] with your child? |
| **Interview guide for situations 5** | | | | |
| Fictional way to school | Now please think about tomorrow, when your child goes to school. How do you plan (together with your child) the way to school? Or does your child plan the way to school alone? | Relevant factors<br><br>Decision | What factors are you or your child considering for planning tomorrow? What are you thinking about it?<br><br>To what extent do you involve your child? | What would change your decision? Are you satisfied with the decision? How do you evaluate this decision? |

## B. Interview guideline - youth

| Interview topic (general) | Guiding question | Interview topic (specific) | Follow-up questions I | Follow-up questions II |
|---|---|---|---|---|
| **Interview guide for situations 1-4** | | | | |
| Way – decision making process | Think again exactly about the situation before you [mode of travel]. Can you describe how it came about that you [mode of travel]? | Stress | What was the situation like? Was it stressful? | Was there anything special about the day? |
| | | Weather | What was the weather like? | |
| | | Behavior | What did you do before you left the house? | |
| | Tell me about how all went with your parents. | Behavior family | How did you behave? How did your mom/dad/siblings behave? | How did you feel at that time? What was running through your mind? |
| | | Decision | Who decided that you [mode of travel]?/ How did you decide to [mode of travel]? | How do you feel about that? That you can decide alone / That your parents decide for you? How did you come to your decision to [mode of travel]? |
| | | Rules | Are there any rules in your family? | Do you know why your parents make the decision the way they do? |
| | | Persuasion/reason | Was there anything in particular that convinced you to [mode of travel]? | |
| | | Motivation | What did motivate you? | |
| Way – physical environment | Think about where you drove/walked along. Can you describe the way exactly so that I can get an idea of it? | Distance | How long did you spend on the way? How far is the way? | How do you feel about the way? |
| | | Behavior | How did you drive/walk? Do you do anything special on the way? | How did you feel while [mode of travel]? How was [mode of travel] for you? |
| | | Way - characteristics | How did you like the way? What do you like about the way? What do you not like about it? | |

| | | | | |
|---|---|---|---|---|
| | | | What did you like about [mode of travel]? | |
| Way – social environment | Did anyone accompany you on the way? Can you describe the situation on the way in detail? | Company | Can you tell me about how you rode together?<br>Can you tell me what you did along the way?<br><br>Do you meet other people along the way? | What was it like between you?<br>Was there anything that you particularly liked?<br>Was there anything you did not like so much? |
| **Interview guide for situation 5** | | | | |
| Fictional way to school | Now think about tomorrow. Can you describe to me how you decide how to get to school? How do you plan the way to school? | Relevant factors<br><br>Decision | Which factors do you take into account in the planning?<br>What are you considering?<br>Do you check with your parents?<br>Whom do you involve in the decision?<br>How do you come to the decision? | What would change your decision?<br>Are you satisfied with the decision?<br>How do you evaluate this decision? |