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

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SCHOLARONE™
Manuscripts

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3 1 **Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods**
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5 2 **Cross-Sectional ARRIVE Study**
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43 20 **Abstract:**

44
45 21 **Introduction:** Active travel is an important source of physical activity and is a primary contributor to
46
47 22 overall health among adolescents. To understand and promote active travel behavior in adolescents,
48
49 23 developing a more robust understanding of the predictors of active travel and its associated decision-
50
51 24 making processes are needed. Situated within a theoretical socio-ecological framework for adolescent
52
53 25 travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several
54
55 26 predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making
56
57 27 processes of both adolescents and parents.
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3 28 **Methods and analysis:** Our mixed-methods approach will feature online surveys and semi-structured
4
5 29 interviews. The online questionnaire, developed in accordance with a theoretical framework of
6
7 30 adolescent active travel, will examine adolescent travel behavior with respect to four different
8
9 31 destinations while controlling for multiple relevant individual, social, and physical environment factors.
10
11 32 To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered
12
13 33 by a representative sample of adolescents (11-15 years old) and their parents from Germany.
14
15 34 Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework
16
17 35 of adolescent active travel, will seek to explore the decision-making process of families regarding travel
18
19 36 mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To
20
21 37 investigate travel decision-making processes, adolescents and their parents will be invited to talk about
22
23 38 trips they undertook using both active and passive transport modes during the last week. Thematic
24
25 39 analyses will be conducted to highlight the central concerns, priorities, and values of participants'
26
27 40 decision-making processes.

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29
30 41 **Ethics and dissemination:** This study has received ethical approval from the ethics commission of the
31
32 42 Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific
33
34 43 conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly
35
36 44 available to relevant health, policy, and research stakeholders and groups.
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41 **Strength and limitations of this study**

42
43 47 Bullet points:

- 44
45 48 • The ARRIVE study includes a large representative sample of parents and adolescents from
46
47 49 diverse neighborhoods and regions and different socio-economic backgrounds from Germany.
- 48
49 50 • Situated within a theoretical socio-ecological framework, multiple theoretically relevant
50
51 51 predictors of adolescent active travel behavior and different modes of transport to four distinct
52
53 52 destinations will be assessed.
- 54
55 53 • Reliable and valid tools in the form of online surveys, which were developed based on the
56
57 54 central tenets of a theoretical socio-ecological framework of adolescent active travel, will be
58
59 55 used to assess adolescent active travel behavior and its predictors.
60

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3 56 • Semi-structured interviews will seek to generate a novel and nuanced understanding of the
4
5 57 familial decision-making processes regarding transport mode choices from parental and
6
7 58 adolescent perspectives.
8
9 59 • Limitations include the cross-sectional design, self-report survey data, and a lack of objectively
10
11 60 measured physical environment characteristics.
12
13
14 61

15
16 62 **Keywords (3-10):**

17
18 63 Active commuting, active transport, fathers, mothers, family, mixed-methods, framework, interview,
19
20 64 online questionnaire
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23 65

24
25 66 **Introduction**

26
27 67 Regular physical activity is an important source of overall health, can decrease the risk of non-
28
29 68 communicable diseases, and is linked to improved mental health (1). Long-term health benefits of
30
31 69 physical activity are well documented for children, adolescents (2, 3), and adults (4). However,
32
33 70 concerning low levels of physical activity among children, adolescent (5), and adults (6) in countries
34
35 71 across the globe demands urgent action. The World Health Organization (WHO) has observed that
36
37 72 current efforts to reduce global inactivity rates have been largely ineffective, and that more innovative
38
39 73 and comprehensive approaches to promote physical activity are needed (7).

40
41
42 74 Active travel, or any form of human-powered transportation (e.g., walking, biking), as a daily routine
43
44 75 (e.g., trips to/from school) is a low-cost and widely accessible source of physical activity (8).

45
46 76 Longitudinal data supports that nine- to 18-year-old active commuters have higher levels of physical
47
48 77 activity during young adulthood and can maintain these behaviors for up to 12 years (9). Active travel
49
50 78 can also improve the emotional health of both adolescents and adults by increasing levels of happiness
51
52 79 and relaxation (10). Furthermore, trips made by bike or by foot are a sustainable means of daily transport;
53
54 80 have little-to-no CO₂ emissions; and are more affordable, reliable, cleaner, and less congested than trips
55
56 81 made by car (11).

57
58
59 82 Despite these many potential benefits of active commuting, percentages of active commuters have
60
61 83 declined in most countries (12-16). In Germany, like in many other countries, for example, only a

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2
3 84 significant minority of adolescents currently walk or cycle to school (12, 17-19). Recent nationwide data
4
5 85 from the German MoMo Study showed that 17.7% of adolescent girls and 20.2% of adolescent boys
6
7 86 regularly walk to school and 21.5% of girls and 25.2% of boys take their bike, respectively (12).
8
9 87 To better understand adolescent travel mode decisions and travel behavior, and to enable the
10
11 88 development of evidence-based intervention programs that promote active travel in adolescents, a more
12
13 89 comprehensive analysis of the predictors of adolescent active travel and decision-making processes that
14
15 90 generates new insights and helps to illuminate new paths for programming is warranted. At present,
16
17 91 cross-sectional (20-23) and longitudinal (19, 24, 25) research has identified various individual- and
18
19 92 neighborhood-level factors related to adolescent active travel. However, while these studies and extant
20
21 93 theoretical socio-ecological models (26) and active travel frameworks (27-30) have outlined that
22
23 94 adolescent active travel is a multi-level phenomenon, little is known about the influence of family-based
24
25 95 predictors of adolescent active travel behavior, the decision-making processes within the family, and
26
27 96 especially about adolescent travel behavior to non-school destinations.
28
29 97 One comparatively understudied influence of potential consequence regarding adolescent active travel
30
31 98 behavior is family environment predictors. Although existing research confirms the importance of
32
33 99 parental controls with respect to adolescent transport mode choice (31-33), comprehensive studies of
34
35 100 family environment predictors of adolescent active commuting remain rather limited (34). Safety aspects
36
37 101 in terms of traffic safety and a child's own ability to travel safely and independently strongly influence
38
39 102 parental decision making on transport mode (31, 32, 35). Additionally, some parents prefer car usage to
40
41 103 spend time with their children (35). Other relevant factors, which influence parental decision on travel
42
43 104 behavior may include weather conditions (32), social norms and convenience (31, 35), and parenting
44
45 105 practices (32). Regarding the role of distance to school with respect to parental decision making, existing
46
47 106 evidence is more inconclusive: while one Swedish study (35) revealed that parents chauffeured their
48
49 107 children to school regardless of distance, another from Canada (31) found that transport mode choice
50
51 108 was influenced by perceptions of travel time and distance to school.
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54
55 109 Presently, a large body of literature has highlighted the relevance of active travel as one domain of
56
57 110 physical activity in adolescents, and the necessity to consider multiple socio-ecological levels of
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3 111 influence regarding active travel. However, a number of research gaps regarding the predictors of and
4
5 112 decision-making associated with active travel in adolescents still exist.

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7 113 While existing literature has focused significantly on active travel to/ from school, only a few studies
8
9 114 have considered other highly frequented destinations. Trips to leisure facilities, shops, or the homes of
10
11 115 friends and relatives often represent as much or a greater proportion of all trips traveled by adolescents
12
13 116 than school commutes. For example, in Germany, adolescents 10-19 years old accumulate on average
14
15 117 2.8 trips taking 72 minutes and having a total distance of 29 kilometers per day (36). Of these trips,
16
17 118 school commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5%
18
19 119 are related to shopping and everyday activities, and around 4% are made while accompanying
20
21 120 adults/parents to other locations. As it seems that there is a dearth of knowledge pertaining to how this
22
23 121 variety of daily trips to destinations other than school may contribute to adolescent health, study into
24
25 122 this topic represents an important opportunity as it may offer new insights into adolescent active travel
26
27 123 in reference to a more extensive set of predictors and social contexts, and ultimately help to promote
28
29 124 more active lifestyles.

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31
32 125 The dynamics and impacts of parental and adolescent decision-making processes on adolescent active
33
34 126 travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the
35
36 127 perceived social and physical environment facilitators and barriers to active travel among parents may
37
38 128 vary across diverse cohorts from various geographical regions and degrees of urbanization (37, 38).
39
40 129 Furthermore, while many previous studies have focused on children, few have addressed active travel
41
42 130 behavior in adolescents (37). Moreover, previous studies have not considered adolescent active travel
43
44 131 behavior in the context of the differing perspectives and attitudes of multiple family members (39, 40)
45
46 132 resulting in most existing studies focusing exclusively on either youth or parental perspectives and
47
48 133 neglecting the interrelation of both perspectives (41, 42). Such a precedent is an important oversight
49
50 134 given that in their comparative study of children and parental barriers on active commuting to school,
51
52 135 Aranda-Balboa et al. (43) found that there are significant differences between adolescents' and parents'
53
54 136 perspectives in terms of perceived social and environmental determinants of active travel exist.
55
56 137 Moreover, while other evidence has posited that child gender plays a significant role with regard to
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1
2
3 138 physical activity and travel behavior (44-46), it has been observed that parental perspectives of this issue
4
5 139 have been largely limited to the views of mothers (e.g., (32, 47)).

6
7 140 Additionally, only a few qualitative studies exist that provide a deeper understanding of the
8
9 141 interrelationships and familial decision-making processes on active travel behavior in adolescents (31,
10
11 142 32, 35). The inclusion of qualitative methods in the study of this issue can be beneficial as they may
12
13 143 help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus
14
15 144 on the experiences, meanings, and perspectives of the participants (48).

16
17 145 To better understand and promote adolescent active travel there are a few important research
18
19 146 opportunities to address, namely: family context predictors of adolescent active travel, the value and
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21 147 impact of non-school commuting trips, and the influence of the decision-making processes of
22
23 148 adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the
24
25 149 famIlly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of
26
27 150 adolescent active travel behavior through conducting a theoretically-informed, multi-component, and
28
29 151 mixed-methods investigation of German adolescents and parents.

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34 35 153 **Methods and analysis**

36 37 154 **Study design**

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39 155 The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding
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41 156 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented
42
43 157 destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure
44
45 158 facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making
46
47 159 processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two
48
49 160 complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both
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51 161 studies will collect data from multiple groups, specifically adolescents between 11-15 years old and their
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53 162 parents. Data collection for both studies will take place between June and October 2021.

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57 58 164 **Theoretical framework**

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3 165 We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the
4
5 166 Environmental Determinants of Active Travel in Children" (30) (see Figure 1). This framework serves
6
7 167 as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents'
8
9 168 active travel based on the social-ecological model (21, 34). The framework considers physical (e.g.,
10
11 169 neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both
12
13 170 parents and youth (e.g., sociodemographic and psychosocial variables, attitudes). In the ARRIVE study,
14
15 171 we used these conceptual categories to identify relevant predictors of interest—e.g., personal
16
17 172 characteristics, attitudes, parental and adolescent perceptions of physical and social environment
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19 173 barriers—that we will examine in our statistical models in order to explore how they impact the main
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21 174 outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (49-51).
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26 176 *Figure 1. Theoretical Framework for the ARRIVE study*
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30 178 **Quantitative study**

32 179 *Aims*

34 180 The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical
35
36 181 relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants
37
38 182 of Active Travel in Children" (30). To systematically evaluate this theoretical model, our specific aims
39
40 183 are threefold. First, we will seek to identify predictors of adolescent travel behavior with respect to four
41
42 184 different destinations in order to discern whether the predictive strength of these correlates varies
43
44 185 between trip destinations. Second, we will aim to develop a more comprehensive understanding of
45
46 186 adolescent transport mode choice in the family context by comparing parent and adolescent perspectives
47
48 187 regarding transport mode choice. Third, we will investigate the moderating effects of several
49
50 188 theoretically relevant socio-demographic characteristics (e.g., sex/gender, migration background, and
51
52 189 residential area) on adolescent travel behavior.
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58 191 *Sampling strategy*

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3 192 The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided
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5 193 by Forsa, a leading organization for public opinion polls. The recruitment for the survey will be
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7 194 conducted entirely offline via telephone interviews, so as to ensure that those lacking internet access are
8
9 195 proportionately represented in the study. The panel is representative of the German population regarding
10
11 196 age, gender, education and place of residence. Based on this panel, a sample of adults living together
12
13 197 with adolescents aged 11- 15 years old will be recruited. The sample will include roughly the same
14
15 198 number of mothers and fathers. After giving informed consent to be contacted for the survey,
16
17 199 participants will receive an invitation e-mail with a link to the questionnaire.

20 200 Equivalent samples of parents (N = 500) and adolescents (N=500) will complete the survey. As previous
21
22 201 regression models suggest that individual and environmental predictors tend to explain approximately
23
24 202 8-40% of the total explained variance in active travel (18, 52, 53), a conservative value of 10% was
25
26 203 assumed to calculate effect size f^2 . The G*power a priori sample size calculation conducted at a power
27
28 204 of 0.8 and a significance level of 0.05 for a maximum of 25 potential correlates suggested a minimum
29
30 205 sample size of 226. To get deeper insights into gender differences, we plan to stratify our sample by
31
32 206 gender. Consequently, to allow for this stratification, we increased the sample size by roughly 50%
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34 207 resulting in final sample estimates of around 500 parents and 500 adolescents.

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38 39 209 *Data collection*

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41 210 Participants will be able to answer the online questionnaire using one of a tablet, smartphone, or
42
43 211 computer. The questionnaire includes two parts: a parent-focused section, and an adolescent-focused
44
45 212 section. After answering their portion of the questionnaire, parents will be asked to provide the link to
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47 213 their child or, if there is more than one child in this age group in the family, to one randomly selected
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49 214 child. To this end, parents will be instructed to select the child whose first name appears first in the
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51 215 alphabet to fill out the adolescent portion of the survey. The survey is anticipated to take about 15
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53 216 minutes to complete for adolescents and parents together.

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57 58 218 *Measures*

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3 219 To cover all relevant constructs, an online questionnaire has been developed based on already existing
4
5 220 scales (that were partly translated into German), modified scales, and additional single item questions.
6
7 221 The selection of scales and questions were derived from the central tenets of the theoretical framework;
8
9 222 all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. A detailed
10
11 223 description of all measures applied in the online questionnaire for parents and adolescents is provided
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13 224 in Table 1.
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17
18 226 *Table 1. Overview on Instrument used in the Parental and Adolescent Questionnaire*
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21 22 228 *Data analysis*

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24 229 Data analysis will include descriptive statistics, an examination of normally distributed data, and
25
26 230 examinations of the homogeneity of variance. To prove internal consistencies of the adapted scales,
27
28 231 Cronbach's alpha will be calculated. Differences between groups (e.g., age, gender) will be calculated
29
30 232 using t-tests and analysis of variance for continuous variables, and chi-squares for categorical variables.
31
32 233 Outcome measures will consist of a categorical variable representing the different transport modes (e.g.,
33
34 234 walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode)
35
36 235 for each destination, and an overall score of active transport trips made. Multinomial (different transport
37
38 236 modes) and binary (active vs. passive travel) logistic regression models controlling for multiple relevant
39
40 237 sociodemographic variables will be used to identify predictors of adolescent active travel. Structural
41
42 238 equation model including moderation and mediation analyses will be used to evaluate the multi-step
43
44 239 pathways outlined in the theoretical framework. With regard to the relationship between parental and
45
46 240 adolescent travel behavior, correlation analyses will be conducted. To compare parental and adolescents'
47
48 241 perspective on barriers of active travel, binary logistic regression models will be performed. Analyses
49
50 242 will be conducted with R, Matlab, and SPSS.
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54 55 244 **Qualitative study**

56 57 245 *Aims*

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3 246 The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the
4
5 247 decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box).
6
7 248 Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode
8
9 249 choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated
10
11 250 by the adolescents and parents themselves. To complement our online survey which aims to examine if
12
13 251 and how various socio-demographic and socio-environmental factors predict adolescent travel behavior,
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15 252 this qualitative investigation seeks to understand the experiences of adolescent travel behavior by
16
17 253 precisely exploring what and why certain influences centrally impact parental and adolescent decision-
18
19 254 making processes regarding transport mode choice.
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23 24 256 *Sampling strategy*

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26 257 Participants for the qualitative survey will be recruited using theoretical sampling methods (54).
27
28 258 Therefore, the sample will not be defined by the onset of the study, but will be selected against the
29
30 259 background of theoretical problems outlined earlier and in accordance with our proposed analysis
31
32 260 processes. Our sampling methods will thus initially be based on ensuring the samples contain diversity
33
34 261 with respect to socio-economic status, migration status, gender, and environmental conditions (e.g.,
35
36 262 urban and rural living locations). When possible, we will interview both parents to capture the
37
38 263 perspectives of fathers and mothers. We anticipate that the final sample will consist of 10-15 adolescents
39
40 264 and 15-20 parents.
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42
43 265

44 45 266 *Data collection*

46
47 267 Interviews will be conducted with adolescent and parent participants separately. Prior to the data
48
49 268 collection process all interviewers received formal training from an interview expert. Sample interviews
50
51 269 were conducted to ensure the appropriateness of the interview guides.

52
53 270 Interviews are anticipated to take around 30 minutes to complete. However, because deviations are
54
55 271 possible, for each participant an appointment time of 60 minutes will be made. After giving informed
56
57 272 consent and agreeing on an appointment, each participant will receive an individual link for an online
58
59 273 meeting to conduct the interview. Participants will be able to complete their interview from any desired

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2
3 274 place so long as they have a stable internet connection and quiet surrounding. Before the start of the
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5 275 recording, the objective and the interview procedure will be explained and participants will be reassured
6
7 276 of the voluntary nature of their involvement and their right to refuse to answer any questions. After
8
9 277 clarifying any questions that participants may have, the audio recording device will be turned on and the
10
11 278 interview will begin. At the end of the interview, the audio recording will stop.
12

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14 279

15 280 *Interview Guideline*

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17
18 281 The focus of the interviews for both groups of participants will be the travel behavior of adolescents and
19
20 282 the associated decision-making process. During the interviews, adolescents and their parents will be
21
22 283 encouraged to relive their travel experiences and their decision-making processes regarding mode choice
23
24 284 in relation to four different situations. In order to generate a thorough understanding of the differences
25
26 285 in decision-making processes when considering the choice of active vs. passive transport to the distinct
27
28 286 locations, different interview paths will be followed to ensure that the interview inquires about four (two
29
30 287 active, two passive trips) different travel type-location examples (see Figure 2). At the start of each
31
32 288 interview parents and adolescents will be instructed to first talk about a recent trip the latter made during
33
34 289 one of the days prior to the interview. This first trip may be undertaken by either an active or passive
35
36 290 means. Next, and to facilitate a comparison of factors affecting adolescent travel mode decision-making
37
38 291 processes, participants will be asked to remember a trip to the same destination that they made using
39
40 292 another transport mode (passive/active). To generate additional depth regarding understanding the
41
42 293 potential variety of relevant factors influencing participants' decision-making processes, this procedure
43
44 294 will be repeated for another destination that the adolescent traveled to in the previous week.
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48 49 296 *Figure 2. Structure of the interview guide – decision-tree*

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53 298 When discussing each of the four distinct trips, participants will be asked to describe their experiences
54
55 299 of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks:
56
57 300 the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation
58
59 301 on the journey itself (i.e., social and environmental factors). To garner further information pertaining to
60

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

1
2
3 324 regard to the quantitative survey, no personally identifiable information will be included in the data set
4
5 325 and transferred from forsa to the study team. In the interviews, participants will not be addressed by
6
7 326 name, nor will any personal identifying information be requested. All data will be stored on central
8
9 327 servers of the Technical University of Munich/Germany and the University of Erlangen-
10
11 328 Nuremberg/Germany.

12
13 329 The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly
14
15 330 journals with international audiences, and will be presented at academic conferences. Additionally, the
16
17 331 results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made
18
19 332 publicly available for interested individuals, families, teachers, and caregivers via a project website and
20
21 333 public knowledge translation activities (e.g., public talks, community information sessions).
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23
24 334

25 26 335 **Patient and public involvement statement**

27
28 336 No medical patients and/or members of the public were involved in setting the research question nor
29
30 337 they were involved in developing plans for design (or implementation) of this study protocol.
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33 338

34 35 339 **Discussion**

36
37 340 Increasing physical activity in adolescents is an immediate and serious challenge for modern societies,
38
39 341 but one that if effectively addressed can contribute to preventing a number of chronic and non-
40
41 342 communicable diseases (7). The ARRIVE study aims to contribute to this prevention work by providing
42
43 343 a comprehensive multi-component and multi-group analysis of the socio-ecological determinants of
44
45 344 adolescent active travel behavior. Quantitative analyses of several theoretically relevant predictors of
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47 345 adolescent active travel are intended to provide the necessary empirical evidence to illustrate the
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49 346 influence of family context influences and non-school commutes on travel behaviors. Qualitative semi-
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51 347 structured interviews are anticipated to provide deeper insights into the decision making-processes of
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53 348 both adolescents and parents regarding travel mode behaviors. Together, the findings from both
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55 349 components of the ARRIVE study should be of value to both practitioners and researchers as they will
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57 350 offer a comprehensive evaluation of a more diverse set of trips, family predictors, and decision-making
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3 351 processes associated with adolescent active travel, as well as provide empirical evidence to support
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5 352 public health active travel interventions for targeted adolescent groups and families.
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9 354 **Authors' contributions**

11 355 All authors made substantial contribution to the concept and design of the ARRIVE study. AKR and IM
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13 356 prepared the first draft of the protocol article and finalized the manuscript. All authors contributed to the
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15 357 preparation of the manuscript, provided edits to the manuscript and read and approved the final
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17 358 manuscript.
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22 360 **Competing interests**

24 361 The authors declare that they have no competing interests.
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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.	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 (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 $\alpha = 0.870$; 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 $\alpha = 0.72$) (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 ($\kappa = 0.61-0.94$) (67).
Perceived social and physical environment	Modified Version of the Barreras percibidas en el desplazamiento activo al centro educativo (BATAACE) (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 BATAACE showed good test-retest reliability (ICC range: 0.68-0.77) and internal consistency (Cronbach's alpha $\alpha = 0.59-0.76$) 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 $\alpha = 0.85$; 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 $\alpha = 0.81$, competence satisfaction $\alpha = 0.92$, and relatedness satisfaction $\alpha = 0.82$) 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 $\alpha = 0.70-0.91$) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (71).

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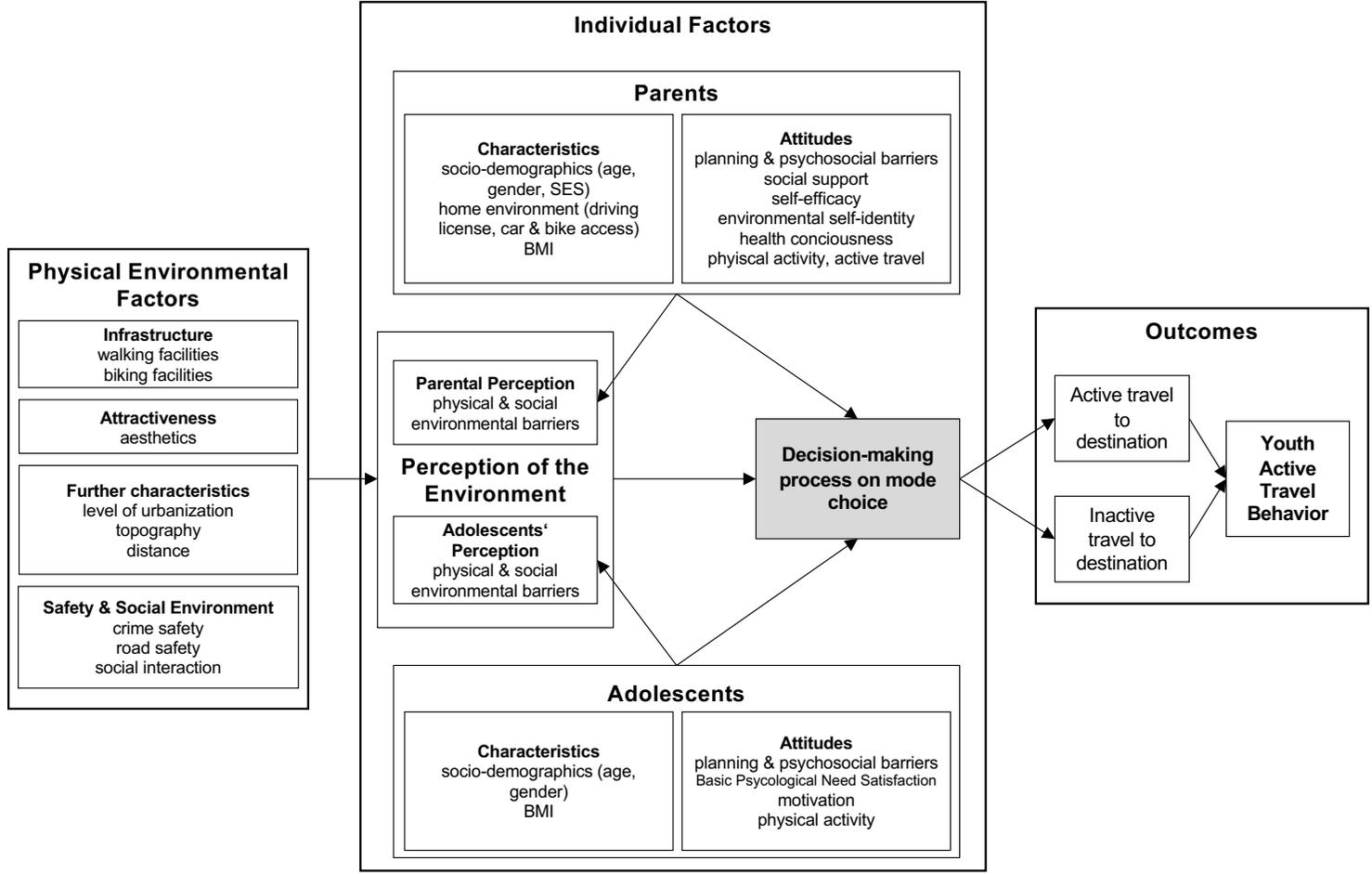
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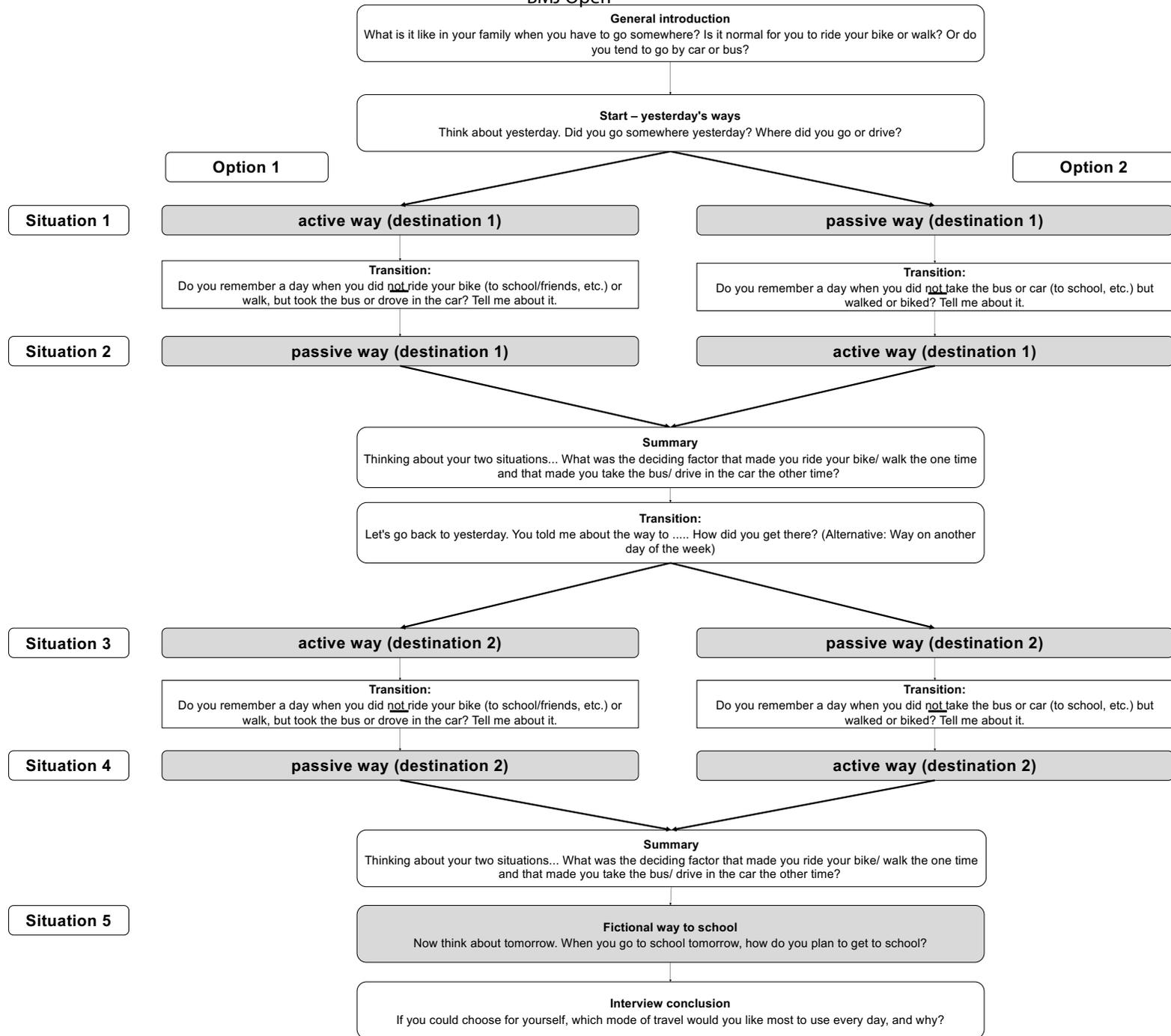
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Supplementary material

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?
		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]? 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? 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	How do you think your child likes the way?	How do you feel about it?
		Behavior child – way	Can you describe what your child has done/experienced along the way?	
Way – social environment	Did someone accompany your child?	Friends company	How does it happen?	What do you say to that?
		Parents company	What do you do on the way together? Can you describe why you accompany your child?	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	What factors are you or your child considering for planning tomorrow? What are you thinking about it?	What would change your decision? Are you satisfied with the decision? How do you evaluate this decision?
		Decision	To what extent do you involve your child?	

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?	
		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]?	
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?	Motivation	What did motivate you?	
		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? Can you tell me what you did along the way?	What was it like between you? Was there anything that you particularly liked? Was there anything you did not like so much?
			Do you meet other people along the way?	
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 Decision	Which factors do you take into account in the planning? What are you considering? Do you check with your parents? Whom do you involve in the decision? How do you come to the decision?	What would change your decision? Are you satisfied with the decision? 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.

BMJ Open

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

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Manuscripts

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3 1 **Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods**

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5 2 **Cross-Sectional ARRIVE Study**

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9 4 Anne K. Reimers^{1#*}, Isabel Marzi^{1#}, Franziska Beck¹, Eliane Engels¹, Denise Renninger², Adrian
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3 **Abstract:**
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5 **Introduction:** Active travel is an important source of physical activity and a primary contributor to
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7 overall health among adolescents. To understand and promote active travel behavior in adolescents,
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9 developing a more robust understanding of the predictors of active travel and its associated decision-
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11 making processes is needed. Situated within a theoretical socio-ecological framework for adolescent
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13 travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several
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15 predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making
16
17 processes of both adolescents and parents.
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20 **Methods and analysis:** Our mixed-methods approach will feature online surveys and semi-structured
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22 interviews. The online questionnaire, developed in accordance with a theoretical framework of
23
24 adolescent active travel, will examine adolescent travel behavior with respect to four different
25
26 destinations while controlling for multiple relevant individual, social, and physical environment factors.
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28 To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered
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30 by a representative sample of German adolescents (11–15 years old) and their parents.
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33 Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework
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35 of adolescent active travel, will seek to explore the decision-making process of families regarding travel
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37 mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To
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39 investigate travel decision-making processes, adolescents and their parents will be invited to talk about
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41 trips they undertook using both active and passive transport modes during the last week. Thematic
42
43 analyses will be conducted to highlight the central concerns, priorities, and values of participants'
44
45 decision-making processes.
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48 **Ethics and dissemination:** This study has received ethical approval from the ethics commission of the
49
50 Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific
51
52 conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly
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54 available to relevant health, policy, and research stakeholders and groups.
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46 **Strength and limitations of this study**

47 **Bullet points:**

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

66 **Keywords (3–10):**

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

69

70 **Introduction**

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

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

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

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

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3 98 active commuting remain rather limited (31). To date, studies have largely focused on examining only
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5 99 singular elements of the family-level. For example, recent works have found safety aspects in terms of
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7 100 traffic safety and a child's own ability to travel safely and independently strongly influence parental
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9 101 decision making on transport mode (28, 29, 32), and that some parents prefer car usage to spend time
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11 102 with their children (32). Other noted relevant factors in this regard include social norms and convenience
12
13 103 (28, 32), and parenting practices (29) as significant individual predictors. In other cases, however, family
14
15 104 environment influences are ambiguous. When examining the role of distance to school and its interaction
16
17 105 with family-level factors, existing evidence is inconclusive: while one Swedish study (32) revealed that
18
19 106 parents chauffeured their teenagers to school regardless of distance, another from Canada (28) found
20
21 107 that transport mode choice was influenced by perceptions of travel time and distance to school.
22
23 108 Ultimately, given this combination of a lack of comprehensive investigations and uncertainty in other
24
25 109 areas, there is a need to more comprehensively (e.g., examine the interaction of parent and adolescent
26
27 110 perceptions) consider family environment influences of adolescent active travel.
28
29 111 Similarly, while existing literature has focused significantly on active travel to/ from school, only a few
30
31 112 studies have considered other highly frequented destinations. Trips to leisure facilities, shops, or the
32
33 113 homes of friends and relatives often represent as much or a greater proportion of all trips traveled by
34
35 114 adolescents than school commutes. For example, in Germany, adolescents accumulate on average 2.8
36
37 115 trips taking 72 minutes and having a total distance of 29 kilometers per day (33). Of these trips, school
38
39 116 commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5% are
40
41 117 related to shopping and everyday activities, and around 4% are made while accompanying adults/parents
42
43 118 to other locations. Despite these documented trends, there is a relative dearth of knowledge pertaining
44
45 119 to how this variety of daily trips to destinations other than school may contribute to adolescent health
46
47 120 representing another important avenue for future study.
48
49 121 The dynamics and impacts of parental and adolescent decision-making processes on adolescent active
50
51 122 travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the
52
53 123 perceived social and physical environment facilitators and barriers to active travel among parents may
54
55 124 vary across diverse cohorts from various geographical regions and degrees of urbanization (34, 35).
56
57 125 Furthermore, while many previous studies have focused on children, few have addressed active travel
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1
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3 126 behavior in adolescents (34). Moreover, previous studies have not considered adolescent active travel
4
5 127 behavior in the context of the differing perspectives and attitudes of multiple family members (36, 37)
6
7 128 resulting in most existing studies focusing exclusively on either youth or parental perspectives and
8
9 129 neglecting the interrelation of both perspectives (38, 39). Such a precedent is an important oversight
10
11 130 given that in their comparative study of children and adolescents as well as parental barriers on active
12
13 131 commuting to school, Aranda-Balboa et al. (40) found that there are significant differences between
14
15 132 adolescents' and parents' perspectives in terms of perceived social and environmental determinants of
16
17 133 active travel.

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19
20 134 To better understand and promote adolescent active travel there are a few important research
21
22 135 opportunities to address, namely: family environment predictors of adolescent active travel, the value
23
24 136 and impact of non-school commuting trips, and the influence of the decision-making processes of
25
26 137 adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the
27
28 138 famIlly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of
29
30 139 adolescent active travel behavior through conducting a theoretically-informed, multi-component, and
31
32 140 mixed-methods investigation of German adolescents and parents.

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35 141

36 37 142 **Methods and analysis**

38 39 143 **Study design**

40
41 144 The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding
42
43 145 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented
44
45 146 destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure
46
47 147 facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making
48
49 148 processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two
50
51 149 complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both
52
53 150 studies will collect data from multiple groups, specifically adolescents between 11–15 years old and
54
55 151 their parents. Data collection for both studies will take place between June and December 2021.

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57
58 152

59 60 153 **Theoretical framework**

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2
3 154 We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the
4
5 155 Environmental Determinants of Active Travel in Children" (27) (see Figure 1). This framework serves
6
7 156 as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents'
8
9 157 active travel based on the social-ecological model (18, 31). The framework considers physical (e.g.,
10
11 158 neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both
12
13 159 parents and youth (e.g., sociodemographic and psychosocial variables, attitudes). In the ARRIVE study,
14
15 160 we used these conceptual categories to identify relevant predictors of interest—e.g., personal
16
17 161 characteristics, attitudes, parental and adolescent perceptions of physical and social environment
18
19 162 barriers—that will be examined in our statistical models in order to explore how they impact the main
20
21 163 outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (41-43).
22
23
24 164

25
26 165 *Figure 1. Theoretical Framework for the ARRIVE study*
27
28 166

29 30 167 **Quantitative study**

31 32 168 *Aims*

33
34 169 The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical
35
36 170 relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants
37
38 171 of Active Travel in Children" (27). To systematically evaluate this theoretical model, our specific aims
39
40 172 are threefold. First, we will seek to identify predictors of adolescent travel behavior with respect to four
41
42 173 different destinations in order to discern whether the predictive strength of these correlates varies
43
44 174 between trip destinations. Second, we will aim to develop a more comprehensive understanding of
45
46 175 adolescent transport mode choice in the family context by comparing parent and adolescent perspectives
47
48 176 regarding transport mode choice. Third, we will investigate the moderating effects of several
49
50 177 theoretically relevant socio-demographic characteristics (e.g., sex/gender, migration background, and
51
52 178 degree of urbanization) on adolescent travel behavior.
53
54
55

56 179

57 58 180 *Sampling strategy* 59 60

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2
3 181 The survey makes use of an existing nationwide online panel (forsa.omninet) to which access is provided
4
5 182 by Forsa, a leading organization for public opinion polls. The recruitment for the survey will be
6
7 183 conducted entirely offline via telephone interviews, so as to ensure that those lacking internet access are
8
9 184 proportionately represented in the study. The panel contains people living in Germany and is
10
11 185 representative of the German population regarding age, sex/gender, education and place of residence.
12
13 186 Based on this panel, a sample of adults living together with adolescents aged 11–15 years old will be
14
15 187 recruited. The sample will include roughly the same number of mothers and fathers. After giving
16
17 188 informed consent to be contacted for the survey, participants will receive an invitation e-mail with a link
18
19 189 to the questionnaire.

20
21
22 190 As suggested by Bujang et al. (44) for observational studies with large population sizes a minimum
23
24 191 sample size of 500 is necessary to derive logistic regression analyses. By using real patient data, it was
25
26 192 shown that a minimum sample size of 500 “is able to produce statistics that are nearly representative of
27
28 193 the true values in the target population” (44). Thus, equivalent samples of parents (N = 500) and
29
30 194 adolescents (N=500) will complete the survey.

31
32
33 195

34 196 *Data collection*

35
36 197 Participants will be able to answer the online questionnaire using one of a tablet, smartphone, or
37
38 198 computer. The questionnaire includes two parts: a parent-focused section, and an adolescent-focused
39
40 199 section. After answering their portion of the questionnaire, parents will be asked to provide the link to
41
42 200 their adolescent or, if there is more than one adolescent in this age group in the family, to one randomly
43
44 201 selected adolescent. To this end, parents who have multiple potential participants in their family will be
45
46 202 instructed to select the adolescent whose first letter of their first name appears the earliest in the alphabet
47
48 203 to fill out the adolescent portion of the survey. The survey is anticipated to take about 15 minutes to
49
50 204 complete for adolescents and parents together.

51
52
53 205

54 206 *Measures*

55
56 207 To cover all relevant constructs, an online questionnaire has been developed based on already existing
57
58 208 scales (that were partly translated into German), modified scales, and additional single item questions.

1
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3 209 The selection of scales and questions were derived from the central tenets of the theoretical framework;
4
5 210 all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. Based on a
6
7 211 literature search on activity settings of adolescents, four destinations adolescents frequently visit and
8
9 212 which are the most popular places for adolescents in the walkable neighborhood have been selected to
10
11 213 assess travel behavior in youth (41, 42, 45, 46). A detailed description of all measures applied in the
12
13 214 online questionnaire for parents and adolescents is provided in Table 1.
14
15
16 215

17
18 216 *Table 1. Overview on Instrument used in the Parental and Adolescent Questionnaire*
19

20 217

21
22 218 *Data analysis*

23
24 219 Descriptive analysis

25
26 220 Data analysis will include descriptive statistics, an examination of normally distributed data, and
27
28 221 examinations of the homogeneity of variance. Descriptive statistics will include means (M) and standard
29
30 222 deviations (SD) for continuous variables, and frequencies (%) for categorical variables (e.g., boys and
31
32 223 girls and mothers and fathers). Frequency distribution of transport mode for each destination will be
33
34 224 calculated separately for boys and girls. To examine internal consistencies of the adapted scales,
35
36 225 Cronbach's alpha will be calculated with the respective values indicating excellent > 0.9, good > 0.8,
37
38 226 acceptable > 0.7, questionable > 0.6, poor > 0.5, and unacceptable < 0.5 fit (47).
39
40

41 227 Outcome measures will consist of a categorical variable representing the different transport modes (e.g.,
42
43 228 walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode)
44
45 229 for each destination, and an overall score of active transport including all destinations. This overall score
46
47 230 will be calculated based on the proportion of active trips in relation to all reported trips resulting in a
48
49 231 interval scaled variable with values between 0 (all trips *passive*) to 1 (all trips *active*).

50
51 232 Differences in transport mode choice and predictor variables between different groups (e.g., age,
52
53 233 sex/gender) will be calculated using t-tests and analysis of variance for continuous variables, and chi-
54
55 234 squares for categorical variables. For example, differences in transport mode choice between boys and
56
57 235 girls and adolescents living in different regions with different degrees of urbanization (cities, medium-
58
59 236 sized towns, small towns, rural areas) will be calculated using Pearson-Chi2-test and post-hoc analysis

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2
3 237 (48) as well as the comparison of transport mode across destinations according to parental sex/gender
4
5 238 (mothers and fathers). To identify differences in travel distance between transport modes one-way
6
7 239 analysis of variance will be calculated.
8

9 240

11 241 Aim 1: Identifying predictors of adolescent travel behavior

13 242 Multinomial (different transport modes) and binary (active vs. passive travel) logistic regression models
14
15 243 controlling for multiple relevant socio-demographic variables will be used to identify predictors of
16
17 244 adolescent active travel. Due to the heterogeneity of outcome measures, separate logistic regression
18
19 245 analyses will be conducted for each destination using the dichotomous variables of transport mode
20
21 246 choice as dependent variable, the individual, social and physical environmental variables as predictors,
22
23 247 and socio-demographic factors (e.g., age, education) as confounders. Adjusted odds ratio (aOR) and
24
25 248 95%-confidence intervals will be reported. For some analyses, the overall score of active travel will be
26
27 249 used as categorical, dependent variable, for example, to assess the effect of the motivational regulations
28
29 250 on active travel behavior in adolescents. The regression analysis will either be performed for the whole
30
31 251 sample or due to theoretical assumptions separately for male and female adolescents to account for
32
33 252 sex/gender differences. To assess associations between travel behavior in adolescents and their parents,
34
35 253 separate sex/gender analyses with parent-adolescent-dyads (mother-daughter, mother-son, father-
36
37 254 daughter, and father-son) will be conducted by binary logistic regressions.
38
39
40

41 255

43 256 Aim 2: Comparing parental and adolescents' perspectives on transport mode choice

45 257 To investigate parental and adolescents' perspectives on social and physical barriers of active travel,
46
47 258 several multiple regression models will be performed. The overall score for transport mode in
48
49 259 adolescents will be set as the dependent variable and each barrier as an independent variable. Thus, for
50
51 260 each comparable barrier a separate multiple regression will be implemented.
52

53 261

55 262 Aim 3: Investigating moderating effects of relevant socio-demographic characteristics

57 263 To assess whether the association between the social and physical environment and adolescents' travel
58
59 264 behavior are moderated by socio-demographic characteristics (e.g., sex/gender, degree of urbanization),
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1
2
3 265 we will run 1) logistic regression models controlling for socio-demographic variables, and 2) logistic
4
5 266 regression analyses including interactions effects.
6

7 267
8
9 268 If appropriate, further exploratory analysis based on the theoretical framework will be conducted within
10
11 269 the ARRIVE project. For all analysis, a level of $\alpha = 0.05$ will be set as a threshold to determine statistical
12
13 270 significance. Analyses will be conducted with R, Matlab, and SPSS.
14

15
16 271

17 272 **Qualitative study**

18 273 *Aims*

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21
22 274 The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the
23
24 275 decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box).
25
26 276 Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode
27
28 277 choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated
29
30 278 by the adolescents and parents themselves. To complement our online survey which aims to examine if
31
32 279 and how various socio-demographic and socio-environmental factors predict adolescent travel behavior,
33
34 280 this qualitative investigation seeks to understand the experiences of adolescent travel behavior by
35
36 281 precisely exploring what and why certain influences centrally impact parental and adolescent decision-
37
38 282 making processes regarding transport mode choice. Specifically, the qualitative investigation will focus
39
40 283 on the following research questions:

- 41
42
43 284 - What physical environment and individual factors influence transport mode choice in
44
45 285 adolescents?
46
47 286 - How do adolescents experience the decision-making process on transport mode choice?
48
49 287 - How do parents experience the decision-making process on transport mode choice in
50
51 288 adolescents?
52
53 289 - Are there any differences in adolescents' and parental perspectives on transport mode choice?
54
55

56 290

57 291 *Sampling strategy*

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2
3 292 In addition to the online sample, we will also be recruiting another set of adolescents and their parents
4
5 293 to take part in the qualitative investigation. These participants will be recruited using theoretical
6
7 294 sampling methods (49). Therefore, the sample will not be defined by the onset of the study, but will be
8
9 295 selected against the background of theoretical problems outlined earlier and in accordance with our
10
11 296 proposed analysis processes. Our sampling methods will thus initially be based on ensuring the samples
12
13 297 contain diversity with respect to socio-economic status, migration status, sex/gender, and environmental
14
15 298 conditions (e.g., urban and rural living locations). When possible, we will interview both parents to
16
17 299 capture the perspectives of fathers and mothers. We anticipate that the final sample will consist of 10–
18
19 300 15 adolescents and 15–20 parents.
20
21
22 301

23 24 302 *Data collection*

25
26 303 Interviews will be conducted with adolescent and parent participants separately. Prior to the data
27
28 304 collection process all interviewers received formal training from an interview expert. Sample interviews
29
30 305 were conducted to ensure the appropriateness of the interview guides.

31
32 306 Interviews are anticipated to take around 30 minutes to complete. However, because deviations are
33
34 307 possible, for each participant an appointment time of 60 minutes will be made. After giving informed
35
36 308 consent and agreeing on an appointment, each participant will receive an individual link for an online
37
38 309 meeting to conduct the interview. Participants will be able to complete their interview from any desired
39
40 310 place so long as they have a stable internet connection and quiet surrounding. Before the start of the
41
42 311 recording, the objective and the interview procedure will be explained and participants will be reassured
43
44 312 of the voluntary nature of their involvement and their right to refuse to answer any questions. After
45
46 313 clarifying any questions that participants may have, the audio recording device will be turned on and the
47
48 314 interview will begin. At the end of the interview, the audio recording will stop.
49
50
51 315

52 53 316 *Interview Guideline*

54
55 317 The focus of the interviews for both groups of participants will be the travel behavior of adolescents and
56
57 318 the associated decision-making process. During the interviews, adolescents and their parents will be
58
59 319 encouraged to recount their travel experiences and their decision-making processes regarding mode

1
2
3 320 choice in relation to four different situations. In order to generate a thorough understanding of the
4
5 321 differences in decision-making processes when considering the choice of active vs. passive transport to
6
7 322 the distinct locations, different interview paths will be followed to ensure that the interview inquires
8
9 323 about four (two active, two passive trips) different travel type-location examples (see Figure 2). At the
10
11 324 start of each interview parents and adolescents will be instructed to first talk about a recent trip the latter
12
13 325 made during one of the days prior to the interview. This first trip may be undertaken by either an active
14
15 326 or passive means. Next, and to facilitate a comparison of factors affecting adolescent travel mode
16
17 327 decision-making processes, participants will be asked to remember a trip to the same destination that
18
19 328 they made using another transport mode (passive/active). To generate additional depth regarding
20
21 329 understanding the potential variety of relevant factors influencing participants' decision-making
22
23 330 processes, this procedure will be repeated for another destination that the adolescent traveled to in the
24
25 331 previous week. In the event that an adolescent participant reports that they never changed transport mode
26
27 332 to the two selected destinations, the interviewer will ask about any trips made with the opposite
28
29 333 (passive/active) transport mode to explore how their habits and perceptions might be changed.
30
31
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34

35 335 *Figure 2. Structure of the interview guide – decision-tree*

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37 336
38
39 337 When discussing each of the four distinct trips, participants will be asked to describe their experiences
40
41 338 of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks:
42
43 339 the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation
44
45 340 on the journey itself (i.e., social and environmental factors). To garner further information pertaining to
46
47 341 the various circumstances which might affect the travel planning process, adolescents and parents will
48
49 342 also be asked about a hypothetical commute to school, and specifically what factors (e.g., concerns,
50
51 343 priorities) they would foremost consider when planning the trip. Interviews will close with adolescents
52
53 344 and parents being asked which transport mode they would prefer and why. More detailed information
54
55 345 regarding both interview guides is enclosed in the supplementary materials.
56
57
58
59

347 *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

348

349

350 *Data analysis*

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

364

365 **Ethics and dissemination**

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

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3 369 B). Participation in both parts of the study is voluntary. Participants will not receive any reimbursement
4
5 370 or compensation for participating in one part of the study. Informed assent will be obtained from all
6
7 371 adolescents and informed consent will be obtained from all parents that participate in this study. With
8
9 372 regard to the quantitative survey, no personally identifiable information will be included in the data set
10
11 373 and transferred from forsa to the study team. In the interviews, participants will not be addressed by
12
13 374 name, nor will any personal identifying information be requested. All data will be stored on central
14
15 375 servers of the Technical University of Munich/Germany and the University of Erlangen-
16
17 376 Nuremberg/Germany.
18
19 377 The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly
20
21 378 journals with international audiences, and will be presented at academic conferences. Additionally, the
22
23 379 results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made
24
25 380 publicly available for interested individuals, families, teachers, and caregivers via a project website and
26
27 381 public knowledge translation activities (e.g., public talks, community information sessions).
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383 **Patient and public involvement statement**

384 No medical patients and/or members of the public were involved in setting the research question nor
385 they were involved in developing plans for design (or implementation) of this study protocol.
386

387 **Discussion**

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

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3 396 Until now, only a few qualitative studies exist that provide a deeper understanding of the
4
5 397 interrelationships and familial decision-making processes on active travel behavior in adolescents (28,
6
7 398 29, 32). The inclusion of qualitative methods in the study of this issue can be beneficial as they may
8
9 399 help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus
10
11 400 on the experiences, meanings, and perspectives of the participants (53). Additionally, previous evidence
12
13 401 has posited that child or adolescent sex/gender plays a significant role with regard to physical activity
14
15 402 and travel behavior (54-56), it has been observed that parental perspectives of this issue have been
16
17 403 largely limited to the views of mothers (e.g., (29, 57)).

18
19
20 404 The ARRIVE study aims to address these research gaps, by providing a comprehensive multi-
21
22 405 component and multi-group analysis of the socio-ecological determinants of adolescent active travel
23
24 406 behavior and its associated decision-making processes. Quantitative analyses of several theoretically
25
26 407 relevant predictors of adolescent active travel are intended to provide the necessary empirical evidence
27
28 408 to illustrate the relationships of the family environment with non-school commutes and travel behaviors.
29
30 409 Qualitative semi-structured interviews are anticipated to provide deeper insights into the decision
31
32 410 making-processes of both adolescents and parents regarding travel mode behaviors. Together, the
33
34 411 findings from both components of the ARRIVE study should be of value to both practitioners and
35
36 412 researchers as they will offer a comprehensive evaluation of a more diverse set of trips, family
37
38 413 predictors, and decision-making processes associated with adolescent active travel, as well as provide
39
40 414 empirical evidence to support public health active travel interventions for targeted adolescent groups
41
42 415 and families.

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45 416 To build on the expected findings of the ARRIVE study in future research, targeted active travel
46
47 417 interventions, especially those featuring gamification elements (58), could be a starting point for larger-
48
49 418 scale prevention efforts aimed to reduce non-communicable diseases and to improve public health. For
50
51 419 example, longitudinal data supports that nine to 18-year-old active commuters have higher levels of
52
53 420 physical activity during young adulthood and can maintain these behaviors for up to 12 years (59), thus
54
55 421 targeted and gamified early-years interventions may be prudent prevention strategies. Other potential
56
57 422 benefits of regular active travel, or targeted interventions, include the improved emotional health and
58
59 423 happiness of both adolescents and adults (60), improvements in cardiovascular health (e.g., exercise

1
2
3 424 capacity, maximal power, blood pressure and blood parameters) in adults (61-63) and adolescents (64,
4
5 425 65), and cleaner and less congested neighbourhoods (66, 67)—all points which future intervention studies
6
7 426 could also evaluate alongside the findings (e.g., articulated decision-making processes) of our ARRIVE
8
9 427 study.

10 428

11 429

12 430 **Authors' contributions**

13 431 AKR, IM, FB, EE, DR, CK and YD made substantial contribution to the concept and design of the
14 432 ARRIVE study. AKR and IM prepared the first draft of the protocol article and finalized the manuscript.
15 433 FB, EE, DR, AB, CK and YD made substantial contributions to the manuscript, provided edits to the
16 434 manuscript and read and approved the final manuscript.

17 435

18 436 **Competing interests**

19 437 The authors declare that they have no competing interests.

20 438

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23 441 profit sectors.

24 442

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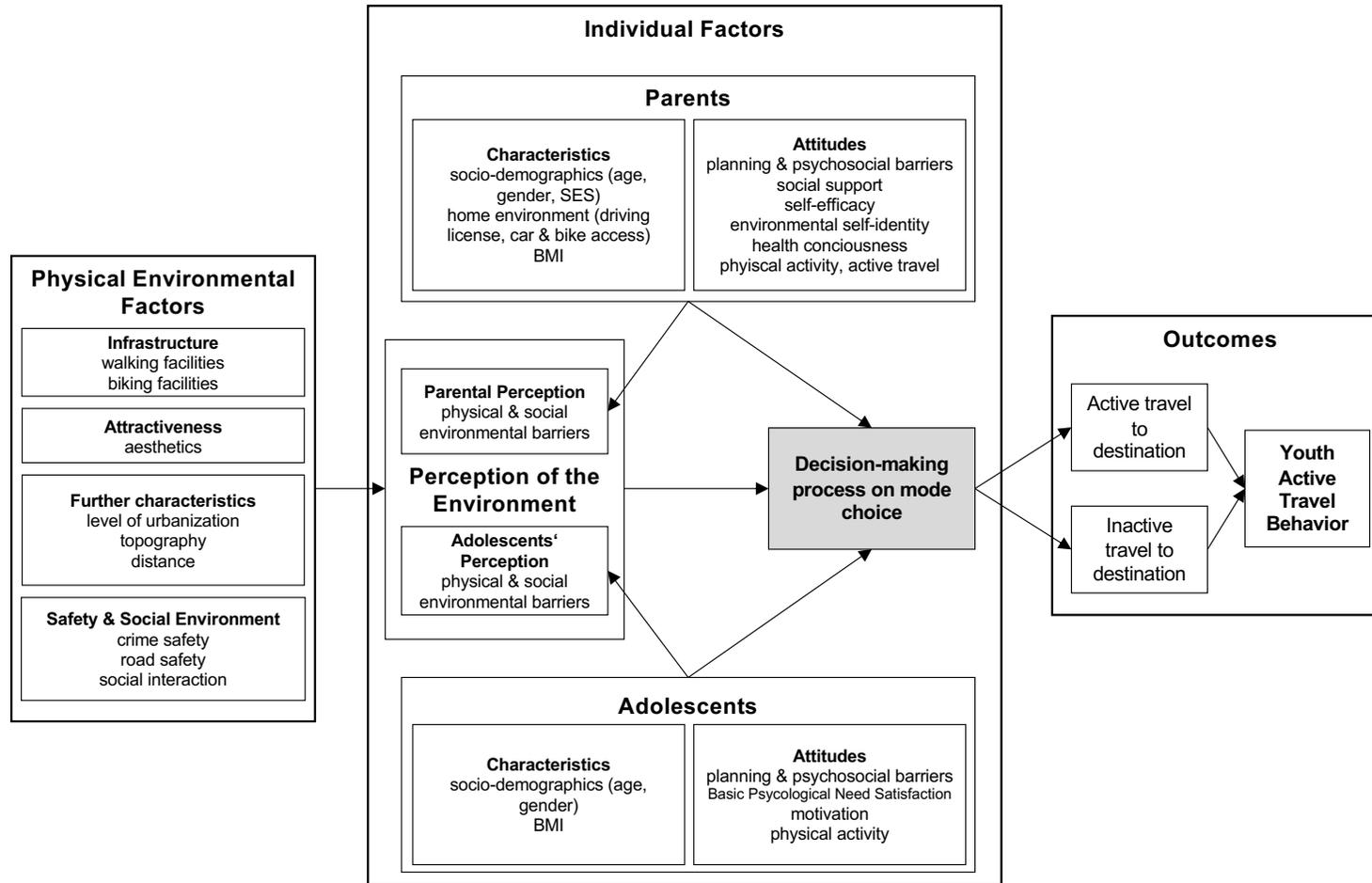
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1 **Table 1: Overview on Instrument used in the Parental and Adolescent Questionnaire**

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.	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 (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 $\alpha = 0.870$; 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 $\alpha = 0.72$) (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 ($\kappa = 0.61-0.94$) (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 $\alpha = 0.59-0.76$) 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 $\alpha = 0.85$; 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 $\alpha = 0.81$, competence satisfaction $\alpha = 0.92$, and relatedness satisfaction $\alpha = 0.82$) 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 $\alpha = 0.70-0.91$) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (81).

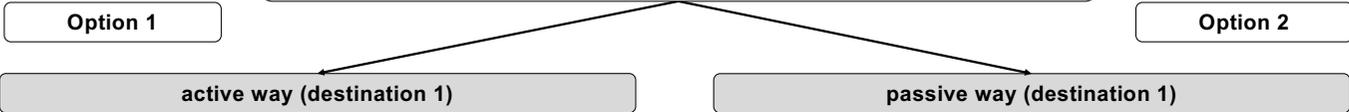


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BMJ Open

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?



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?

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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?
		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]? 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? Is there anything on the way that worries you?	How do you deal with it?

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	Can you describe the way as precisely as possible so that I can get an idea?	Child's perspective	How do you think your child likes the way?	How do you feel about it?
		Behavior child – way	Can you describe what your child has done/experienced along the way?	
Way – social environment	Did someone accompany your child?	Friends company	How does it happen?	What do you say to that?
		Parents company	What do you do on the way together? Can you describe why you accompany your child?	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	What factors are you or your child considering for planning tomorrow? What are you thinking about it?	What would change your decision? Are you satisfied with the decision? How do you evaluate this decision?
		Decision	To what extent do you involve your child?	

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3 **B. Interview guideline - youth**
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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]?	
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?	Motivation	What did motivate you?		
		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?		

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			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? Can you tell me what you did along the way?	What was it like between you? Was there anything that you particularly liked? Was there anything you did not like so much?
			Do you meet other people along the way?	

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 Decision	Which factors do you take into account in the planning? What are you considering? Do you check with your parents? Whom do you involve in the decision? How do you come to the decision?	What would change your decision? Are you satisfied with the decision? How do you evaluate this decision?
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Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods Cross-Sectional ARRIVE Study

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3 1 **Active Travel Behavior in the Family Environment: Protocol for the Mixed-Methods**

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5 2 **Cross-Sectional ARRIVE Study**

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3 **Abstract:**
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5 **Introduction:** Active travel is an important source of physical activity and a primary contributor to
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7 overall health among adolescents. To understand and promote active travel behavior in adolescents,
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9 developing a more robust understanding of the predictors of active travel and its associated decision-
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11 making processes is needed. Situated within a theoretical socio-ecological framework for adolescent
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13 travel behavior, the mixed-methods ARRIVE study aims to quantitatively assess the influence of several
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15 predictors of adolescent travel behavior, and to qualitatively understand the associated decision-making
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17 processes of both adolescents and parents.
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20 **Methods and analysis:** Our mixed-methods approach will feature online surveys and semi-structured
21
22 interviews. The online questionnaire, developed in accordance with a theoretical framework of
23
24 adolescent active travel, will examine adolescent travel behavior with respect to four different
25
26 destinations while controlling for multiple relevant individual, social, and physical environment factors.
27
28 To enable the comparison of adolescent and parental perspectives, the questionnaire will be answered
29
30 by a representative sample of German adolescents (11–15 years old) and their parents.
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32 Our semi-structured interviews, likewise framed based on the central tenets of the theoretical framework
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34 of adolescent active travel, will seek to explore the decision-making process of families regarding travel
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36 mode choice via conducting interviews with each member (i.e., father, mother, adolescent). To
37
38 investigate travel decision-making processes, adolescents and their parents will be invited to talk about
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40 trips they undertook using both active and passive transport modes during the last week. Thematic
41
42 analyses will be conducted to highlight the central concerns, priorities, and values of participants'
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44 decision-making processes.
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47 **Ethics and dissemination:** This study has received ethical approval from the ethics commission of the
48
49 Friedrich-Alexander-University Erlangen-Nuremberg. Study results will be disseminated at scientific
50
51 conferences and published in peer-reviewed journals. Additionally, study findings will be made publicly
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53 available to relevant health, policy, and research stakeholders and groups.
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46 **Strength and limitations of this study**

47 **Bullet points:**

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

66 **Keywords (3–10):**

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

69

70 **Introduction**

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

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

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

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

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3 98 active commuting remain rather limited (31). To date, studies have largely focused on examining only
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5 99 singular elements of the family-level. For example, recent works have found safety aspects in terms of
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7 100 traffic safety and a child's own ability to travel safely and independently strongly influence parental
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9 101 decision making on transport mode (28, 29, 32), and that some parents prefer car usage to spend time
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11 102 with their children (32). Other noted relevant factors in this regard include social norms and convenience
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13 103 (28, 32), and parenting practices (29) as significant individual predictors. In other cases, however, family
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15 104 environment influences are ambiguous. When examining the role of distance to school and its interaction
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17 105 with family-level factors, existing evidence is inconclusive: while one Swedish study (32) revealed that
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19 106 parents chauffeured their teenagers to school regardless of distance, another from Canada (28) found
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21 107 that transport mode choice was influenced by perceptions of travel time and distance to school.
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23 108 Ultimately, given this combination of a lack of comprehensive investigations and uncertainty in other
24
25 109 areas, there is a need to more comprehensively (e.g., examine the interaction of parent and adolescent
26
27 110 perceptions) consider family environment influences of adolescent active travel.
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29 111 Similarly, while existing literature has focused significantly on active travel to/ from school, only a few
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31 112 studies have considered other highly frequented destinations. Trips to leisure facilities, shops, or the
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33 113 homes of friends and relatives often represent as much or a greater proportion of all trips traveled by
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35 114 adolescents than school commutes. For example, in Germany, adolescents accumulate on average 2.8
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37 115 trips taking 72 minutes and having a total distance of 29 kilometers per day (33). Of these trips, school
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39 116 commutes account for 35.5% of trips, while 39.5% are made related to leisure activities, 14.5% are
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41 117 related to shopping and everyday activities, and around 4% are made while accompanying adults/parents
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43 118 to other locations. Despite these documented trends, there is a relative dearth of knowledge pertaining
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45 119 to how this variety of daily trips to destinations other than school may contribute to adolescent health
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47 120 representing another important avenue for future study.
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49 121 The dynamics and impacts of parental and adolescent decision-making processes on adolescent active
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51 122 travel is likewise relatively understudied. Perhaps most notably, little is currently known about how the
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53 123 perceived social and physical environment facilitators and barriers to active travel among parents may
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55 124 vary across diverse cohorts from various geographical regions and degrees of urbanization (34, 35).
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57 125 Furthermore, while many previous studies have focused on children, few have addressed active travel
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3 126 behavior in adolescents (34). Moreover, previous studies have not considered adolescent active travel
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5 127 behavior in the context of the differing perspectives and attitudes of multiple family members (36, 37)
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7 128 resulting in most existing studies focusing exclusively on either youth or parental perspectives and
8
9 129 neglecting the interrelation of both perspectives (38, 39). Such a precedent is an important oversight
10
11 130 given that in their comparative study of children and adolescents as well as parental barriers on active
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13 131 commuting to school, Aranda-Balboa et al. (40) found that there are significant differences between
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15 132 adolescents' and parents' perspectives in terms of perceived social and environmental determinants of
16
17 133 active travel.

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20 134 To better understand and promote adolescent active travel there are a few important research
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22 135 opportunities to address, namely: family environment predictors of adolescent active travel, the value
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24 136 and impact of non-school commuting trips, and the influence of the decision-making processes of
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26 137 adolescents and parents regarding travel behavior. The ARRIVE study (Active tRavel behavioR in the
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28 138 famIlly EnVironmEnt) aims to address these gaps and develop a more comprehensive understanding of
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30 139 adolescent active travel behavior through conducting a theoretically-informed, multi-component, and
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32 140 mixed-methods investigation of German adolescents and parents.

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36 37 142 **Methods and analysis**

38 39 143 **Study design**

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41 144 The ARRIVE study, a mixed-methods cross-sectional study, intends to generate novel insights regarding
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43 145 1) a range of predictors of adolescent active travel by considering trips to four commonly frequented
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45 146 destinations (travel to/from school/workplace, homes of friends and/or relatives, shops, leisure
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47 147 facilities), and 2) the intra-familial dynamics (i.e., family context predictors and decision-making
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49 148 processes) that impact adolescent travel behaviors. ARRIVE's mixed-methods approach includes two
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51 149 complementary studies: quantitative online surveys and qualitative semi-structured interviews. Both
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53 150 studies will collect data from multiple groups, specifically adolescents between 11–15 years old and
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55 151 their parents. Data collection for both studies will take place between June and December 2021.

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59 60 153 **Theoretical framework**

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3 154 We developed the ARRIVE study based on Panter et al.'s "Conceptual Framework for the
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5 155 Environmental Determinants of Active Travel in Children" (27) (see Figure 1). This framework serves
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7 156 as the study's theoretical foundation as it provides a multi-level outline of the predictors of adolescents'
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9 157 active travel based on the social-ecological model (18, 31). The framework considers physical (e.g.,
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11 158 neighborhood design) and social (e.g., crime) environment factors, as well as individual factors for both
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13 159 parents and youth (e.g., socio-demographic and psychosocial variables, attitudes). In the ARRIVE study,
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15 160 we used these conceptual categories to identify relevant predictors of interest—e.g., personal
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17 161 characteristics, attitudes, parental and adolescent perceptions of physical and social environment
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19 162 barriers—that will be examined in our statistical models in order to explore how they impact the main
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21 163 outcome (adolescent travel behavior) in relation to the four commonly frequented destinations (41-43).
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26 165 *Figure 1. Theoretical Framework for the ARRIVE study*
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29 30 167 **Quantitative study**

31 32 168 *Aims*

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34 169 The overarching aim of the quantitative online survey will be to empirically evaluate the theoretical
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36 170 relationships proposed in Panter et al.'s "Conceptual Framework for the Environmental Determinants
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38 171 of Active Travel in Children" (27). In a first step, we will comprehensively describe travel behavior in
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40 172 adolescents from Germany in dependence of destination and adolescents' socio-demographic
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42 173 characteristics. To systematically evaluate this theoretical model, our specific aims are threefold. First,
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44 174 we will seek to identify predictors of adolescent travel behavior with respect to four different
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46 175 destinations in order to discern whether the predictive strength of these correlates varies between trip
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48 176 destinations. Second, we will aim to develop a more comprehensive understanding of adolescent
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50 177 transport mode choice in the family context by comparing parent and adolescent perspectives regarding
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52 178 transport mode choice. Third, we will investigate the moderating effects of several theoretically relevant
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54 179 socio-demographic characteristics (e.g., sex/gender, migration background, and degree of urbanization)
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56 180 on adolescent travel behavior.
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182 *Sampling strategy*

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

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

198 *Data collection*

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

208 *Measures*

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3 209 To cover all relevant constructs, an online questionnaire has been developed based on already existing
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5 210 scales (that were partly translated into German), modified scales, and additional single item questions.
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7 211 The selection of scales and questions were derived from the central tenets of the theoretical framework;
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9 212 all constructs mentioned in Figure 1 will be assessed via adolescent and parent self-reports. Based on a
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11 213 literature search on activity settings of adolescents, four destinations adolescents frequently visit and
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13 214 which are the most popular places for adolescents in the walkable neighborhood have been selected to
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15 215 assess travel behavior in youth (41, 42, 45, 46). A detailed description of all measures applied in the
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17 216 online questionnaire for parents and adolescents is provided in Table 1.
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21 218 *Data analysis*

22 219 Descriptive analysis

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24 220 Data analysis will include descriptive statistics, an examination of normally distributed data, and
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26 221 examinations of the homogeneity of variance. Descriptive statistics will include means (M) and standard
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28 222 deviations (SD) for continuous variables, and frequencies (%) for categorical variables (e.g., boys and
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30 223 girls and mothers and fathers). Frequency distribution of transport mode for each destination will be
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32 224 calculated separately for boys and girls. To examine internal consistencies of the adapted scales,
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34 225 Cronbach's alpha will be calculated with the respective values indicating excellent > 0.9, good > 0.8,
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36 226 acceptable > 0.7, questionable > 0.6, poor > 0.5, and unacceptable < 0.5 fit (47).
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41 228 Outcome measures will consist of a categorical variable representing the different transport modes (e.g.,
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43 229 walking, cycling, driving) per destination, a dichotomous variable (passive vs. active transport mode)
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45 230 for each destination, and an overall score of active transport including all destinations. This overall score
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47 231 will be calculated based on the proportion of active trips in relation to all reported trips resulting in an
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49 interval scaled variable with values between 0 (all trips *passive*) to 1 (all trips *active*).
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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 ($\alpha = 0.86$), 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 ($\alpha = 0.870$; 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 ($\alpha = 0.72$) (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 ($\kappa = 0.61-0.94$) (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 ($\alpha = 0.59-0.76$) in a sample of 465 adolescents (58).
Perceived parental 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 ($\alpha = 0.85$; 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 $\alpha = 0.81$, competence satisfaction $\alpha = 0.92$, and relatedness satisfaction $\alpha = 0.82$) 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 ($\alpha = 0.70-0.91$) and stability (ICC=0.74) and predictive validity (total variance explained: 57%) (61).

233 Notes: Cronbach's $\alpha = \alpha$; ICC= intraclass correlation coefficient; $\kappa =$ Cohen's Kappa; min=
234 minutes; PA= physical activity

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3 235 Aim 1: Description of travel behavior in adolescents from Germany
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5 236 Differences in transport mode choice and predictor variables between different groups (e.g., age,
6
7 237 sex/gender) will be calculated using t-tests and analysis of variance for continuous variables, and chi-
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9 238 squares for categorical variables. For example, differences in transport mode choice between boys and
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11 239 girls and adolescents living in different regions with different degrees of urbanization (cities, medium-
12
13 240 sized towns, small towns, rural areas) will be calculated using Pearson-Chi2-test and post-hoc analysis
14
15 241 (62) as well as the comparison of transport mode across destinations according to parental sex/gender
16
17 242 (mothers and fathers). To identify differences in travel distance between transport modes one-way
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19 243 analysis of variance will be calculated.
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24 245 Aim 2: Identifying predictors of adolescent travel behavior
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26 246 Multinomial (different transport modes) and binary (active vs. passive travel) logistic regression models
27
28 247 controlling for multiple relevant socio-demographic variables will be used to identify predictors of
29
30 248 adolescent active travel. Due to the heterogeneity of outcome measures, separate logistic regression
31
32 249 analyses will be conducted for each destination using the dichotomous variables of transport mode
33
34 250 choice as dependent variable, the individual, social and physical environmental variables as predictors.
35
36 251 In all analyses, socio-demographic factors (e.g., age, education) will be included as confounders.
37
38 252 Adjusted odds ratio (aOR) and 95%-confidence intervals will be reported. For some analyses, the overall
39
40 253 score of active travel will be used as categorical, dependent variable, for example, to assess the effect of
41
42 254 the motivational regulations on active travel behavior in adolescents. The regression analysis will either
43
44 255 be performed for the whole sample or due to theoretical assumptions separately for male and female
45
46 256 adolescents to account for sex/gender differences. To assess associations between travel behavior in
47
48 257 adolescents and their parents, separate sex/gender analyses with parent-adolescent-dyads (mother-
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50 258 daughter, mother-son, father-daughter, and father-son) will be conducted by binary logistic regressions,
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52 259 with adolescents' travel behavior as the outcome and parental travel modes as the predictors.
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58 261 Aim 3: Comparing parental and adolescents' perspectives on transport mode choice
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3 262 To investigate parental and adolescents' perspectives on social and physical barriers of active travel,
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5 263 several multiple regression models will be performed. The overall score for transport mode in
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7 264 adolescents will be set as the dependent variable and each barrier as an independent variable. Thus, for
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9 265 each comparable barrier a separate multiple regression will be implemented.
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14 267 **Aim 4: Investigating moderating effects of relevant socio-demographic characteristics**

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16 268 To assess whether the association between the social and physical environment and adolescents' travel
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18 269 behavior are moderated by socio-demographic characteristics (e.g., sex/gender, degree of urbanization),
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20 270 we will run 1) logistic regression models controlling for socio-demographic variables, and 2) logistic
21
22 271 regression analyses including interactions effects.
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26 273 If appropriate, further exploratory analysis based on the theoretical framework will be conducted within
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28 274 the ARRIVE project. For all analysis, a level of $\alpha = 0.05$ will be set as a threshold to determine statistical
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30 275 significance. Analyses will be conducted with R, Matlab, and SPSS.
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33 34 277 **Qualitative study**

35 36 278 *Aims*

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39 279 The aim of the qualitative semi-structured interviews will be to develop a deeper understanding of the
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41 280 decision-making processes relevant to adolescent transport mode choice (see Figure 1, grey box).

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43 281 Accordingly, the qualitative interviews will seek to provide a nuanced understanding of transport mode
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45 282 choices by identifying novel concerns, preferences, and values relevant to travel behavior as articulated
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47 283 by the adolescents and parents themselves. To complement our online survey which aims to examine if
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49 284 and how various socio-demographic and socio-environmental factors predict adolescent travel behavior,
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51 285 this qualitative investigation seeks to understand the experiences of adolescent travel behavior by
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53 286 precisely exploring what and why certain influences centrally impact parental and adolescent decision-
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55 287 making processes regarding transport mode choice. Specifically, the qualitative investigation will focus
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57 288 on the following research questions:
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3 289 - What physical environment and individual factors influence transport mode choice in
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5 290 adolescents?
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7 291 - How do adolescents experience the decision-making process on transport mode choice?
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9 292 - How do parents experience the decision-making process on transport mode choice in
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11 293 adolescents?
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13 294 - Are there any differences in adolescents' and parental perspectives on transport mode choice?
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18 296 *Sampling strategy*

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20 297 In addition to the online sample, we will also be recruiting another set of adolescents and their parents
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22 298 to take part in the qualitative investigation. These participants will be recruited using theoretical
23
24 299 sampling methods (63). Therefore, the sample will not be defined by the onset of the study, but will be
25
26 300 selected against the background of theoretical problems outlined earlier and in accordance with our
27
28 301 proposed analysis processes. Our sampling methods will thus initially be based on ensuring the samples
29
30 302 contain diversity with respect to socio-economic status, migration status, sex/gender, and environmental
31
32 303 conditions (e.g., urban and rural living locations). When possible, we will interview both parents to
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34 304 capture the perspectives of fathers and mothers. We anticipate that the final sample will consist of 10–
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36 305 15 adolescents and 15–20 parents.
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41 307 *Data collection*

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43 308 Interviews will be conducted with adolescent and parent participants separately. Prior to the data
44
45 309 collection process all interviewers received formal training from an interview expert. Sample interviews
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47 310 were conducted to ensure the appropriateness of the interview guides.

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49 311 Interviews are anticipated to take around 30 minutes to complete. However, because deviations are
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51 312 possible, for each participant an appointment time of 60 minutes will be made. After giving informed
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53 313 consent and agreeing on an appointment, each participant will receive an individual link for an online
54
55 314 meeting to conduct the interview. Participants will be able to complete their interview from any desired
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57 315 place so long as they have a stable internet connection and quiet surrounding. Before the start of the
58
59 316 recording, the objective and the interview procedure will be explained and participants will be reassured

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3 317 of the voluntary nature of their involvement and their right to refuse to answer any questions. After
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5 318 clarifying any questions that participants may have, the audio recording device will be turned on and the
6
7 319 interview will begin. At the end of the interview, the audio recording will stop.
8

9 320

11 321 *Interview Guideline*

13 322 The focus of the interviews for both groups of participants will be the travel behavior of adolescents and
14
15 323 the associated decision-making process. During the interviews, adolescents and their parents will be
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17 324 encouraged to recount their travel experiences and their decision-making processes regarding mode
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19 325 choice in relation to four different situations. In order to generate a thorough understanding of the
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21 326 differences in decision-making processes when considering the choice of active vs. passive transport to
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23 327 the distinct locations, different interview paths will be followed to ensure that the interview inquires
24
25 328 about four (two active, two passive trips) different travel type-location examples (see Figure 2). At the
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27 329 start of each interview parents and adolescents will be instructed to first talk about a recent trip the latter
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29 330 made during one of the days prior to the interview. This first trip may be undertaken by either an active
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31 331 or passive means. Next, and to facilitate a comparison of factors affecting adolescent travel mode
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33 332 decision-making processes, participants will be asked to remember a trip to the same destination that
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35 333 they made using another transport mode (passive/active). To generate additional depth regarding
36
37 334 understanding the potential variety of relevant factors influencing participants' decision-making
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39 335 processes, this procedure will be repeated for another destination that the adolescent traveled to in the
40
41 336 previous week. In the event that an adolescent participant reports that they never changed transport mode
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43 337 to the two selected destinations, the interviewer will ask about any trips made with the opposite
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45 338 (passive/active) transport mode to explore how their habits and perceptions might be changed.
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51 340 *Figure 2. Structure of the interview guide – decision-tree*

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55 342 When discussing each of the four distinct trips, participants will be asked to describe their experiences
56
57 343 of traveling in reference to a series of topics (see Table 2). These topics are grouped into two blocks:
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59 344 the participant's situation at home (i.e., conditions present before the adolescent's trip), and the situation
60

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.

351

352 *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

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354

355 *Data analysis*

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

1
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3 366 may not align well with the original deductive categories. Subsequently, emerging differences and
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5 367 commonalities from the deductive-inductive analysis will be discussed together to develop consensus.
6
7 368 In cases where a consensus may not be reached, a third researcher will join the discussion.
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9 369

11 370 **Ethics and dissemination**

13 371 The ARRIVE study is designed in accordance with the ethical principles for research involving human
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15 372 subjects of the Declaration of Helsinki. Ethical approval for the study and its procedures were received
16
17 373 from the ethics commission of the Friedrich-Alexander-University Erlangen-Nuremberg (Reg. 249_21
18
19 374 B). Participation in both parts of the study is voluntary. Participants will not receive any reimbursement
20
21 375 or compensation for participating in one part of the study. Informed assent will be obtained from all
22
23 376 adolescents and informed consent will be obtained from all parents that participate in this study. With
24
25 377 regard to the quantitative survey, no personally identifiable information will be included in the data set
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27 378 and transferred from forsa to the study team. In the interviews, participants will not be addressed by
28
29 379 name, nor will any personal identifying information be requested. All data will be stored on central
30
31 380 servers of the Technical University of Munich/Germany and the University of Erlangen-
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33 381 Nuremberg/Germany.

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36 382 The results of the ARRIVE study will be disseminated through peer-review journal articles, particularly
37
38 383 journals with international audiences, and will be presented at academic conferences. Additionally, the
39
40 384 results of this study will be disseminated to relevant stakeholders, and policy makers, as well as be made
41
42 385 publicly available for interested individuals, families, teachers, and caregivers via a project website and
43
44 386 public knowledge translation activities (e.g., public talks, community information sessions).
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49 388 **Patient and public involvement statement**

51 389 No medical patients and/or members of the public were involved in setting the research question nor
52
53 390 they were involved in developing plans for design (or implementation) of this study protocol.
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58 392 **Discussion**

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3 393 Increasing physical activity in adolescents is an immediate and serious challenge for modern societies,
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5 394 but one that if effectively addressed can contribute to preventing a number of chronic and non-
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7 395 communicable diseases (7). Recent recommendations by the European Society of Cardiology (ESC)
8
9 396 suggest approaches targeting optimizing lifestyle activities to change physical activity behaviors and
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11 397 reduce sedentary time as important preventive measures in this regard (66). Better understanding the
12
13 398 decision-making processes of both adolescents and parents regarding multiple forms of, and influences
14
15 399 on, daily adolescent active travel behavior can be an effective strategy in supporting these desired
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17 400 lifestyle activity alterations.

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19
20 401 Until now, only a few qualitative studies exist that provide a deeper understanding of the
21
22 402 interrelationships and familial decision-making processes on active travel behavior in adolescents (28,
23
24 403 29, 32). The inclusion of qualitative methods in the study of this issue can be beneficial as they may
25
26 404 help to capture, re-construct, and comprehend the social reality of groups or individuals as they focus
27
28 405 on the experiences, meanings, and perspectives of the participants (67). Additionally, previous evidence
29
30 406 has posited that child or adolescent sex/gender plays a significant role with regard to physical activity
31
32 407 and travel behavior (68-70), it has been observed that parental perspectives of this issue have been
33
34 408 largely limited to the views of mothers (e.g., (29, 71)).

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36
37 409 The ARRIVE study aims to address these research gaps, by providing a comprehensive multi-
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39 410 component and multi-group analysis of the socio-ecological determinants of adolescent active travel
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41 411 behavior and its associated decision-making processes. Quantitative analyses of several theoretically
42
43 412 relevant predictors of adolescent active travel are intended to provide the necessary empirical evidence
44
45 413 to illustrate the relationships of the family environment with non-school commutes and travel behaviors.
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47 414 Qualitative semi-structured interviews are anticipated to provide deeper insights into the decision
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49 415 making-processes of both adolescents and parents regarding travel mode behaviors. Together, the
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51 416 findings from both components of the ARRIVE study should be of value to both practitioners and
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53 417 researchers as they will offer a comprehensive evaluation of a more diverse set of trips, family
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55 418 predictors, and decision-making processes associated with adolescent active travel, as well as provide
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57 419 empirical evidence to support public health active travel interventions for targeted adolescent groups
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59 420 and families.

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3 421 To build on the expected findings of the ARRIVE study in future research, targeted active travel
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5 422 interventions, especially those featuring gamification elements (72), could be a starting point for larger-
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7 423 scale prevention efforts aimed to reduce non-communicable diseases and to improve public health. For
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9 424 example, longitudinal data supports that nine to 18-year-old active commuters have higher levels of
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11 425 physical activity during young adulthood and can maintain these behaviors for up to 12 years (73), thus
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13 426 targeted and gamified early-years interventions may be prudent prevention strategies. Other potential
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15 427 benefits of regular active travel, or targeted interventions, include the improved emotional health and
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17 428 happiness of both adolescents and adults (74), improvements in cardiovascular health (e.g., exercise
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19 429 capacity, maximal power, blood pressure and blood parameters) in adults (75-77) and adolescents (78,
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21 430 79), and cleaner and less congested neighbourhoods (80, 81)—all points which future intervention studies
22
23 431 could also evaluate alongside the findings (e.g., articulated decision-making processes) of our ARRIVE
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25 432 study.
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33 **Authors' contributions**

34
35 436 AKR, IM, FB, EE, DR, CK and YD made substantial contribution to the concept and design of the
36
37 437 ARRIVE study. AKR and IM prepared the first draft of the protocol article and finalized the manuscript.
38
39 438 FB, EE, DR, AB, CK and YD made substantial contributions to the manuscript, provided edits to the
40
41 439 manuscript and read and approved the final manuscript.
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45 441 **Competing interests**

46
47 442 The authors declare that they have no competing interests.
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51

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55
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59

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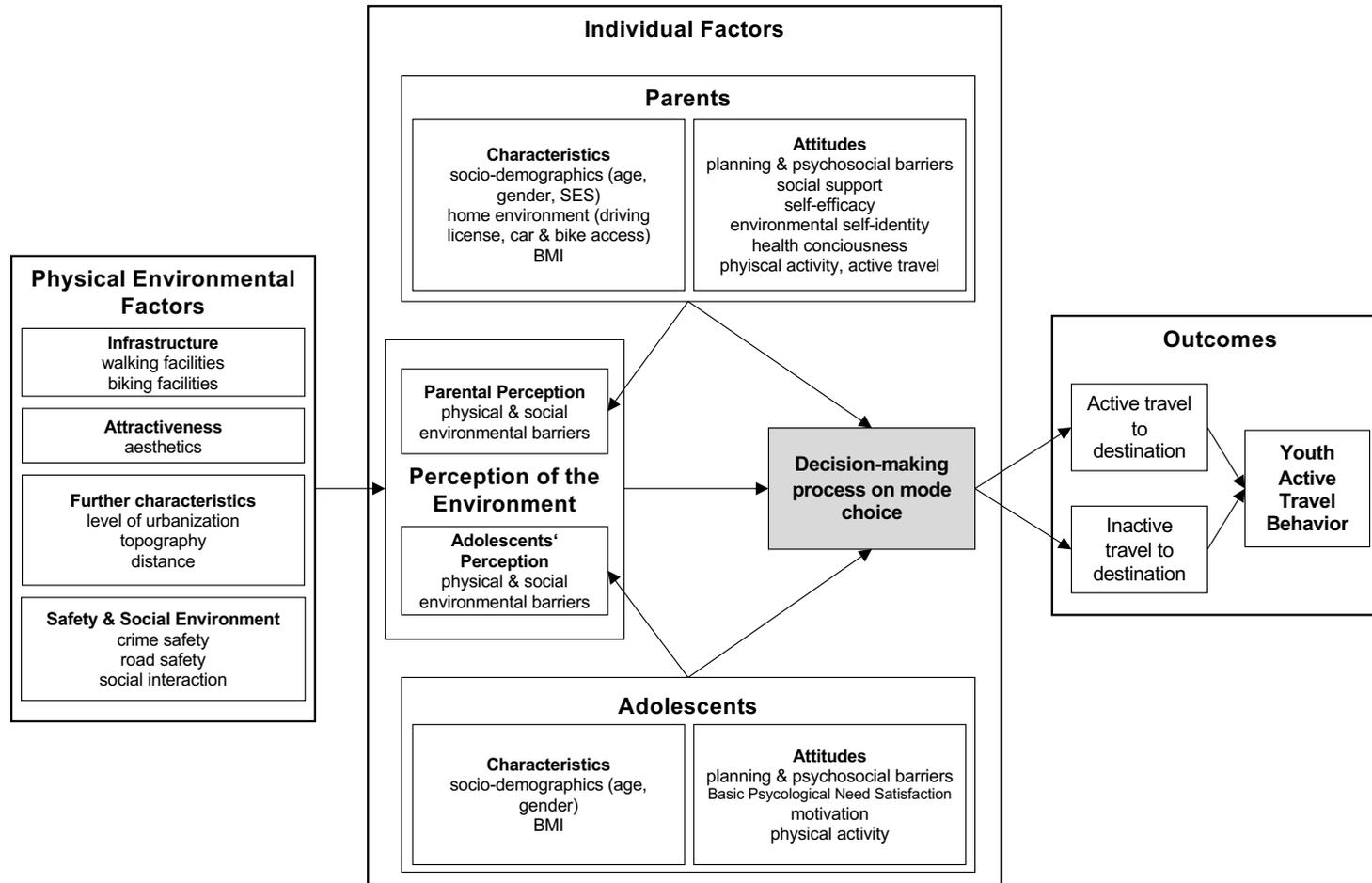
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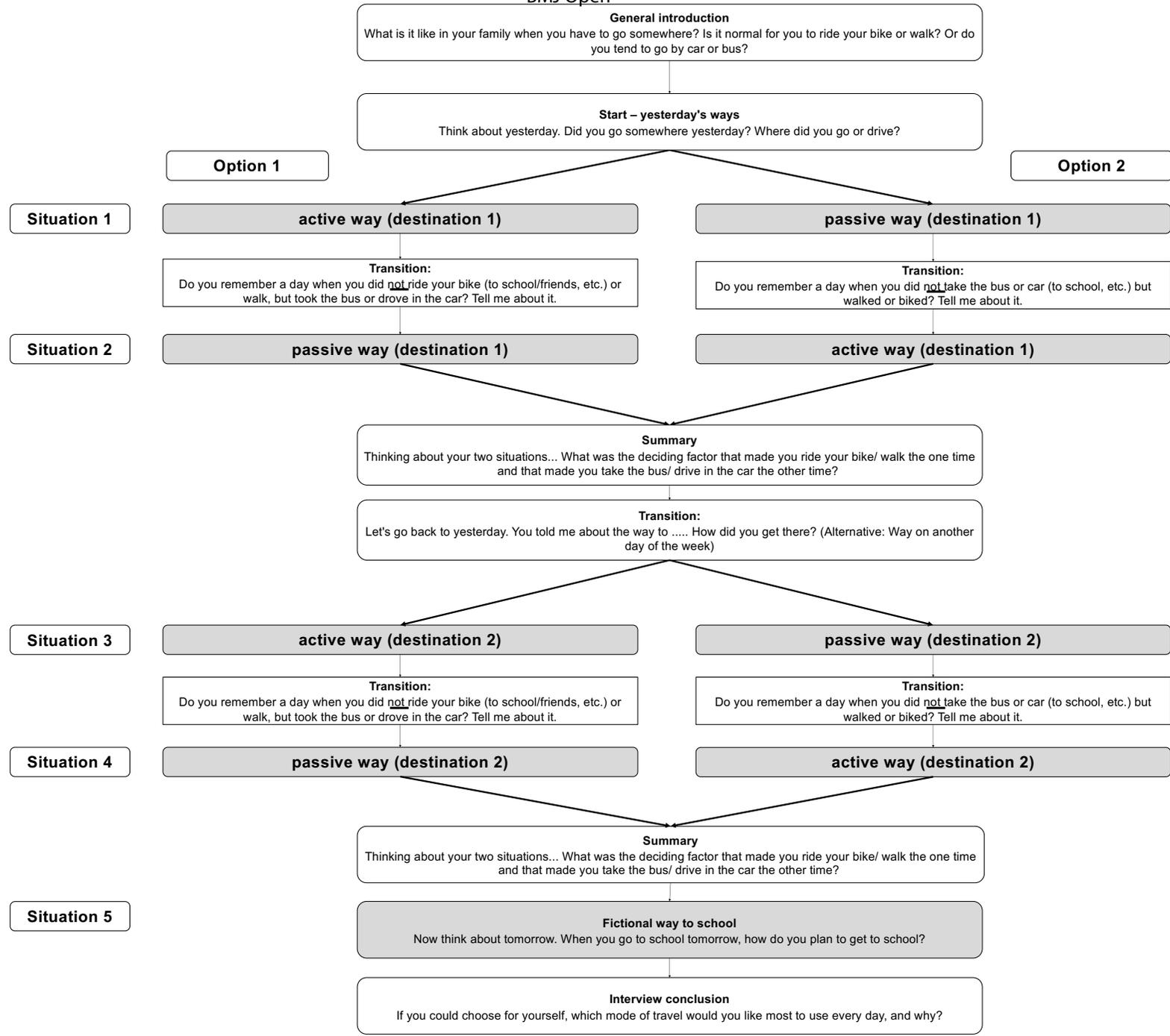
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Supplementary material

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?
		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]? 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? Is there anything on the way that worries you?	How do you deal with it?

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	Can you describe the way as precisely as possible so that I can get an idea?	Child's perspective	How do you think your child likes the way?	How do you feel about it?
		Behavior child – way	Can you describe what your child has done/experienced along the way?	
Way – social environment	Did someone accompany your child?	Friends company	How does it happen?	What do you say to that?
		Parents company	What do you do on the way together? Can you describe why you accompany your child?	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	What factors are you or your child considering for planning tomorrow? What are you thinking about it?	What would change your decision? Are you satisfied with the decision? How do you evaluate this decision?
		Decision	To what extent do you involve your child?	

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?	
		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]?	
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?	Motivation	What did motivate you?	
		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?	

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			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? Can you tell me what you did along the way?	What was it like between you? Was there anything that you particularly liked? Was there anything you did not like so much?
			Do you meet other people along the way?	

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 Decision	Which factors do you take into account in the planning? What are you considering? Do you check with your parents? Whom do you involve in the decision? How do you come to the decision?	What would change your decision? Are you satisfied with the decision? How do you evaluate this decision?
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