

# BMJ Open Active travel behaviour in the family environment: protocol for the mixed-methods cross-sectional ARRIVE study

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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 behaviour 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 socioecological framework for adolescent travel behaviour, the mixed-methods Active tRavel behavioR in the family enVironmEnt study aims to quantitatively assess the influence of several predictors of adolescent travel behaviour, 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 semistructured interviews. The online questionnaire, developed in accordance with a theoretical framework of adolescent active travel, will examine adolescent travel behaviour 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 semistructured 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 (ie, 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.

## 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.<sup>1</sup> Long-term health benefits of physical activity are

## Strengths and limitations of this study

- The quantitative part of the Active tRavel behavioR in the family enVironmEnt study includes a large representative sample of German parents and adolescents from diverse neighbourhoods and regions and different socioeconomic backgrounds. However, the sample might not be representative of typical German travel behaviours as they result from many additional factors like urban infrastructure accessibility, family work arrangements and other sociodemographic factors (eg, vehicle ownership) that we are not able to control for in this study.
- Situated within a theoretical socioecological framework, multiple theoretically relevant predictors of adolescent active travel behaviour 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 socioecological framework of adolescent active travel, will be used to assess adolescent active travel behaviour and its predictors.
- Semistructured 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.

well documented for children, adolescents<sup>2,3</sup> and adults.<sup>4</sup> However, concerning low levels of physical activity among children, adolescent<sup>5</sup> and adults<sup>6</sup> in countries across the globe demands urgent action. The 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.<sup>7</sup>

Active travel, that is any form of human-powered transportation (eg, walking, biking), as a daily routine (eg, trips to/from school) is a low-cost and widely accessible source of



physical activity.<sup>8</sup> But despite many potential benefits of active commuting, percentages of active commuters have declined in most countries.<sup>9–13</sup> In Germany, like in many other countries, for example, only a significant minority of adolescents currently walk or cycle to school.<sup>9 14–16</sup> 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.<sup>9</sup>

To better understand adolescent travel mode decisions and travel behaviour, as well as to enable the development of evidence-based intervention programmes 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<sup>17–20</sup> and longitudinal<sup>16 21 22</sup> research has identified various individual-level and neighborhood-level factors related to adolescent active travel. However, while these studies and extant theoretical socioecological models<sup>23</sup> and active travel frameworks<sup>24–27</sup> 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 behaviour, the decision-making processes within the family and especially about adolescent travel behaviour to non-school destinations.

One comparatively understudied influence of potential consequence regarding adolescent active travel behaviour is family environment predictors (eg, parental support, role modelling, availability of a bicycle). Although recent study confirms the importance of parental controls with respect to adolescent transport mode choice,<sup>28–30</sup> comprehensive studies of family environment predictors of adolescent active commuting remain rather limited.<sup>31</sup> 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,<sup>28 29 32</sup> and that some parents prefer car usage to spend time with their children.<sup>32</sup> Other noted relevant factors in this regard include social norms and convenience,<sup>28 32</sup> and parenting practices<sup>29</sup> 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<sup>32</sup> revealed that parents chauffeured their teenagers to school regardless of distance, another from Canada<sup>28</sup> 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 (eg, 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 travelled by adolescents than school commutes. For example, in Germany, adolescents accumulate on average 2.8 trips taking 72 min and having a total distance of 29 km/day.<sup>33</sup> 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.

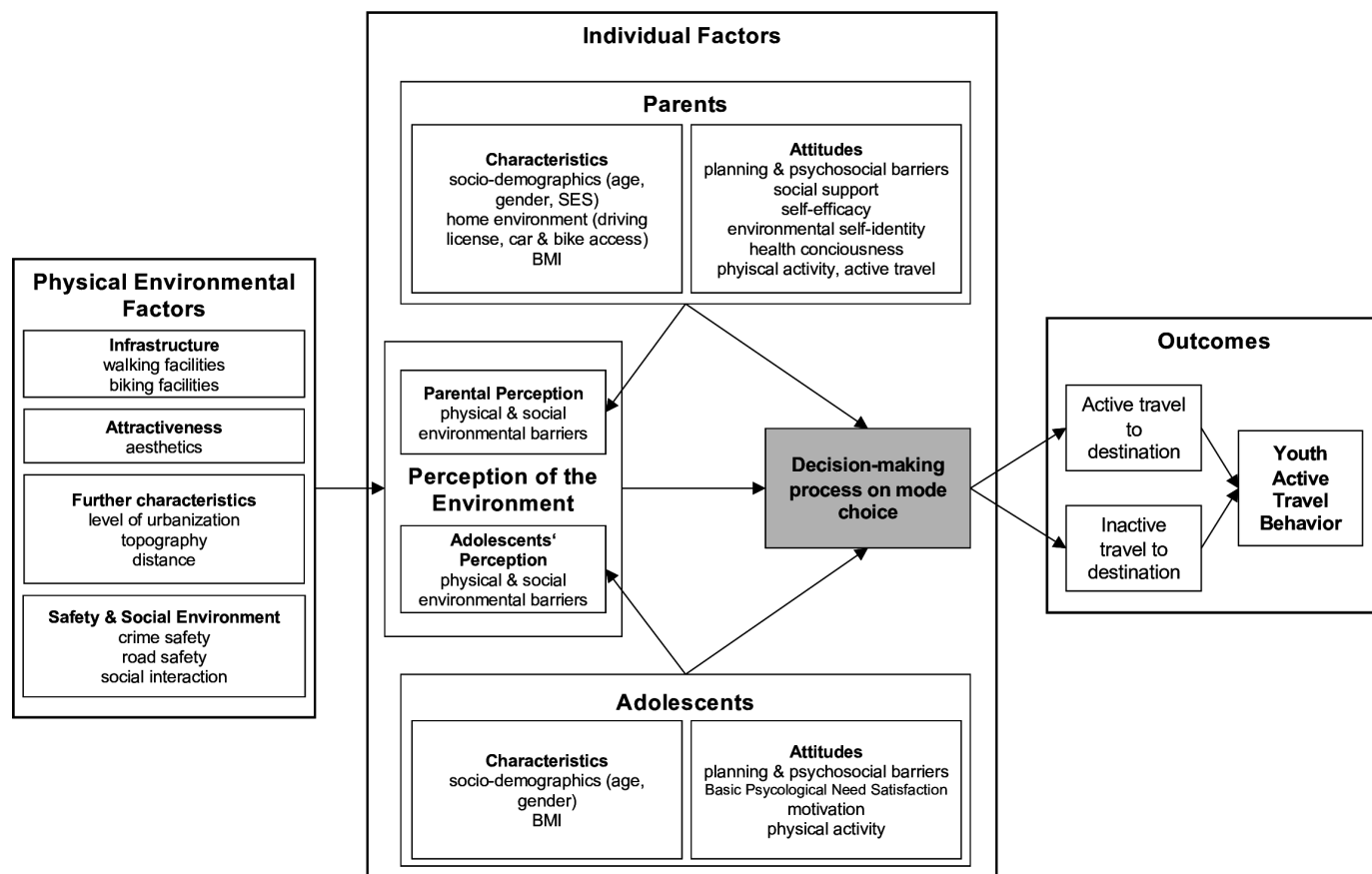
The dynamics and impacts of parental and adolescent decision-making processes on adolescent active travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the perceived social and physical environment facilitators and barriers to active travel among parents may vary across diverse cohorts from various geographical regions and degrees of urbanisation.<sup>34 35</sup> Furthermore, while many previous studies have focused on children, few have addressed active travel behaviour in adolescents.<sup>34</sup> Moreover, previous studies have not considered adolescent active travel behaviour in the context of the differing perspectives and attitudes of multiple family members<sup>36 37</sup> resulting in most existing studies focusing exclusively on either youth or parental perspectives and neglecting the inter-relation of both perspectives.<sup>38 39</sup> 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*<sup>40</sup> 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 behaviour. 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 behaviour through conducting a theoretically informed, multicomponent 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



**Figure 1** Theoretical framework for the ARRIVE study. BMI, body mass index; SES, socioeconomic status.

(travel to/from school/workplace, homes of friends and/or relatives, shops, leisure facilities), and (2) the intra-familial dynamics (ie, family context predictors and decision-making processes) that impact adolescent travel behaviours. ARRIVE's mixed-methods approach includes two complementary studies: quantitative online surveys and qualitative semistructured 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'<sup>27</sup> (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.<sup>18 31</sup> The framework considers physical (eg, neighbourhood design) and social (eg, crime) environment factors, as well as individual factors for both parents and youth (eg, sociodemographic and psychosocial variables, attitudes). In the ARRIVE study, we used these conceptual categories to identify relevant predictors of interest—eg, 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 behaviour) in relation to the four commonly frequented destinations.<sup>41–43</sup>

### 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'.<sup>27</sup> In a first step, we will comprehensively describe travel behaviour in adolescents from Germany in dependence of destination and adolescents' sociodemographic characteristics. To systematically evaluate this theoretical model, our specific aims are threefold. First, we will seek to identify predictors of adolescent travel behaviour 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 (eg, sex/gender, migration background and degree of urbanisation) on adolescent travel behaviour.

### Sampling strategy

The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided by Forsa, a leading organisation 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 email with a link to the questionnaire.

As suggested by Bujang *et al*<sup>44</sup> 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'.<sup>44</sup> 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 min 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 neighbourhood have been selected to assess travel behaviour in youth.<sup>41 42 45 46</sup> 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 SD for continuous variables, and frequencies (%) for categorical variables (eg, 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.<sup>47</sup>

Outcome measures will consist of a categorical variable representing the different transport modes (eg, 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).

#### Aim 1: description of travel behaviour in adolescents from Germany

Differences in transport mode choice and predictor variables between different groups (eg, age, sex/gender) will be calculated using t-tests and analysis of variance for continuous variables, and  $\chi^2$  for categorical variables. For example, differences in transport mode choice between boys and girls and adolescents living in different regions with different degrees of urbanisation (cities, medium-sized towns, small towns, rural areas) will be calculated using Pearson- $\chi^2$ -test and post hoc analysis<sup>48</sup> 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 behaviour

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. 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, sociodemographic factors (eg, age, education) will be included as confounders. Adjusted odds ratio and 95% CIs 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 behaviour 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

**Table 1** Overview on instrument used in the parental and adolescent questionnaire

Construct	Instrument	Description	Reliability and validity
<i>Parent questionnaire</i>			
Parents' and child's sociodemographics	Demographic standards <sup>68</sup>	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 type.	–
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 urbanisation	BIK regions <sup>69</sup>	Parents indicate the degree of urbanisation in dependence of inhabitants in their hometown (>100 000 inhabitants: city; 20 000–99 999 inhabitants: medium-sized town; 5000–19 999 inhabitants: small town; <5000 inhabitants: rural).	–
Home environment	Mobilität in Deutschland (MID) <sup>45</sup>	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 kilometres.	–
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 150 min 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). <sup>70</sup>
Joint physical activity with child	Modified item from the MoMo-Physical-Activity-Questionnaire (MoMo-AFB) <sup>71</sup>	Parents indicate on how many days in a normal week they are more than 60 min physically active with their child.	–
Active travel	Mobilität in Deutschland (MID) <sup>45</sup>	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) <sup>72</sup>	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 ( $\alpha=0.86$ ), moderate reliability (ICC=0.51–0.55) and moderate validity. <sup>72</sup>
Parents' self-efficacy	Modified version of the Parents' Self-efficacy Scale <sup>73</sup>	A 13-item scale is used to assess parents' scheduling self-efficacy, parents' barrier self-efficacy and parents' support-seeking self-efficacy.	Cronbach's $\alpha$ 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. <sup>73</sup>
Environmental self-identity	Environmental Self-identity Scale <sup>74</sup>	Parents indicate their agreement to three items on environmental friendliness.	The scale showed good internal consistency ( $\alpha=0.870$ ; average corrected item-total correlations=0.755). <sup>74</sup>
Health consciousness	Health Consciousness Scale <sup>75</sup>	Parents indicate their agreement to five items related to health practices on a 5-point Likert scale.	The scale showed good internal consistency ( $\alpha=0.72$ ). <sup>75</sup>

Continued

Table 1 Continued			
Construct	Instrument	Description	Reliability and validity
<i>Adolescent questionnaire</i>			
WHO PA guideline compliance	MoMo-Physical-Activity-Questionnaire for Adolescents (MoMo-AFB) <sup>71</sup>	Adolescents indicate on how many days in a normal week they are physically active for 60 min or more.	In 9–17 year olds, the MoMo-AFB showed good test–retest reliability (ICC=0.68) and validity (Spearman $r=0.29$ ). <sup>76</sup>
Active travel	MiD <sup>45</sup> and New Version of Mode and Frequency of Commuting To and From School <sup>77</sup>	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 ( $\kappa=0.61–0.94$ ). <sup>77</sup>
Perceived social and physical environment	Modified Version of the Barreras percibidas en el desplazamiento activo al centro educativo (BATACE) <sup>78</sup>	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 ( $\alpha=0.59–0.76$ ) in a sample of 465 adolescents. <sup>78</sup>
Perceived parental autonomy support for active travel	Modified Version of the Perceived Autonomy Support Scale for Active Commuting to and from School (PASS-ACS) <sup>79</sup>	A 4-item scale assesses perceived parental support for active travel.	The PASS-ACS is a valid and reliable ( $\alpha=0.85$ ; ICC=0.88) tool to assess adolescents' perceived support for active travel. <sup>79</sup>
Basic psychological need satisfaction	Modified Version of the Basic Psychological Need Satisfaction in Active Commuting to and from School (BPNS-ACS) <sup>80</sup>	A 12-item scale is used to assess adolescents' autonomy, competence and relatedness need satisfaction with regard to active travel behaviour.	In 675 students (10–18 years), the BPNS-ACS showed acceptable internal consistency (autonomy satisfaction $\alpha=0.81$ , competence satisfaction $\alpha=0.92$ and relatedness satisfaction $\alpha=0.82$ ) and predictive validity (total variance explained: 24%). <sup>80</sup>
Motivation for active travel	Modified version of the Behavioural Regulation in Active Commuting to and from School (BR-ACS) Questionnaire <sup>81</sup>	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 ( $\alpha=0.70–0.91$ ) and stability (ICC=0.74) and predictive validity (total variance explained: 57%). <sup>81</sup>

Notes:

ICC, intraclass correlation coefficient; min, minutes; PA, physical activity;  $\alpha$ , Cronbach's alpha;  $\kappa$ , Cohen's Kappa.

sex/gender differences. To assess associations between travel behaviour 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 behaviour 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 behaviour are moderated by sociodemographic characteristics (eg, sex/gender, degree of urbanisation), we will run (1) logistic regression models controlling for sociodemographic 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 semistructured 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 behaviour as articulated by the adolescents and parents themselves. To complement our online survey which aims to examine if and how various sociodemographic and socioenvironmental factors predict adolescent travel behaviour, this qualitative investigation seeks to understand the experiences of adolescent travel behaviour 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.<sup>49</sup> 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 socioeconomic status, migration status, sex/gender and environmental conditions (eg, 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.

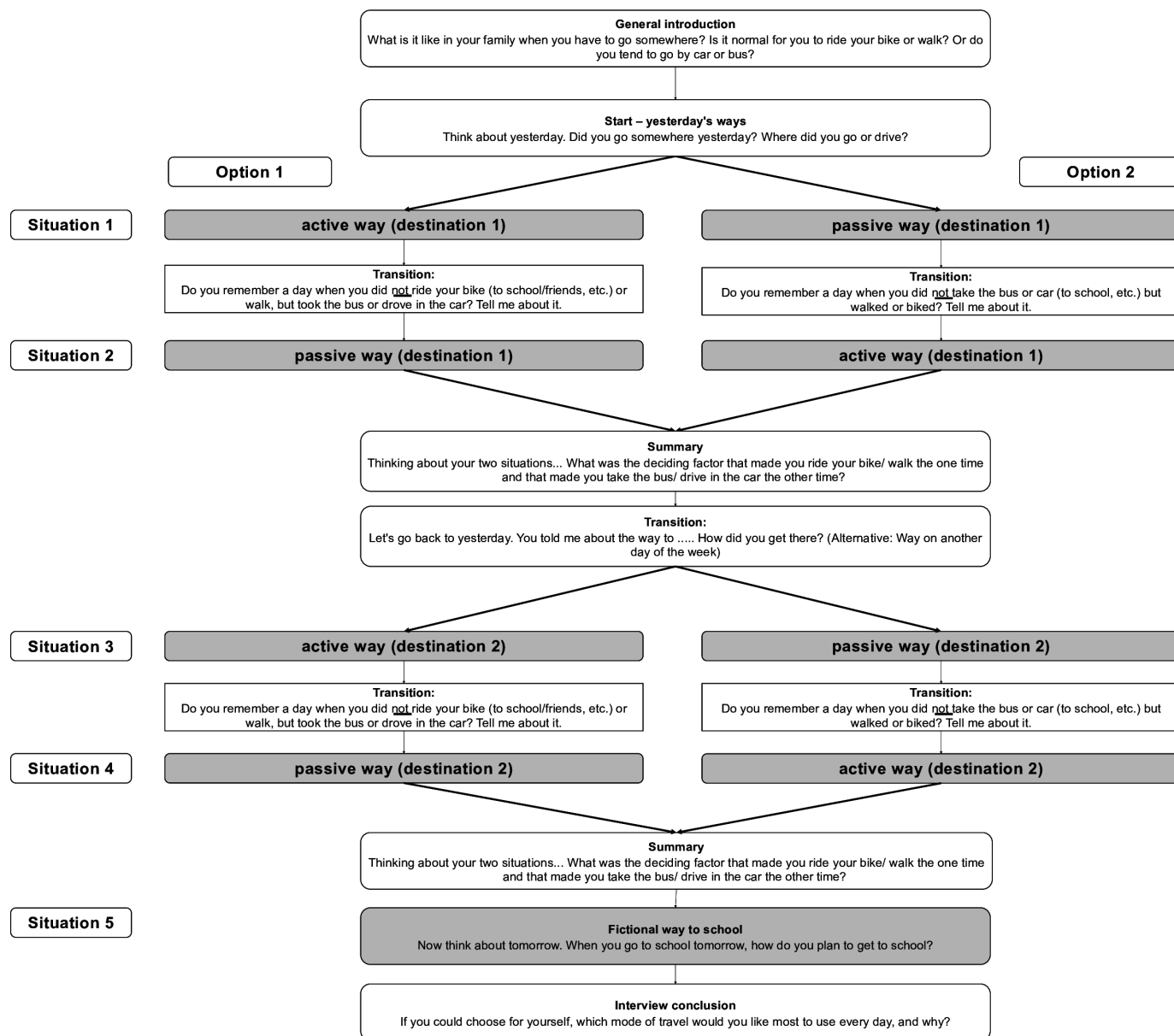
#### Data collection

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 min to complete. However, because deviations are possible, for each participant an appointment time of 60 min 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 behaviour 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 versus 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)



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

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 travelled 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.

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



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

	Situation	Topic	Examples
Active/passive transport mode to destination	Situation at home	General aspects	Eg, weather, stress, behaviour, particularities
		Decision-making process	Eg, own behaviour, parental behaviour, decision on mode choice, rules, motivation
	Situation on the route	Physical environment	Eg, distance, characteristics of way, like/dislike
		Social environment	Eg, friends, siblings, companionship
Hypothetical way to school	Situation at home	Relevant factors	Eg, weather, school situation, daily schedule
		Decision-making process	Eg, parental influence, motivation, attitudes

why. More detailed information regarding both interview guides is enclosed in online supplemental material 1.

### 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<sup>50</sup> or content analysis.<sup>51</sup> In the first step, two researchers will independently analyse 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 (eg, attractiveness, infrastructure, social environment), parent characteristics and attitudes (eg, socioeconomic status, social support), adolescent characteristics and attitudes (eg, age, motivation), and environmental perceptions (eg, 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 (eg, 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.<sup>7</sup> Recent recommendations by the European Society of Cardiology (ESC) suggest approaches targeting optimising lifestyle activities to change physical activity behaviours and reduce sedentary time as important preventive measures in this regard.<sup>52</sup> Better understanding the decision-making processes of both adolescents and parents regarding multiple forms of, and influences on, daily adolescent active travel behaviour 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 inter-relationships and familial decision-making processes on active travel behaviour in adolescents.<sup>28 29 32</sup> The inclusion of qualitative methods in the study of this issue can be beneficial as they may help to capture, reconstruct and comprehend the social reality of groups or individuals as they focus on the experiences, meanings and perspectives of the participants.<sup>53</sup> Additionally, previous evidence has posited that child or adolescent sex/gender plays a significant role with regard to physical activity and travel behaviour,<sup>54–56</sup> it has been observed that parental perspectives of this issue have been largely limited to the views of mothers (eg,<sup>29 57</sup>).

The ARRIVE study aims to address these research gaps, by providing a comprehensive multicomponent and multigroup analysis of the socioecological determinants of adolescent active travel behaviour 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 behaviours. Qualitative semistructured interviews are anticipated to provide deeper insights into the decision-making processes of both adolescents and parents regarding travel mode behaviours. 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,<sup>58</sup> 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 support that 9–18-year-old active commuters have higher levels of physical activity during young adulthood and can maintain these behaviours for up to 12 years,<sup>59</sup> 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,<sup>60</sup> improvements in cardiovascular health (eg, exercise capacity, maximal power, blood pressure and blood parameters) in adults<sup>61–63</sup> and adolescents<sup>64 65</sup> and cleaner and less congested neighbourhoods<sup>66 67</sup>—all points which future intervention studies could also evaluate alongside the findings (eg, articulated decision-making processes) of our ARRIVE study.

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substantial contributions to the manuscript, provided edits to the manuscript and read and approved the final manuscript.

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