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Children's independent travel to and from primary school: Evidence from a suburban town in Germany

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ABSTRACT

The paper studies the factors that contribute to understand children's independent travel – i.e. not being escorted by an adult – to and from primary school in Germany. Binary logit regression is employed, and the data used are taken from a survey among parents of children in seven schools in a medium-sized suburban town. This is the first paper from Germany that simultaneously looks at the full range of dimensions that may help understand children's independent travel: (1) trip characteristics, (2) child characteristics, (3) the household context, (4) subjective concerns, attitudes and perceptions, (5) the transport environment, (6) the built environment and (7) the social environment. In contrast to the majority of studies in the field, an attempt was made to capture a holistic picture of the transport and land-use environment along the route, while at the same time some key attributes of the route were used as separate variables. Perhaps the most notable contribution to research is the distinct differences that we found between outward and return trips. While the morning trip was characterised by distinct impacts of the built and transport environment, most variables turned out insignificant in the afternoon model. Conversely, more attitudinal dimensions turned out significant in the return trip. Some of our findings are clearly relevant for policy. For instance, traffic calming is associated with higher levels of independent travel, while routes characterised by industry and trade, high-speed roads, and zebra-crossings that need to be crossed are associated with lower levels of independent travel. The effects of perceptions and attitudes we find can be taken as starting points for soft policies such as awareness campaigns or traffic education.

1. Introduction

Research on children's school travel dates back to the 1970s (Rigby, 1979; see for a comprehensive review of early studies EPPI, 2001). But the past decade has seen an unprecedented growth in this research and in research on child mobility in general (see Carver et al., 2013a/b; Buliung et al., 2017; Stark et al., 2018, for recent studies). The growing interest is motivated by a strong shift from active modes, especially walking, to being driven, and the associated decline in independent travel that has been observed in various countries throughout the world (McDonald, 2005, and Rothman et al., 2018, for the US; Shaw et al., 2013, for the UK and Germany; Kyttä et al., 2015, for Finland; Schoeppe et al., 2016, for Australia). This raises concerns about increasing child obesity, deficits in motor skills and lack of physical activity (Lau et al., 2017; Race et al., 2017), and children's decreased independence, problems in

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cognitive development and knowledge about their environment (Fang and Lin, 2017). What is more, increased driving to school has been shown to have negative environmental, social and financial effects (Lu et al., 2017; Rothman et al., 2017; He and Giuliano, in press).

Research on children's travel includes multiple perspectives in terms of motivation, scope, methodology, and target variables. Key target variables include travel mode, escort, and children's independent mobility (CIM) als expressed in 'mobility licences', i.e. parental allowances for travelling or being outside without supervision (Hillman et al., 1990). Some studies look at both mobility licences and realised travel (Kyttä et al., 2015; Schoeppe et al., 2016). Notably, the use of active modes and CIM tends to be equated in some studies. This may be justified in strongly car-based environments where CIM coincides largely with the use of active modes (Carver et al., 2014, for Australia; Hsu and Saphores, 2014, 550 for California), but in less car-based environments parents may accompany their children on foot, bicycle or public transport (Björklid and Gummesson, 2013, for Sweden; Scheiner, 2016, for Germany; Buliung et al., 2017, for Toronto). Hence, there is need to distinguish between CIM and mode choice.

The travel mode literature is somewhat more rooted in transport studies, while the CIM literature may have deeper roots in children's and health studies. However, in recent years the fields have tended to strongly overlap. It should also be noted that most travel mode studies focus on school trips, while there is less research on other trip purposes (see for a comparison between the two Stark et al., 2018). On the other hand, the use of mobility licences tends to focus less strongly on isolated trips or purposes, but includes licences to cross the road alone, go out alone after dark etc. Another related field concerns studies that employ a parental perspective on child escorting. These typically consider escort trips an integral part of intra-family worksharing (for studies that link CIM and gender worksharing see Scheiner, 2016; He and Giuliano, 2017).

This paper uses standardised data collected in 2017 in a questionnaire survey in the mid-sized suburban town of Lünen, Germany. It studies CIM on trips to primary school and back home. There is a striking lack of research on the topic in Germany, despite early German contributions to research about CIM (Hillman et al., 1990; Flade and Limbourg, 1997), and despite ongoing public discussion of parental driving to schools (Vollmuth, 2017; Prengel, 2018). More specifically, to the best of our knowledge this is only the second study from Germany that investigates CIM using multivariate methods to simultaneously include multiple factors. The first (Scheiner, 2016) used nation-wide data; however, these data lack georeferences as well as attitudinal information.

The next section provides a brief literature review. Section 3 introduces data and methods, and Section 4 presents the results. The paper concludes with a summary and draws conclusions for policy and research.

2. Background – children's independent mobility

There are literature reviews for various sub-areas in children's travel, including CIM (Sharmin and Kamruzzaman, 2017), methods of capturing CIM (Bates and Stone, 2015), children's mode use (Sirard and Slater, 2008; Rothman et al., 2018; Rojas Lopez and Wong, 2017), environmental factors that affect the use of active modes (Pont et al, 2009; D'Haese et al., 2015), interventions to promote active travel (Smith et al., 2015; Pang et al., 2017; Larouche et al. 2018), associations between children's travel and their health status (Schoeppe et al., 2013), and children's mobility/school travel in general (McDonald, 2005; McMillan, 2005; Curtis et al., 2015). This also includes multiple review sections in empirical studies on CIM (Shaw et al., 2013; Kyttä et al., 2015; Buliung et al., 2017). Hence, this section focuses – though not exclusively – on studies of CIM from the past few years that employ standardised data. There is, however, much overlap between studies of mode use and studies of independent mobility.

CIM is generally considered as permission to get around in the neighbourhood or city without adult supervision (Hillman et al., 1990; Carver et al., 2013a; Loebach and Gilliland, 2016; Buliung et al., 2017; see Mikkelsen and Christensen, 2009, for a critical perspective). In the transport literature CIM is often studied using binary measures of either being escorted by an adult for a given trip or not, i.e. by actual independent travel (Buliung et al., 2017). Carver et al. (2013a) study associations between licences for independent mobility and actual independent – without adult escort – travel to school, and Loebach and Gilliland (2016) do the same but look at activity space metrics.

A wide range of circumstances and constraints have been found to be potentially associated with CIM. These are on various levels that interact with each other. This understanding resonates with ecological behavioural models of health behaviour where intrapersonal, interpersonal, organisational, community, and public policy factors have been identified as the levels of impact (Sallis et al., 2008). Factors relevant for CIM have been found on all these levels, and they are discussed in the following. We distinguish seven dimensions (note that some cut across various levels): (1) trip characteristics, (2) child characteristics, (3) the household context, (4) subjective concerns, attitudes and perceptions, (5) the transport environment, (6) the built environment and (7) the social environment.

Trip characteristics. The key characteristic of a trip that is associated with CIM is distance: longer distances to school go along with lower levels of CIM (Scheiner, 2016; Buliung et al., 2017; He and Giuliano, 2017; Sharmin and Kamruzzaman, 2017). This is to a large extent due to the fact that longer trips require motorised modes that are typically not available to children. CIM may also be affected by topography (slope) along the route (Lin and Chang, 2010) and weather variations (van Goeverden and de Boer, 2013, for the Netherlands and Flanders; Kamargianni et al., 2015, for Cyprus; all refer to mode use).

The homebound trip is more often conducted independently of parents than the morning trip to school (Lin and Chang 2010, for Taiwan; Scheiner, 2016, for Germany). Parents may be more prepared to take their child to school in the morning than to pick him/her up in the afternoon due to punctuality considerations relating to school start, their own work schedules, safety issues or aiming to get up later in the morning.

Child characteristics. The probability of being independently mobile increases with age (Pacilli et al., 2013; Scheiner, 2016; Buliung et al., 2017) although age effects may vary with the urban environment (Lopes et al., 2014; Scheiner, 2016). Boys tend to be

independently mobile earlier than girls (Pacilli et al., 2013; Schoeppe et al., 2016; Ermagun and Samimi, 2016; Scheiner, 2016; Buliung et al., 2017), which is likely due to parental concerns about harassment and the vulnerability of girls (Alparone and Pacilli, 2012; Zhang et al., 2017). Other studies find no significant gender differences (He and Giuliano, 2017, for California).

The household context. A child's family context strongly affects CIM in myriad and very nuanced ways.

Various studies found that children living in high-status households – measured by income, parental education, home ownership, or other variables – travel less independently (Yoon et al., 2011; Hsu and Saphores, 2014; all for the US; Ermagun and Samimi, 2016, for Iran; Scheiner, 2016, for Germany), perhaps because their parents are more protective (Yoon et al., 2011; Kamargianni et al., 2015) or more eager to choose 'better', more distant schools. High-status households also more often include two employed parents and have multiple cars, which facilitates dropping a child off at school on the commute, as long as the work schedule is flexible or fits school start time (and location) (Buliung et al., 2017; Zhang et al., 2017; He and Giuliano, 2017). On the other hand, dual-earner couples face more severe time constraints. For instance, mothers with longer working hours and/or longer commutes are less likely to escort their children (He and Giuliano, 2017).

Household car ownership, being a key resource for travel, has consistently been found to increase the chance of children being driven (van Goeverden and de Boer, 2013; Ermagun and Samimi, 2016; Zhang et al., 2017; Stark et al. 2018) at the expense of independent travel and using active modes (Shaw et al., 2013; Carver et al., 2014; Waygood and Susilo, 2015).

Household composition may play a role in terms of parents and siblings. Having siblings has been found to increase CIM and active travel, as joint travel especially with older siblings may reduce parental fear (Carver et al., 2014; He and Giuliano, 2017). What is more, single parents may have less chance to escort their children due to time constraints (He and Giuliano, 2017).

Subjective concerns and attitudes. Among the main drivers for parental escort are their own (or their children's) safety and security concerns that may refer to traffic, bullying, or sexual offences (Alparone and Pacilli, 2012; Björklid and Gummesson, 2013; Carver et al., 2014; Hsu and Saphores, 2014; Waygood and Susilo, 2015; Buliung et al., 2017). Such fears are themselves to some extent a function of the environment (Evers et al., 2014; Guliani et al., 2015). The interrelations between subjective perceptions and the actual environment may lead to unexpected results, which are not easy to interpret. For instance, Waygood and Susilo (2015) find a parental perception that traffic is slow and safe has a negative effect on the probability that their child walks to school. They suggest that this perception 'may be associated with neighbourhoods that have low congestion, thus making it easier for the parent to drive their child' (Waygood and Susilo, 2015, 128).

Another dimension of parental attitudes is that driving is simply convenient and fast (McDonald and Aalborg, 2009; Stone et al., 2014), and a welcome opportunity for parents to spend time with their child (Carver et al., 2013b).

The transport environment. The organisation of transport along the route may prevent parents from allowing their children to walk or cycle independently. This includes, e.g., high traffic levels, high speed levels, wide streets, a lack of pavements or cycle paths, the need to cross intersections and, more generally, stress resulting from motorised traffic (Björklid and Gummesson, 2013, for Sweden; see for mode choice studies Stone et al., 2014; Buliung et al., 2017 (all in Canada); Zhang et al., 2017 (China)). Conversely, factors such as pavements, connected cycling networks, traffic calming measures, good road connectivity, the existence of shortcuts and general walkability have been reported to positively affect walking and/or cycling (Villanueva et al., 2013 (Perth, Australia); Stone et al., 2014; Guliani et al., 2015 (all from Canada); Kamargianni et al., 2015 (Cyprus); most papers study mode choice). The effects of the transport environment are not always intuitive. For example, Björklid and Gummesson (2013) found in a Swedish neighbourhood characterised by segregated traffic that children's mobility licences were very limited while still most children walked to school.

It is often difficult to draw consistent conclusions from the multitude of attributes and associated effects of the road network. For instance, Guliani et al. (2015) find that the need to cross major roads increases the likelihood that a child walks. This sounds counterintuitive but, as the authors suggest, the presence of major intersections reflects good connectivity in the road network which may in turn increase active and independent travel (see discussion in Stone et al., 2014).

The built environment. More general measures of urbanity, such as population density, land-use diversity or city population size may encourage active and independent travel (Drianda and Kinoshita, 2011 (Japan); Hsu and Saphores, 2014; He and Giuliano, 2017 (both from California); Loebach and Gilliland, 2016 (Canada); see for mode choice Curtis et al., 2015; Waygood and Susilo, 2015). Urbanity may, however, be associated with parental traffic-safety and security concerns (Lopes et al., 2014). This may explain why other studies find a negative relationship between urbanisation and CIM (Kyttä, 2004) or land-use mix and CIM (Sharmin and Kamruzzaman, 2017, in a meta-analysis). Taken overall, results on the role of the built environment are varied and not fully consistent (see Kyttä et al., 2015; Sharmeen and Kamruzzaman, 2017, for discussion).

The social environment. Neighbourhood social capital, social trust or a sense of community may motivate parents to not drive their children on short trips (Alparone and Pacilli, 2012; Carver et al., 2013b; Carver et al., 2014; Lopes et al., 2014; Kyttä et al., 2015). Children have been found to be more likely to walk to school in neighbourhoods where other people walk (Mitra and Buliung, 2012). Social pressure by peers has also been found to affect adolescents' willingness to cycle to school (Frater et al., 2017).

Viewed overall, the literature provides a rich set of factors that potentially affect CIM. These may intersect in various ways. Hence, it does not come as a surprise that there are inconsistencies between various studies in terms of findings, and between findings and their interpretation. This seems to be particularly – although not exclusively – pertinent for the role of attitudinal and environmental variables. Arguably, there can hardly be a single study that integrates all potentially relevant variables and their interactions in a comprehensive way. For Germany, this is the first study that simultaneously models associations between CIM on the school trip and a large number of variables that reflect all the dimensions discussed above.

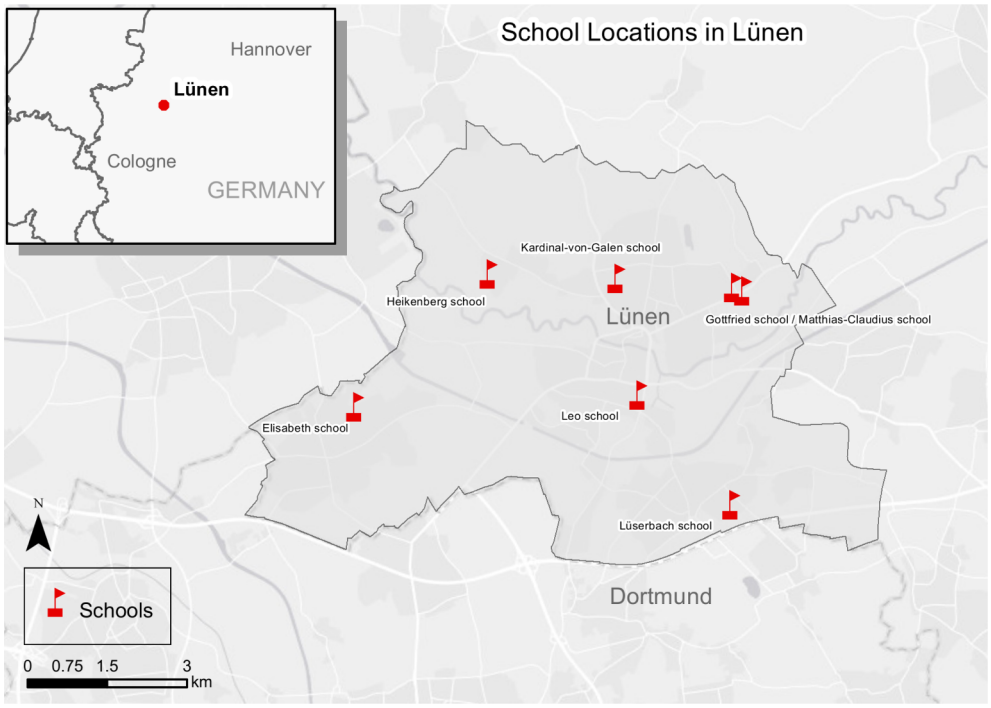

Fig. 1. Locations of the surveyed schools in Lünen.
Source: authors' concept.

3. Data and method

3.1. Survey and study site

The data used for this paper were collected in January 2017 in a questionnaire survey. Parents of children in seven primary schools (years 1–4, age 6–10, out of a total of 14 primary schools) in Lünen, North Rhine-Westphalia, were asked to complete a questionnaire that was distributed via teachers in the classrooms and collected a week later (with a second round of collection two weeks later to account for late responses). All children in the seven schools (n = 1763) received a questionnaire. Separated parents were informed that the questionnaire should be completed by the parent where the child spends most of his/her time on schooldays. A response rate of 60.3% resulted in n = 1064 completed questionnaires. This unusually large response rate testifies to the strong motivation of schools and parents to support school travel studies.

The schools were not sampled randomly. Rather an attempt was made to invite all 14 schools to participate, but some declined. This was based on the principals' reasoning that questionnaires in various languages would be needed in their schools due to high levels of immigrant children. Hence, our sample is ethnically biased, but still includes 13% of parents with non-German nationality. This well reflects the share of immigrant children (15%) in the sampled schools as taken from municipal school statistics (unpublished), but is considerably lower than the corresponding share for all primary schools in Lünen (29%).

Lünen is a medium-sized town located at the border between the metropolitan Ruhr area and the more rural Münsterland. It has a distinct suburban character, and it can be considered a typical representation of mid-to-late 20th century developments in low-to-middle-class regions.

The school locations are shown in Fig. 1. The Kardinal-von-Galen school is close to the town centre. It has the highest share of walking, while other modes are below average. This corresponds with short trips to school, i.e. a small catchment area.

The catholic Leo school is positioned south of the town centre. It is known to be attractive for some German-born parents, reflected in the long distances travelled to school. The school has a strikingly low share of immigrant students. Only 2% of the students do not speak German at home, as compared to 15% for all schools taken together (values for 2016/17 provided by the city of Lünen, unpublished). The Leo school is located very close to an overly wide main road with heavy traffic load, which is reflected in low subjective safety, and strong car use in school trips.

The Lüserbach school, located at the southern border of town also shows a high share of car use, but still a strong share of walking children. This may be a reflection of long mean distances travelled to school, while the distance median is low. This implies that many students live in proximity to the school, while others travel long distances.

The Elisabeth school students also travel short distances on average. Virtually all students live in Brambauer, the neighbourhood that hosts the school. As the school is located at the periphery of the neighbourhood, the share of cycling is above average.

The Gottfried school and Matthias-Claudius school show high shares of bus use and, in the case of the Gottfried school, cycling.

Both schools are located side by side in a comparatively affluent residential area at the edge of town. Distances travelled are longer in the Matthias-Claudius school than in the Gottfried school, which explains the strong use of the bus, while the remote location also helps explain the high shares of cycling and bus use in the Gottfried school.

The Heikenberg school is again located at the edge of town, but in the north-west. In terms of mode use it comes closest to the average of all schools, although trip distances are somewhat higher than average.

The weather at the time of survey was cool, but sunny and dry (no snow), with daytime temperatures slightly exceeding freezing point. The following information was collected:

- the child's trip to and from school: usual mode and company in the week prior to the survey and in summertime (separate for outward and return trip), reasons for escort, distance to school
- child sociodemographics: age, gender, school year
- household sociodemographics: household type, age of other children in the household, household income, the respondent's and his/her partner's age, gender, nationality, education level (school and job training), employment situation
- travel behaviour of the responding parent and her/his partner: driving license possession, number of cars, travel mode to work (or education, if applicable)
- the responding parent's attitudes and concerns about safety, security, the social environment, and the transport environment on the route to school
- the responding parent's attitudes about gender role worksharing in the household (four items)
- the household residential address.

Privacy considerations led to a questionnaire instruction explicitly stating that information on the home address and household income was not mandatory (though this is a matter of course). We received full information for regression modelling in 605 cases (morning trip) and 594 cases (afternoon trip), with 477 respondents omitting the income question, and 385 respondents omitting their address. The net sample of roughly n = 600 still reflects a good response rate of 35% of the gross (n = 1763).

3.2. The transport and built environment

The survey data were matched with detailed geoinformation that was extracted from digital sources and collected on site in August 2017. Route information was collected for the shortest walking route including paths and tracks suitable only for non-motorised transport. These formal or informal shortcuts were detected manually on site.

The geodata used includes information on speed limits, the classification of roads, pavement designs, pedestrian crossing facilities, parking regulations, right-of-way regulations at intersections, land-use, and traffic safety along the route. The survey of parking regulations was limited to intersections where it is most likely that parked vehicles restrict the view for crossing pedestrians. Information on traffic loads was not available, but it can be assumed that the classification of a road is strongly associated with traffic loads. Similarly, industry and trade areas taken from the on-site survey are associated with heavy traffic loads. View restrictions include various kinds of artifacts (plants, street furniture, vehicles etc.), and some of them are temporary. An attempt to reduce bias was made by surveying only on weekdays during working hours. Still, the variables may include arbitrary information.

This vast amount of information was used in two different ways. Most research in the field relies heavily on 'variable approaches', i.e. the effects of a number of separate variables on child travel are estimated simultaneously. As many geographical variables correlate with each other, this procedure may mask interactions between the variables, i.e. it does not provide a holistic picture of a route. On the other hand, working with 'holistic' variables that capture the 'entirety' of a route does not allow a detailed look at the effects of certain land-use or road attributes.

We therefore use a combined approach. We assume that three issues are particularly relevant for parental concern: the need to cross roads, the provision of sufficient pavements, and traffic safety. The latter is particularly significant in small or medium-sized towns where people may recall severe accidents including the places where they occurred. Therefore, we work with original measures here, while we reduce other built environment variables in a principal component analysis to account for the general character of the route.

3.2.1. Traffic safety

We use accident data covering the period 2008–2016 that distinguish victims by age group, mode and injury severity. We tested several measures and found that accident hot spots contribute to explain CIM better than the mere number of injuries along a route. This is especially true with respect to hot spots where pedestrian injuries (regardless of age) or, even more so, child injuries (pedestrian or cyclist) have occurred. These two types of hot spots are only moderately correlated. We merged both into one binary variable that captures whether or not the child needs to pass one or more of these types of hot spot. We define a 'hot spot' as a place where at least four pedestrians were injured or killed in the observation period, or at least three children were injured or killed as pedestrians or cyclists. These thresholds result in 16 and 15 hot spots, respectively, and 26 hot spots overall (as five sites belong to both types). All hot spots are intersections. The operational definition includes a radius of 30 m around the centre of the intersection.

3.2.2. Road crossings and pavement width

Data on road infrastructure along the route does not necessarily refer to the exact route a child actually takes. For instance, there may be a convenient pavement on one side of the road, but not on the other. However, the child may need to cross the road two

Table 1
Built environment. Principal component analysis results.

	General residential area 1	Centre area 2	Industry and trade area 3	Major road with restrict-ed view 4	Woodland 5	Play street 6	Traffic calming 7	High speed road 8
Housing dominates (1, 3)	**0.88**	−0.02	0.07	0.05	−0.08	0.19	0.23	−0.07
Kerb-side parking (2)	**0.83**	0.29	0.01	0.15	0.04	0.15	0.21	−0.08
Speed limit 30 km/h (1)	**0.78**	−0.14	0.19	0.24	0.16	0.26	0.16	−0.12
Parking on pavement (2)	**0.76**	0.29	0.03	−0.11	0.04	−0.05	−0.11	0.04
Well-lit (1)	**0.71**	0.28	0.14	0.10	0.23	0.21	0.45	0.16
Cross parking (2)	**0.69**	−0.01	−0.02	0.10	0.08	−0.20	0.00	0.08
Right of way reg.: Yield sign (2)	**0.66**	0.44	0.15	−0.16	0.00	0.17	0.24	0.23
Shopping (minor) (1, 3)	**0.66**	0.14	0.31	−0.02	−0.14	−0.08	0.19	0.36
Parking on carriageway (2)	**0.65**	−0.05	0.11	0.36	0.02	0.17	−0.22	−0.01
Right of way reg.: Priority to the right (2)	**0.64**	−0.22	−0.05	0.40	0.12	0.11	0.37	−0.10
Pavement width < 1.5 m, side 1 (1)	**0.64**	−0.04	0.04	0.34	0.01	0.03	−0.35	−0.17
Shopping dominates (1, 3)	0.01	**0.86**	0.05	0.08	0.02	0.01	−0.01	0.04
Angle parking (2)	0.10	**0.80**	−0.09	0.33	−0.01	0.04	0.02	−0.11
Right of way reg.: Light signal (2)	0.26	**0.72**	0.05	0.05	0.16	−0.04	−0.10	0.39
Route crosses industrial area (1)	0.05	0.00	**0.80**	0.07	0.31	0.02	−0.06	−0.18
Route crosses trade/retail area (1)	0.08	−0.04	**0.71**	0.17	−0.07	0.02	−0.02	0.26
Trade and industry dominates (1, 3)	−0.01	0.11	**0.68**	−0.01	0.12	−0.06	0.13	−0.31
Trade and industry (minor) (1, 3)	0.36	0.00	**0.62**	0.01	0.05	0.15	0.11	0.24
View restrictions (number)	0.13	0.31	0.15	**0.86**	−0.07	0.19	0.01	0.06
Major road (1)	0.13	0.31	0.15	**0.86**	−0.07	0.19	0.01	0.06
Pavement width < 1.5m, side 2 (1)	0.31	−0.09	−0.02	**0.65**	0.27	−0.30	0.02	−0.07
Woodland dominates (1, 3)	0.00	0.10	0.00	−0.08	**0.84**	0.02	0.08	0.05
Track separate from road (1)	0.08	0.00	0.18	0.08	**0.72**	0.45	0.06	0.09
Route crosses woodland (1)	0.03	−0.03	0.54	0.09	**0.67**	0.08	−0.04	0.13
Green area dominates (1, 3)	0.18	0.09	0.19	0.06	**0.61**	0.48	0.28	0.28
No pavement, side 2 (1)	0.09	−0.12	−0.07	0.07	0.11	**0.82**	0.00	0.09
Speed limit 10 km/h (1)	0.06	0.17	0.05	0.05	0.14	**0.76**	−0.02	−0.06
No pavement, side 1 (1)	0.35	−0.10	0.28	0.15	0.31	**0.45**	0.37	0.10
No parking (2)	0.32	0.02	−0.07	−0.04	0.20	0.23	**0.81**	0.14
Right of way reg.: roundabout (2)	0.02	−0.05	0.10	0.02	0.00	−0.12	**0.77**	−0.13
Speed limit > 50 km/h (1)	−0.06	0.12	−0.01	0.02	0.25	0.07	−0.02	**0.79**
R^2	75.1							

(1) Measured in metres along the route.
(2) Number of intersections along the route where this is the case.
(3) Land-use functions were manually surveyed in addition to using the local land-use plan, as a manual inspection provides more detail. A distinction was made between dominant and minor (additional) land uses in a road section linking two junctions. The dominant or minor character was rated by trained student staff and confirmed by a second person.
The strongest loading of a variable on any factor is shown in bold.

additional times to use the convenient pavement.

We manually reconstructed the best route based on local knowledge and plausibility considerations. We extracted width of pavement (none, < 1 m, 1–1.5 m, > 1.5 m) and number of road crossings required by type (light signal, zebra crossing, pedestrian refuge island, kerb extension ('bulb-out'), no facility (which mainly refers to low-speed residential roads)). Two variables exhibited significant effects in bivariate regression: the number of zebra crossings that need to be crossed and the length of road sections with narrow pavements (< 1 m). These two variables are used for analysis. We tentatively tested binary representations of the variables but these exhibited clearly less effect on CIM. Interestingly, the length of road sections with no pavement did not show any effect, probably because these mainly refer to tracks at a distance from roads.

3.2.3. Other built environment variables

A total of 31 variables (excluding those discussed above) were inspected with regard to bivariate correlations. Strong correlations led to the decision to reduce the variables using principal component analysis with Varimax rotation. Using Eigenvalues > 1 as thresholds resulted in eight dimensions explaining 75.1% of the variance of the initial variables (Table 1). This procedure has been

used before in related research (Broberg et al., 2013) and validated by Helbich (2017) who finds that the use of principal components results in a better explanation of variance in child mode choice than individual variables or composite measures. A stepwise modelling process was separately conducted for the morning and afternoon trip. Various factors were excluded and re-included, resulting in four out of eight factors that exhibited significant effects on CIM in the morning trip model, but none in the return trip model.

Two factors (Table 1) may require some explanation. The term 'general residential area' (Factor 1) is taken from German land-use planning. It refers to a residential area with some limited non-residential use, such as retail, services and businesses, but not industrial use. Such areas may be located either close to a city centre or – as in our case – in more remote, former villages that have become part of an urban area. Given their historical growth, they are often characterised by irregular parking and sub-standard pedestrian and cycling facilities that fail to meet today's planning standards. 'Traffic calming' (Factor 7) may not seem to be an intuitive name for a factor characterised by roundabouts and 'no parking'. The reason for the naming is that the older parts of Lünen are characterised by heavy, often illegal, kerb-side parking as there was no dedicated parking provision in the earlier 20th century. More recent residential developments typically have dedicated off-street, but no kerb-side parking, while the neighbourhood road network is characterised by small roundabouts and traffic calming.

Correlations between various built environment variables may result in multicollinearity and, thus, biased estimations (Stone et al., 2014). We checked all variables for bivariate correlations. We found notable correlations ($|r| > 0.3$) between the following: general residential area and accident hot spot ($r = 0.38$); traffic calming and zebra crossings ($r = 0.66$); zebra crossings and accident hot spot ($r = 0.31$); and diffuse fear and strong protective attitude ($r = 0.46$; see below for variables). We tentatively excluded one of two correlated variables from our models. This resulted in somewhat reduced effects for the remaining variable, respectively, but all effects remained significant and in the same direction. Hence, we do not feel that multicollinearity is a strong issue here. Table 3 gives an overview of the variables finally used in the models.

3.3. Parental concerns, attitudes and perceptions

We also used principal component analysis with Varimax rotation (Eigenvalue > 1) to reduce the 20 items that captured the respondents' attitudes and concerns. This resulted in eight attitudinal dimensions explaining 61.5% of the initial variables' variance (Table 2). This procedure has also been used before in related studies (Guliani et al., 2015). As there is complete attitudinal information in only 851 cases, we use the factors to group variables into mean value scales, as indicated by the horizontal lines in Table 2 that show when at least two valid answers are available for any scale. Three items were excluded to achieve higher scale validity. Cronbach's alpha ranges between 0.60 and 0.86 for all scales but the last ('child is competent'), which has a Cronbach alpha value of only 0.31. After some discussion of this issue we decided to use the scale anyway for theoretical reasons, as it may be expected to exhibit an important effect on CIM (e.g., Villanueva et al., 2013). Four scales show significant effects on the morning trip, and seven in the afternoon model. These are thus retained in the models, respectively.

3.4. Sociodemographics

We tested a variety of sociodemographic variables. The following turned out insignificant in various modelling stages and were excluded from the final models: child gender, parental education level (either separately or for both parents combined), household income and equivalent income, father's and mother's age (the latter was consistently significant in mode choice analysis based on the same data), household car ownership, parental car use to work (either separately or combined). As income has been found to be significant in much previous research we tentatively included it again in the final models, which are more parsimonious than the initial ones, but it was still far from being significant ($p = 0.30$ and $p = 0.32$ for the morning and afternoon model with $n = 399$ and $n = 325$). Hence, we finally excluded income.

We tested some variations of sibling age (having an older sibling, having a younger sibling). Having a sibling of primary school age exhibited the strongest effect and was thus included in the models.

Parental employment, measured either separately for the mother and father or in terms of combinations on the couple level, was insignificant for the morning trip. The same is true for household type (traditional family, single parent, other). For the return trip, however, the parents' employment situation is a significant factor. The strongest effect was achieved by using a variable reflecting the combination of employment situations in a couple. Such a combined variable representing gendered arrangements of employment in couples has rarely been used in previous, related studies (see Yoon et al., 2011; Scheiner, 2016, for exceptions). As not all households are couples, this needs to be complemented by a variable capturing single parents. We make no further distinction for the latter due to the limited group size.

3.5. Trip distance

Trip distance may not be associated with CIM in a linear fashion. Hence, we tested trip distance as a quadratic function. The quadratic term was not significant, and the increase in Pseudo-R^2 was only 0.1%. Hence we include distance as a linear function.

3.6. Independent travel

CIM was recorded by inquiring about regularly accompanying persons, separate for the morning and return trip. There was no distinct definition of the timeframe that this question refers to, but it was placed immediately after asking about the usual travel mode

Table 2
Parental attitudes and concerns. Principal component analysis results.

	Trust in other road users 1	Neighbourhood social capital 2	Diffuse fear 3	Stranger danger 4	Pavements and lighting in good condition 5	Major roads and cars 6	Strong protective attitude 7	Child is competent 8
Other road users give priority to my child at a pedestrian crossing	**0.83**	0.02	−0.02	−0.07	0.08	0.00	0.04	0.09
Drivers are careful when they drive close to my child	**0.81**	0.07	−0.11	0.01	0.08	−0.10	0.04	−0.02
Cyclists watch out for my child	**0.80**	0.10	0.04	−0.08	0.08	0.00	0.05	0.03
I trust that drivers see my child	**0.73**	0.01	0.03	0.02	0.04	−0.04	−0.04	0.03
Most neighbours know me	0.06	**0.92**	0.00	0.01	0.03	−0.01	−0.02	0.05
I know most of my neighbours	0.09	**0.90**	0.00	0.01	0.03	−0.01	−0.02	0.11
In our neighbourhood we care for our neighbours' children	0.07	**0.79**	0.01	0.05	0.00	0.05	−0.09	0.03
I feel uncomfortable when my child walks along dark paths	−0.04	−0.03	**0.79**	0.18	0.01	0.10	−0.03	−0.08
My child should be accompanied by an adult in the dark	−0.03	0.04	**0.75**	0.09	0.00	0.09	0.14	−0.13
I feel safer when my child plays close to our residence when (s)he is outside	−0.03	0.03	**0.64**	0.12	−0.03	−0.03	0.24	−0.04
I feel uncomfortable when my child walks on narrow pavements	−0.04	−0.03	**0.54**	0.21	−0.14	0.06	0.38	0.02
My child is accompanied more often in winter than in summer	*0.12*	*−0.05*	***0.41***	*0.03*	*−0.16*	*−0.02*	*−0.03*	*0.34*
My child could be bullied by adolescents or other children	−0.03	0.01	0.18	**0.87**	−0.03	0.03	0.11	0.04
My child could be harassed or hurt by adolescents or other children	−0.02	0.03	0.06	**0.82**	−0.02	0.00	0.19	−0.03
My child could be harassed by adults	−0.06	0.01	0.28	**0.76**	0.03	0.05	0.02	−0.07
The street lighting on the route to school is sufficient	0.11	0.03	−0.06	−0.01	**0.83**	0.03	0.01	0.03
The pavements on the route to school are wide and in good condition	0.16	0.06	0.03	0.00	**0.80**	0.02	0.04	0.00
Walking and cycling paths on the route to school are dark and lonesome	*0.07*	*0.02*	*0.09*	*−0.02*	***−0.54***	*0.11*	*0.37*	*−0.03*
I consider the route to school safe	*0.28*	*0.01*	*−0.21*	*−0.09*	***0.49***	*−0.37*	*0.08*	*0.29*

(*continued on next page*)

Table 2 (*continued*)

	Trust in other road users 1	Neighbourhood social capital 2	Diffuse fear 3	Stranger danger 4	Pavements and lighting in good condition 5	Major roads and cars 6	Strong protective attitude 7	Child is competent 8
There are roads with high traffic levels on the route to school	−0.14	0.06	0.05	0.01	−0.02	**0.79**	−0.01	−0.08
Roads with high traffic levels on the route to school have light signals	0.15	−0.11	0.07	−0.01	0.15	**0.69**	0.03	0.14
Cars on the route to school are parked in dense lines	−0.11	0.07	0.02	0.07	−0.20	**0.67**	0.07	0.07
I do not want my child to go anywhere without an adult	0.06	−0.06	0.32	0.08	0.03	0.05	**0.71**	−0.13
I want to know exactly what my child is doing at any time	0.02	−0.02	0.24	0.25	−0.02	0.02	**0.66**	0.22
My child is careless in road traffic*	0.03	−0.11	−0.07	0.09	−0.08	−0.01	**0.53**	−0.46
My child is used to getting around in an urban environment	0.12	0.00	−0.15	0.06	0.03	0.09	−0.07	**0.63**
My child knows how to behave with strangers	−0.07	0.35	−0.03	−0.13	0.12	0.01	0.11	**0.56**
R^2	61.5							

The strongest loading of a variable on any factor is shown in bold. The lines indicate which items were grouped into scales.
Items shown in italics were not used for scales.

* Inverted for mean scale. This item has a slightly stronger loading on factor 7, but was used for the 'child is competent' scale for logical reasons.

Table 3
Variables used in regression: descriptive statistics.

	Min	Max	Mean/percent	Standard deviation
Morning trip escorted by adult	0	1	70%	0.46
Return trip escorted by adult	0	1	65%	0.48
Child age	6	11	7.87	1.28
Primary school age sibling	0	1	28%	0.45
Employment combination of parents				
Father: full-time, mother part-time (ref.)			41%	
Father: full-time, mother: full-time	0	1	10%	0.29
Father: full-time, mother: side job or not employed	0	1	26%	0.44
Father not full-time, mother: full-time	0	1	2%	0.13
Father not full-time, mother: not full-time	0	1	8%	0.28
Single parent	0	1	13%	0.33
Trip distance (km)	0.01	11	1.69	1.40
Built and transport environment				
General residential area	−2.0	3.6	0.00	1.00
Traffic calming	−1.5	5.4	0.01	1.00
Industry and trade	−1.4	6.0	−0.03	0.61
High-speed road	−2.9	6.9	0.01	1.00
Narrow pavement (< 1 m) along the route to school (km)	0	9.8	0.84	1.55
Zebra-crossings that need to be crossed (number)	0	4	0.57	0.88
Accident hot spot (pedestrians or children)	0	1	55%	0.50
Attitudes, concerns, perceptions				
Trust in other road users	1	5	2.36	0.87
Neighbourhood trust (social capital)	1	5	3.70	0.96
Diffuse fear	1	5	3.93	0.82
Stranger danger	1	5	3.09	0.95
Major roads and cars	1	5	3.70	0.98
Strong protective attitude	1	5	2.92	1.04
Child is competent	1	5	3.73	0.70
n (morning/return)	605/594			

All binary variables are coded as yes = 1, no = 0.

in the week prior to the survey. Hence, the respondents should have understood that the question referred to the present situation. We separately model the morning and afternoon trips, as is frequently the case in related studies (see discussion in Buliung et al., 2017).

In case of multiple answers we coded the answers father, mother, their partner (in case of separated parents), and other adult person as non-independent travel, even though this may include cases where travelling alone or with siblings or friends were also recorded. We estimated two more models (for the morning and afternoon trips) in which we used travelling alone (yes/no) as the outcome variable in order to check the stability of results. As expected, all coefficients changed signs in these models, but some effects were no longer significant. This should be mostly due to fewer 'yes' cases (129 on the morning trip, 179 in the afternoon, compared to 422 and 388 in the models presented here, respectively).

3.7. Analysis method

Various methods are used to study CIM, including standard percentage and mean value comparisons, binary logistic regression (Carver et al., 2013a; Buliung et al., 2017), multinomial logit regression (see He and Giuliano, 2017, for joint mode and escort modelling; Ermagun and Samimi, 2016, for a comparison of multinomial logit and nested logit models), and structural equation modelling (Kyttä, 2004; Alparone and Pacilli, 2012).

After presenting some bivariate analysis, this paper also uses binary logistic regression. Perceptions and attitudes towards the transport environment may be endogeneous to sociodemographics and especially the objective environment itself. This may lead to biased coefficient estimations. Hence, we follow Stone et al. (2014) and employ hierarchical regression, in which we enter socio-demographics and built environment variables in the first stage, while allowing attitudinal variables to enter only in the second stage. We check the estimations for stability.

4. Results

4.1. Descriptives

A descriptive analysis of escort categorised by age is shown in Table 4. The data include multiple answers. They show the percentage of respondents who ticked an answer box. About two-thirds of students are escorted by an adult at least sometimes. The most frequent escort person is the mother. About one in four students are escorted by their father at least sometimes. Just over 20% of

Table 4
Escort for the morning and afternoon trips by age of child.

	Morning trip – age						Afternoon trip – age					
	5–6	7	8	9	10–11	All	5–6	7	8	9	10–11	All
Adults	81.9	76.3	67.5	62.9	60.3	69.9	83.7	78.7	64.5	51.1	56.6	66.8
Siblings, friends	27.5	28.4	34.1	37.1	37.3	32.8	20.3	24.9	31.5	37.1	36.1	30.0
Alone	8.8	15.6	20.6	25.0	42.1	21.2	11.8	21.3	33.9	38.8	45.9	30.0
Father	38.1	35.0	30.6	17.7	21.4	28.7	36.6	34.4	24.2	16.5	13.9	25.6
Mother	72.5	66.5	54.0	52.0	45.2	58.4	79.1	73.1	56.0	45.1	49.2	60.4
n	160	257	252	248	126	1043	153	253	248	237	122	1013

All figures are based on respondents. Due to multiple responses the percentages do not sum up to 100.

students go to school alone at least on some days, but considerably more (30%) do so on the homebound trip. Gender differences in being escorted are minor and thus not shown in a table. The share of adult escort among girls is 2% and 3% higher in the morning and afternoon, respectively (not significant).

It appears from these figures that fathers are involved in escorting to a considerable extent, though less than mothers. The picture is different, however, when looking at combinations of escorting persons (Table 5). Mothers take over child escort alone in a significant number of cases (36% in the morning). Fathers, in contrast, are hardly mentioned as the sole escort person, but typically appear in combination with the mother, i.e. they escort their child on some days, but not necessarily regularly. If they do so, they tend to do it in the morning (6%), but even less often (3%) in the afternoon (as shown by previous research, Scheiner, 2016).

As expected, there are strong age differences (Table 4). The numbers of those making the school trip alone strongly increases with age. The increase is particularly strong only between the age of nine and ten for the morning trip, but at an earlier age for the afternoon trip. Trips joined by siblings or friends also increase with age, while the share of escorting adults decreases.

A look at the reasons for child escort (Table 6) reveals that danger from traffic and fear of harassment are most frequently stated. It is interesting to see that fear of harassment overwhelmingly refers to adults ('stranger danger') but considerably less so to other children although prevalence rates taken from surveys among adolescents suggest that offenders in school violence and bullying are primarily other adolescents (Baier et al., 2009, 57). This mirrors findings from Sweden (Björklid and Gummesson, 2013, 59).

Other frequent reasons are that the trip can be easily coupled with the work trip, the distance is too long, or the child is too young for independent travel. Feeling that the child is too young is closely associated with fear of traffic danger (Cramérs $V = 0.30$, $p < 0.001$). Interestingly, however, feeling that the child is too young is mainly associated with children younger than eight years. In contrast, traffic danger remains a strong reason in all child age categories, although it also declines with age. Parents' fear of harassment or offence – whether from adults or other children – hardly declines with the child's age at all. Hence, parental fears are strong factors for child escort throughout the primary school years.

There is little difference in reasons for escort between boys and girls, with one exception. Fear of harassment from adults is considerably more prevalent among parents of girls (52%) than parents of boys, although the latter still appear to have a high level of fear (39%).

4.2. Regression models

We start by presenting the morning trip model (Table 7), followed by the afternoon trip model (Table 8). Where a directed hypothesis on effects is intuitive, we employ one-tailed tests of significance. This is true for all variables but two (see table).

As expected, the odds of adult escort decrease with child age. Escort may also be reduced for children who have siblings of primary-school age (just significant). All other sociodemographic variables turned out insignificant, as noted above. A longer trip distance increases the odds of adult escort.

Four general factors describing the built environment along the route significantly affect CIM. Firstly, routes along 'general residential areas' are associated with lower odds of being escorted. We conducted a two-tailed test here as we had no clear expectation concerning the direction of effect. The lower likelihood of being escorted may be due to some schools that are located in central areas

Table 5
Percent of students being escorted on the morning and afternoon trips including combinations of both parents.

	Morning trip	Afternoon trip
Mother, but not father*	35.7	38.0
Father, but not mother*	6.4	3.3
Mother and father*	22.7	22.7
Other persons or alone	35.2	36.0
n	1063	1030

* May include cases with other escort persons or making the trip alone.

Table 6
Reasons for escort by child age and gender.

	Child age					Child gender		Total
	5–6	7	8	9	10–11	Boy	Girl	
Child not yet old enough, cannot yet make the trip alone	52.1	36.4	18.8	6.6	10.7	27.0	24.8	25.8
Distance too long	29.9	31.1	28.1	22.5	26.2	28.0	27.6	27.7
Darkness	2.1	3.5	2.6	6.6	0.0	4.1	2.6	3.4
Traffic danger	52.8	48.2	42.7	37.4	27.4	43.1	43.8	43.4
No (adequate) public transport connection	1.4	1.8	1.0	1.1	0.0	0.7	1.7	1.2
Transport of heavy belongings (schoolbag, musical instrument, sports gear)	0.0	1.8	1.6	0.0	0.0	0.7	1.0	0.8
Fear of harassment (from adults)	49.3	46.1	41.1	46.7	46.4	39.0	51.9	45.5
Fear of harassment (from other children)	19.4	15.8	19.3	12.6	16.7	15.6	17.1	16.4
Coupling with work trip (morning)	26.4	28.5	29.2	34.1	34.5	32.5	27.6	30.0
Coupling with work trip (afternoon)	17.4	26.3	22.4	22.0	21.4	23.2	21.7	22.4
Coupling with other activities (mostly other child escort)	9.0	12.7	12.0	15.4	17.9	12.4	13.6	13.0
Friends or siblings have same route	2.8	0.9	1.6	2.2	1.2	1.9	1.4	1.7
Child wants to be escorted	0.7	3.1	1.6	1.6	1.2	1.9	1.7	1.8
I just want it, have time with my child, am afraid	0.7	0.4	0.5	0.5	3.6	1.0	0.7	0.8
Other reason	0.7	2.2	2.6	2.7	2.4	2.2	2.1	2.1
n (respondents)	144	228	192	182	84	418	420	841

All figures are based on respondents. Due to multiple responses the percentages do not sum up to 100.

Table 7
Binary logit regression of adult escort: morning trip.

	Stage 1			Stage 2		
	B	Exp(B)	Sig.	B	Exp(B)	Sig.
Constant	1.87	6.48	0.00*	−0.26	0.77	0.81*
Child age	−0.30	0.74	0.00	−0.24	0.78	0.00
Primary-school-age sibling	−0.36	0.70	0.04	−0.35	0.70	0.05
Trip distance (km)	0.44	1.56	0.00	0.44	1.55	0.00
Environment (factors)						
General residential area	−0.32	0.73	0.02*	−0.33	0.72	0.02*
Traffic calming	−0.50	0.61	0.00	−0.55	0.58	0.00
Industry and trade	0.54	1.71	0.01	0.49	1.63	0.00
High-speed road	0.25	1.29	0.02	0.22	1.25	0.04
Narrow pavement (< 1 m, length)	0.33	1.39	0.00	0.31	1.37	0.00
Zebra crossings (number)	0.51	1.67	0.00	0.61	1.84	0.00
Accident hot spot (pedestrians or children)	0.69	1.99	0.00	0.73	2.08	0.00
Attitudes, concerns						
Trust in other transport users				−0.22	0.81	0.04
Diffuse fear				0.56	1.76	0.00
Strong protective attitude				0.24	1.27	0.02
Child is competent				−0.19	0.83	0.11
Pseudo R^2 Cox & Snell	0.162			0.226		
Pseudo R^2 Nagelkerke	0.229			0.320		
−2LL	634.66			586.86		
n	605			605		

All binary variables are coded as yes = 1, no = 0. Reference is no adult escort.
* Significance tests two-tailed, otherwise all tests one-tailed.

scoring high on this factor (e.g., Kardinal-von-Galen school), whereas other schools that score low are situated in more remote locations (Elisabeth school) or at problematic locations (Leo school is close to an overly wide main road with heavy traffic load, which is reflected in a low level of subjective safety).

Secondly, traffic calming is associated with lower odds of escort and, hence, higher levels of CIM. Thirdly, routes in areas characterised by industrial land uses are associated with higher odds of escort. This may be due to heavy traffic being prevalent in and around these areas (e.g., Leo school). Fourthly, routes along high-speed roads are associated with higher odds of escort.

Route length along roads with narrow pavements, the number of zebra crossings that need to be crossed, and having to pass a child-accident or pedestrian-accident hot spot are associated with higher odds of being escorted.

Table 8
Binary logit regression of adult escort: afternoon trip.

	Stage 1			Stage 2		
	B	Exp(B)	Sig.	B	Exp(B)	Sig.
Constant	3.43	30.90	0.00*	1.58	4.84	0.14
Child age	−0.44	0.65	0.00	−0.40	0.67	0.00
Primary-school-age sibling	−0.74	0.48	0.00	−0.72	0.49	0.00
Employment combination (ref. father full-time, mother part-time)						
Father full-time, mother full-time	−0.77	0.46	0.01	−1.05	0.35	0.00
Father full-time, mother side job or not employed	−0.46	0.63	0.05*	−0.55	0.58	0.03*
Father not full-time, mother full-time	−0.38	0.68	0.30	−0.91	0.40	0.14
Father not full-time, mother not full-time	−0.09	0.91	0.80*	−0.30	0.74	0.46*
Single parent	0.09	1.09	0.38	−0.09	0.91	0.39
Trip distance (km)	0.45	1.57	0.00	0.46	1.59	0.00
Narrow pavement (< 1 m, length)	0.22	1.25	0.00	0.23	1.26	0.00
Accident hot spot (pedestrians or children)	0.50	1.64	0.01	0.49	1.64	0.01
Attitudes, concerns						
Trust in other transport users				−0.44	0.64	0.00
Neighbourhood social capital				0.18	1.20	0.06
Diffuse fear				0.52	1.68	0.00
Fear of harassment or bullying				−0.24	0.79	0.03
Dense motor traffic and densely parked cars				0.19	1.21	0.04
Strong protective attitude				0.39	1.47	0.00
Child is competent				−0.28	0.76	0.04
Pseudo R^2 (Cox & Snell)	0.178			0.261		
Pseudo R^2 (Nagelkerke)	0.245			0.360		
−2LL	650.51			587.34		
n	594			594		

All binary variables are coded as yes = 1, no = 0. Reference is no adult escort.
* Significance test two-tailed, otherwise all tests one-tailed.

Entering attitudes as a second block of variables in the model results in a considerable increase in explained variance (Nagelkerke's Pseudo R2 increases from 0.229 to 0.320), while it does not strongly alter the effects of other variables. Trust in other transport users decreases the odds of escort. On the other hand, diffuse fear and a strong feeling that the child needs protection increase the odds of escort. Considering the child to be competent was retained in the model as it was significant at an earlier modelling stage, but turns out insignificant in the final version.

The factors found to affect CIM on the afternoon trip (Table 8) strongly differ from the morning trip in various respects. We begin with the parental employment combination. Both parents being in full-time employment reduces the odds of picking up a child after school, compared to the 'standard case' of a full-time working father but part-time working mother. It may be expected that this is due to more severe time constraints among couples with dual full-time employment. For households with a full-time employed mother but no full-time working father we expected the same, even though this does not have to do with time constraints but with different fathering practices that may involve more independence for the child (Barker, 2011). The effect, however, is not significant, possibly due to the very few cases in this category.

We had no clear hypothesis about households where the father works full-time and the mother is not employed or only has a side job. One may argue that these mothers have more time to pick up their child than part-time working mothers, but on the other hand female part-time employment may be exactly the model that permits a mother to take her child home. As a result, having a mother with a side job or who is not employed reduces the odds of being escorted compared with a part-time working mother (both combined with a full-time employed father). While this is hardly related to issues of time budget, it may reflect the higher odds of escort in higher status households found in previous research, as fewer hours of work are typically associated with lower income.

From this reasoning, a similar effect could be expected in households where neither parent works full-time, but no significant effect is found here. Single parents also show no significant difference from the reference category, although one could expect lower levels of escort here (He and Giuliano, 2017).

It is worthwhile to note that the effect of having a sibling of primary-school age is stronger than in the morning model. The marginal probability (constant model) that an adult is stated as an escort person is 43.6% for children without siblings, but 35.2% for children with siblings in the morning. This is a reduction of 8.4 percentage points. The corresponding reduction on the afternoon trip is 12.8 percentage points. This may mean that parents seem to be more prepared to let their child walk or cycle when a sibling joins him or her on the afternoon trip than on the morning trip.

For the built environment, the most notable observation is the striking reduction of effects, compared to the morning trip. None of the built environment factors is significant, and neither is the number of zebra crossings a child needs to cross. The two remaining variables – narrow pavements and accident hot spots along the route – are strongly significant in the expected directions, but more

limited in magnitude than in the morning model. In the morning, narrow pavements increase the propensity of adult escort by 7.8 percentage points, and having to pass an accident hot spot even increases the likelihood of being escorted by 18.1 percentage points. The corresponding values for the afternoon trip are only 3.0 and 5.9 percentage points, respectively.

The effects of those attitudes that were included in the morning trip model are similar to that model. Considering the child to be competent significantly reduces the odds of escort here.

Three more attitudinal dimensions are included that were not part of the morning trip model. Firstly, dense motor traffic and densely parked cars increase the odds of escort, as expected. The other two effects point in an unexpected direction. From a statistical point of view they must thus be interpreted as non-significant, as one-tailed tests were performed. Still, they deserve a brief discussion.

Neighbourhood social capital only just fails to reach statistical significance in an unexpected direction, i.e. stronger social capital tends to be associated with more escort. This counters previous research (Alparone and Pacilli, 2012) as well as intuition. An explanation may be found in special local circumstances. The Lüserbach school may serve as an example. Respondents whose children attend this school show above-average social capital, and the school has a high share of escorting at the same time. The Lüserbach school has the second highest share of car use among the schools, while still having a strong share of walking children. Long mean distances travelled contribute to this finding, while the distance median is low. This implies that a large proportion of students live in close proximity to the school, while others travel long distances. The latter contributes to escorting due to distance, while children travelling very short distances may be escorted because the school is located at the end of a dead-end street where driving parents tend to make risky turnaround manoeuvres. Another explanation – that may well call for more research – may be that parents who report high levels of social capital enjoy the opportunity to interact with other parents when taking their children to school.

The second unexpected observation relates to fear of harassment or bullying. More fear is associated with lower odds of adult escort. This may be because parents who let their child go to school without adult escort may have more fear of harassment than those who take their child to school and back. More research is needed for clarification.

5. Summary and conclusions for policy and research

This paper reported one of the earliest multivariate studies of CIM – i.e. whether being escorted by an adult or not – on primary school trips in Germany. It used data collected in the mid-sized suburban town of Lünen. It is arguably the first paper from Germany that simultaneously looks at the full range of dimensions that may help understand CIM: (1) trip characteristics, (2) child characteristics, (3) the household context, (4) subjective concerns, attitudes and perceptions, (5) the transport environment, (6) the built environment and (7) the social environment. In contrast to the majority of studies in the field, an attempt was made to capture a holistic picture of the transport and land-use environment along the route, while at the same time some key attributes of the route were used as separate variables.

Some of the findings support previous research, such as that independence increases with child age, decreases with distance, or is higher when the child has a sibling of similar age or – especially for the homebound trip – when both parents are full-time employed. In contrast to previous studies, other child and household sociodemographic variables such as child gender, household income or parental education did not turn out to be significant. Interactions with parental travel, such as household car ownership or parental car use, were also not significant.

Perhaps the most notable novel contribution to research is the distinct differences that we found between outward and return trips. While such differences have been theoretically conjectured – and empirically demonstrated – before, it is the distinctiveness in our findings that make them special. This not only refers to parental employment, for which we used a relatively unusual interaction term between the two parents, but also to environmental and attitudinal variables.

Concerning the environment, the most notable observation is the striking reduction of effects in the return trip model, compared to the morning trip. While the morning trip was characterised by distinct impacts of the built and transport environment, most variables turned out insignificant in the afternoon model, and the remaining effects tended to lose in magnitude. Conversely, more attitudinal dimensions turned out significant in the return trip. The direction of effects was not obvious especially in the case of neighbourhood social capital and fear of harassment or bullying. Local circumstances may contribute to understanding the former, but – seen in a wider sense – high levels of social capital may be associated with the wish among parents to interact with other parents when taking their children to school. This interpretation raises an issue of causality (escorting children may strengthen neighbourhood capital). The effect of fear of harassment may also be due to causality issues (letting a child walk independently may increase fear of harassment). Otherwise, the attitudinal effects found were in line with expectations. Trust in other transport users and perceiving the child as competent increase CIM (the latter was only significant on the afternoon trip), while parents' diffuse fear, the perception of dense motor traffic and densely parked cars, and a strong protective attitude decrease CIM.

Recalling that the survey was in wintertime – though the weather was mostly dry and not extremely cold – the stronger role of the environment in the morning and of attitudes in the afternoon might reflect a more general point that may deserve further investigation. The objective built and transport environment may be more important for school travel decisions in cases where (or when) trip circumstances appear risky – in this case, in the dark morning hours. On the other hand, when time and place of the trip have a less challenging character, the details of the environment may not play such a major role. Instead, perceptions and attitudes may be more prevalent in travel decisions. This is of course not to say that our findings suggest that in the latter cases the environment plays no role at all. Routes along insufficient pavements and accident hot spots were found to be significant factors for escort decisions both on the morning and afternoon trips.

In the morning, other environment variables were also found to significantly affect CIM. Traffic calming and routes along 'general residential areas' are associated with higher levels of CIM, while routes characterised by industry and trade, high-speed roads, and zebra-crossings that need to be crossed are associated with lower levels of CIM.

All these findings about the effects of environmental variables are clearly policy-relevant. However, perceptions and attitudes can also be taken as starting points for soft policies such as awareness campaigns or traffic education. These may be employed to reduce parental fears or to increase awareness among other motorised transport users about the concerns of parents that relate to their walking or cycling children. This may help to increase trust in other transport users and reduce fears. Concern that refers to dense traffic and densely parked cars may be reduced by stronger control of irregular parking that contributes to restricting the view in the road network (a pertinent issue in the region).

The positive effect of having a sibling of similar age makes a case for organising CIM in groups, perhaps beginning with walking buses at a younger age and switching to unescorted groups of students later.

Last but not least, the consistent negative effect of distance on CIM suggests maintaining a decentralised system of primary schools even though efficiency considerations related to decreasing numbers of students (demographic change) encourage school closures. These schools should have limited specialisation, at least at primary stage, to avoid parental school choices at greater distances and increasing student segregation.

Many of our findings are in line with previous research and, thus, not particularly surprising. This suggests that they reflect more general parental reasoning and constraints, although clearly spatial, temporal, and social circumstances vary widely and may affect parental decisions on child travel (and the children's own reasoning) in very nuanced ways. The non-significance of some variables (child gender, household income, parental travel behaviour) is clearly less generalisable, but rather may be due to limitations in sampling and/or population heterogeneity or, again, local circumstances.

For future research, it is important to point out the limitations of our study. We would like to highlight four points. Firstly, the relationships between various variables that are associated with CIM are potentially very complex. This calls for more complex analysis methods than regression modelling, such as structural equation modelling or Bayesian networks. Secondly, as most other research in the field our study is based on cross-sectional data. This implies that any statement on the causality of associations is based on theoretical considerations, but not on the temporal order of events and, hence, must be treated with caution. Thirdly, even though we used a considerable set of 'subjective' variables, these were collected in a standardised manner and thus do not reflect the subjective meaning of places, travel modes, and (joint) trip-making for parents and children. This calls for more qualitative research that aims to better capture parental and children's perspectives. Fourthly, while there is a fast-growing body of research on CIM and especially children's mode use, this is less true for route choice. The environmental variables we used were based on our assumptions about route choice, but not necessarily about actual routes chosen. Child route choice studies that take into account non-chosen alternatives could shed more light on the environmental correlates of children's mobility.

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