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Effect of Interaction between Distance and Travel Times on Travel Mode Choice when Escorting Children to and from School

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Abstract

Recent studies suggest that the activity-travel patterns of parents who escort their children to school have both social and environmental impacts. This paper explores the interaction between distance and travel time levels (TTL) for escorted trips to school. The interaction between travel time and distance was modelled formulating a logit-multilevel model to determine the factors that influence adults' transport mode choice to escort children to school in metropolitan areas of Andalusia, Spain, where accompaniment is mainly by car or on foot in a maximum reported distance of 2 km. The findings indicate that (1) the interaction

between distance and time improves the explanatory capacity of the model and (2) the odds ratio value of escorted trips to school by car is much higher when TTL is low (less than 5 minutes) than when TTL is high (more than 15 minutes). These results suggest that in order to encourage people to escort children to and from school on foot, urban policies should include time policy measures to increase the time dedicated to escorting and to improve the socialisation of escorting time.

1. Introduction

Although health benefits for children using active school transportation are greater than the risks (McDonald 2008a; Müller et al. 2008; Sener et al. 2019), recent evidence suggests that this is declining (Buliung et al. 2009; Rothman et al. 2018), as travel to school is heavily influenced by parent(s)/caregiver(s) decisions (McMillan 2005; Sener et al. 2019). Specifically, parents have to decide whether or not to escort children to school and choose the transport mode to do so, decisions which have changed over the last decades (Faulkner et al. 2010; Mitra et al. 2016). On the one hand, the proportion of accompanied trips has increased, thus reducing children's independent mobility (Easton and Ferrari 2015; Schoeppe et al. 2016). On the other, when parents decide to accompany children, motorised modes are increasingly used (Carver et al. 2013; Granville et al. 2002; McDonald 2007; McDonald and Aalborg 2009). Moreover, in most cases, trips are relatively short and could be made on foot or by bike (McDonald et al. 2013; Mitra and Buliung 2015). According to a survey conducted with 1276 Spanish families (Alonso et al. 2009), 83% of children between the age of 8 and 12 years old in Spain were usually accompanied to school and 70% never travelled alone.

This study aims to provide insight into the factors that determine adults' choice of transport mode when escorting children to school. The approach includes the effect of the interaction between distance and travel time on travel mode choice. For this purpose, the interaction between travel time and distance was modelled to determine the factors that influence adults'

transport mode choice for escorting children to school in metropolitan areas of Andalusia, Spain, where accompaniment is mainly by car or on foot in a maximum reported distance of 2 km.

This study belongs to the body of literature on transport mode choice only for escorted school trips once the decision to escort children has been made. It aims to examine the determinants of mode choice for escorted school trips in metropolitan areas of Andalusia, Spain, where accompaniment is mainly by car or on foot in a maximum reported distance of 2 km. Specifically, the paper seeks to provide insight into the socioeconomic, household and built environment variables that determine transport mode choice for adults and children in escorted school trips. Additionally, as a novel contribution, the effect of the interaction between distance and travel time on travel mode choice is analysed. The assumption is that the effect of distance on the probability of travelling by car varies depending on the travel time level (TTL).

To achieve the above objectives, the study is structured into four sections. Firstly, the state of the research on transport mode choice for escorted trips to school is presented. Secondly, the data, methods and variables used are described. Thirdly, the results of the multilevel logit models and the discussion are presented. Lastly, the paper concludes with some policy recommendations and suggestions for further research.

2. Literature review

There is evidence in the literature that the growing trend of chauffeuring children to school is causing them physical and psychological harm, affecting their health and worsening their physical activity, social interactions and possibilities of exploring the local environment (O'Brien et al. 2000; Roth et al. 2012). Indeed, children have fewer opportunities to develop socially and become less active when chauffeuring them to school becomes a daily habit (Granville et al. 2002; Marquet and Miralles-Guasch 2016). Moreover, car overuse increases

carbon dioxide emissions and reduces air quality in a serious context of climate change (Koushki et al. 2002; McDonald and Aalborg 2009; Müller et al. 2008; Van Ristell et al. 2013), while the choice of active transport modes reduces vehicle emissions. Specifically, walking to school leads to a reduction in traffic congestion, especially when there is a reduction in traffic during peak hours and around schools (Badland and Schofield 2005; McDonald et al. 2013; Mitra and Buliung 2015). Several factors that affect transport mode choice in escorted trips to and from school have been explored in the literature, including children, parents or caregivers, and household and built environment characteristics (He 2013; Scheiner 2016; Vovsha and Petersen 2005; Yarlagadda and Srinivasan 2008).

2.1 Built environment

This study considers distance and density as one of the characteristics of the built environment (Ewing and Cervero 2001, 2010). These two characteristics have been shown to influence decisions to escort children or not (Lin and Chang 2010). Specifically, Mitra et al. (2010) showed that the neighbourhood environment around the children's residence had a stronger correlation with transport mode choice than the school's built environment. Moreover, the comfort and safety of the trip and the threat of 'stranger danger' were also found to be reasons for parental chauffeuring in the San Francisco area for children 10 to 14 years old (McDonald and Aalborg 2009). As regards the influence of population density, the results are inconclusive. Some studies have found a positive correlation between larger residential density and increased use of active transport by children and adolescents (Braza et al. 2004; Ding et al. 2011; Kerr et al. 2006), while others have not found any connection (Ewing et al. 2004). Type of housing is also related to the transport mode choice for escorting. Typically, single-family dwellings are associated with a higher probability of travelling by car and a lower probability of walking, while residential blocks in high density zones are

associated with increased walking (Mitra 2013). In the case of Finland, however, a positive correlation was found between low population density and walking to school (Broberg and Sarjala 2015).

2.2. Escorts' socioeconomic characteristics

Escorts' socioeconomic characteristics such as income level, gender, age and full or part-time employment also affect escorting transport modes. If their level of income is high, the probability of chauffeuring increases and is related to the fact that they have a car (Yoon et al. 2011). In fact, families who have a vehicle are more likely to escort their children by car and less likely to accompany them using active transport (Pont et al. 2009; Timperio et al. 2006). Parental employment status, work hours and flexibility of work hours are significant factors influencing escorted school trips (Schwanen 2007; Vovsha and Petersen 2005; Yarlagadda and Srinivasan 2008). Therefore, longer work hours tend to be correlated with a lower escorting probability, while flexible work hours tend to increase escorting probabilities (He 2013; McDonald and Aalborg 2009; Vovsha and Petersen 2005). If escorts work full-time, the probability that they will walk to and from school decreases and the probability that they will drive increases (McDonald 2008b; Yarlagadda and Srinivasan 2008). Along the same lines, if the person who accompanies the child to school is engaged in household chores, the probability of travelling by car decreases (Vovsha and Petersen 2005). As regards gender, it has been widely reported that mothers escort their children to school more than fathers, specifically 60% to 70% of the time, even though both are employed, thus highlighting the gendered nature of childcare (Fyhri and Hjorthol 2009; Motte-Baumvol et al. 2017; Scheiner 2013, 2016; Scheiner and Holz-Rau 2012; Schwanen 2007; Yoon et al. 2011). Another factor that has an impact on an escort's travel mode choice is nationality. The literature has shown that when the companion is a foreigner, there is a greater probability of walking, so that

children of foreign parents are more likely to go to school on foot (Pont et al. 2009; Scheiner 2016).

2.3. Distance and time

Although distance and travel time on foot are considered the most relevant variables when deciding on travel mode, they are not simultaneously incorporated in the explanatory models given that they are already highly correlated variables: the greater the distance, the longer the travel time, and vice versa. Indeed, as Wong et al. (2011 p. 12) stated, "longer travel time implies longer distance". Most studies have found home-to-school distance to be the most important variable when deciding how to travel and it can be expected that longer distances to school increase chauffeuring trips. When parents decide to escort their children to school, the greater the distance between home and school, the more the car is used and the less active school transportation is used (Carver et al. 2013; Gupta et al. 2014; Mammen et al. 2012; Scheiner 2016; Yarlagadda and Srinivasan 2008). Several studies have shown that the longer the distance or walking time, the smaller the probability of choosing active transport modes for escorting trips to school (Daisy and Habib 2014; Han et al. 2019; He 2013; McDonald 2008a; McMillan et al. 2006; Samimi and Ermagun 2013). The distance between the mother's place of work and the school has also been found to be a significant variable, where the greater the distance, the greater the probability of escorting by car. However, this was not the case when measuring the distance between the father's place of work and the school; a difference that has been attributed to gendered childcare roles (He 2013; He and Giuliano 2017). A reasonable walking distance from home to school is considered equal to or less than 2 km. However, there may be differences between countries (Mammen et al. 2012; Nelson et al. 2008; Stone et al. 2014; Vovsha and Petersen 2005), which could be explained by country-specific aspects that modify distance (Waygood and Kitamura 2009; Waygood and Susilo

2011). Moreover, in certain designated school zones the home-to-school distance might not be the same for all families but vary within the city (Chica-Olmo et al. 2018).

Although distance is the main factor considered when analysing escorted trips, some authors have also examined time spent on school travel. In most studies, the importance of travel time is directly related to distance and include walking time as a variable. In this line, Mitra and Buliung (2015) established that shorter travel time means that car transport can be replaced by active transport modes. Other studies have found that parents' positive attitudes to driving as a quicker transport mode explain car use, especially taking into account parental time constraints (McDonald 2008b; McMillan 2007; Westman et al. 2017). As highlighted in Ridgewell et al. (2009) for Brisbane, Australia, although long distances between home and school certainly discourage escorts from walking, time is the most important factor influencing parents' decision to use a car. In this regard, Scheiner (2016) argued that the principal reason for chauffeuring children is that it is perceived as the quickest option (less time), even though it may actually take longer by car than on foot. For instance, walking time to school, which has a fundamental role in land-use decisions, was found to be sensitive to the model specification when walking time and distance were equalised (Ermagun and Samimi 2016). Travel time has also been embodied as an uncertainty factor, particularly if the trip to/from school involves long distances and parents face uncertain travel times (Rasouli and Timmermans 2014).

3. Data and methodology

3.1. Data

This study was carried out for the autonomous region of Andalusia, situated in southern Spain. Andalusia is the second largest and most populated region in the country (18% population; 8.3 million inhabitants) and has nine metropolitan areas that concentrate more than 70% of the population and regional income (IECA, 2012). The average gross domestic

product per capita of the region with respect to the European Union (EU) stood at 74.5% in 2011 (INE 2013).

The data used for the study were taken from the *Social Survey 2011: Mobility in Urban Regions of Andalusia* conducted by the Institute of Statistics and Cartography of Andalusia (IECA), the only mobility survey in Spain that specifically focuses on Andalusia (IECA 2012). The survey collects information on the physical mobility dynamics and patterns of inhabitants living in urban areas and focuses on the intense daily movements that take place on an average working day (the day prior to the survey day). The survey sample size was set at 6,000 households. Three-stage sampling with stratification of the first-stage units (600 census tracts) was used. The second-stage units were dwellings (10 per census tract). In the third stage, an individual over 16 years of age was randomly selected to respond to the survey. Three basic units of analysis were used: family dwellings in urban areas of Andalusia, the population aged 16 and over and trips made by people aged 16 and over. Data are available for a total of 17,190 trips with a 95% confidence level and include various travel modes. The unit of analysis used in this study is the number of trips made by individuals aged over 16 whose main purpose is to pick up/drop off children at school for self-reported distances of 2 km or less. This distance was considered in line with other studies. For example, in their study on active school transport in the Greater Toronto and Hamilton Area of Canada to analyse differences among unescorted and escorted walkers, Mammen et al. (2012) excluded those who lived more than 2 km from the school. For Toronto, Stone et al. (2014) analysed factors that were instrumental in the decision of whether to escort children to and from school by car for self-reported distances of less than 2 km. Additionally, Broberg and Sarjala (2015) included subjects who lived 1 to 3 km from school, given that trips to and from school by motorised modes are practically non-existent (2.8%) in Helsinki for distances of less than 1 km. After excluding trips to and from home, trips to escort children to and from school

account for 15% of total daily trips in the metropolitan areas of Andalusia, which is a similar figure to parents' trips in Germany (16%) (Scheiner 2016). Following these criteria, we selected a sample of 1,104 trips, of which 564 (50.9%) were made by car and 540 (49.1%) on foot (IECA 2012).

3.2. Definition and Measurement of Variables

The variables considered in the study are grouped in accordance with the literature review. The dependent variable, *Travel mode*, is a binary variable that represents the travel mode chosen by the respondents when escorting children to and from school by car (value 1) or on foot (value 0). Only data on trips by car and on foot were used for two reasons. First, in Andalusia 50.4% of escorted trips are made by car, 48.6% on foot and 1% by bus, so bus travel was not considered in the model due to its marginality (IECA 2012). Second, the dichotomisation of a multinomial variable has the advantages that the results are easy to present (Fiorio et al. 2013) and they hardly lose any power (Manor et al. 2000).

The explanatory variables were classified into three groups (Table 1). Specifically, we use data on respondents' self-reported distance, travel time, school transport mode and socioeconomic, household and built environment characteristics. For the built environment variables, distance and population density were considered, where *Distance* is a continuous variable that refers to the kilometres travelled to and from school and *Population density* is a binary variable that takes the value of 1 for compact populations with a density of more than 5000 inhabitants/km^2 and 0 otherwise. For the escorts´ socioeconomic characteristics variables *Gender, Age*, *Nationality*, *Educational level*, *Employment* and *Unpaid domestic and care work* were considered. *Gender* is a binary variable that takes the value of 1 for male and 0 for female. *Age* is a continuous variable that refers to the age of the escort. N*ationality, Educational level*, *Employment* and *Unpaid domestic and care work*, are binary variables. *Nationality* takes the value of 1 for Spanish and 0 otherwise. *Educational level* takes the value

1 if the educational level of the person that accompanies children has higher education, or 0 if it is lower. *Employment* is a dichotomous variable with 1 indicating full-time employment and 0 otherwise. *Unpaid domestic and care work* takes the value 1 if the escort is dedicated solely to unpaid domestic and care work, and 0 otherwise. The variables related to household characteristics are *Income level*, *Type of housing* and *Car availability*. All of them are binary variables. *Income level* refers to household income level variable takes the value 1 if household incomes are below 1.100€/month. *Type of housing* variable is 1 for single-family dwelling and 0 otherwise. *Car availability* is 1 if the escort can access to a car and 0 if do not.

Table 1. Description and values of the variables

Variable	Description	Values
Travel mode (dependent variable)	Travel mode chosen by the respondents when escorting children to and from school	1 = car; 0 = foot
Built environment		
Distance	Distance between home and school	0 Km to 2 Km
Population Density	High population density	1 = Compact areas (with population density of more than 5000 inhabitants/km^2); 0 = other
Socioeconomic characteristics		
Gender	Gender	1 = male; 0 = female
Age	Age	16 to 81 years
Nationality	Nationality	1 = Spanish; 0 = other
Educational level	Higher education	1 = yes; 0 = no
Employment	Employment status	1 = full time; 0 = other
Unpaid domestic and care work	Dedicated solely to unpaid domestic and care work	1 = yes; 0 = no
Household characteristics		
Income level	Monthly income level	1 = monthly income below €1,100; 0 = other
Type of housing	Type of housing	1 = single-family dwelling; 0 = other
Car availability	Access to a car	1 = yes; 0 = no

3.3. Travel time levels

As indicated in the literature review, travel time affects the decision to accompany children to and from school by car or on foot. In this study, we considered the length of the journey as reported by the escort. Based on a maximum distance of 2 km, travel times ranged from 5 to 35 minutes, with an average of approximately 10 minutes. Travel time was divided into TTL in line with other studies. Han et al. (2019) divided escort travel time into three levels: less than 10 minutes; 10 to 30 minutes and more than 30 minutes. The authors found that the probability of parents escorting their children decreases rapidly when travel time increases, and other people escort children, although for mothers the marginal effect is lower. Their results suggest that parents spend less time escorting (≤ 10 min), while other escorts spend more time (> 30 min). Westman et al. (2017) used two TTL (trips of less than 15 minutes and more than 15 minutes) to determine how travel time and transport mode influence children's attitude when they arrive at school. However, these studies did not consider the interaction of self-reported travel time and distance between home and school. Unlike other studies, this paper explores the interaction of distance and self-reported travel time. In this study, TTL was divided into three categories according to the time spent: short (TTL1 ≤ 5 minutes); medium (TTL2 > 5 minutes and ≤ 15 minutes) and long (TTL3 > 15 minutes).

3.4. Regression model

The aim of this work is to model transport mode choice taking into account the built environment, the socioeconomic characteristics of the escorts and household characteristics. As noted above, in addition to these variables, the decision to escort children by car or on foot also depends on the interaction between the distance travelled and the TTL. However, the inclusion of both variables would cause severe multicollinearity problems given their correlation. Consequently, it was deemed more appropriate to use a logit-multilevel random effects model that takes into account the interaction between distance and time. Thus, Eq. (1)

shows a two-level binary logit model with random intercept that was specified to consider the binary structure of the dependent variable (Eq. 1) (Snijders 2011):

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \mathbf{X\beta} + \mathbf{Z\gamma} \qquad (1)$$
$$\text{where: } p_{ij} = \Pr(Y_{ij} = 1)$$

where $\mathbf{X\beta}$ is a combination of fixed effects; $\mathbf{Z\gamma}$ denotes the random effects and Y_{ij} represents the individual's travel mode choice (1 = by car, 0 = on foot) in cluster 3 (TTL).

For a random intercept model, $\mathbf{Z\gamma} = \gamma_{0j}$ with γ_{0j} : $N(0, \sigma_0^2)$.

In this work, the marginal R-squared (R2m) and conditional R-squared (R2c) are calculated. The first represents the variance explained by fixed factors, while the second represents the variance explained by fixed and random factors (Nakagawa and Schielzeth 2010, 2013).

4. Results and discussion

4.1. Descriptive statistics

Table 2 shows the descriptive statistics for the variables considered in the study, which are grouped in accordance with the literature review. 50.9% of trips to and from school were made by car and 49.1% on foot, with an average travel distance of 0.681 km. The percentage of car trips is similar to that reported in studies for the US in 2001, where 52% were made by car within one mile (1.61 km) of the school (McDonald 2008a). In contrast, only 26% of children in the UK were driven to and from school (Easton and Ferrari 2015) and only 25.5% in Canada in 2006 (Mitra et al. 2016).

Table 2. Descriptive statistics for the variables

Variable	MEAN	SD	Min	Max
Travel mode (dependent variable)	0,509	--	0	1
Built environment				
Distance	0,681	0,484	0	2

Population density	0,781	--	0	1
Socioeconomic characteristics				
Gender	0,257	--	0	1
Age	39,354	9,264	16	81
Nationality	0,950	--	0	1
Educational level	0,532	--	0	1
Employment	0,293	--	0	1
Unpaid domestic and care work	0,167	--	0	1
Household characteristics				
Income level	0,307	--	0	1
Type of housing	0,425	--	0	1
Car availability	0,927	--	0	1

A total of 78.1% of the metropolitan areas were compact (i.e. a population density of more than 5000 inhabitants/km^2). As regards the sample, the average age of escorts was 39 years old; 29.3% were in full-time employment and 16% were dedicated solely to domestic and care work (all of them women); 53.22% had completed higher education and 95% were Spanish nationals. It should be noted that 75% of trips were made by females, confirming other studies that show that women are more involved in childcare than men (Fyhri and Hjorthol 2009; Motte-Baumvol et al. 2017; Scheiner 2013, 2016; Schwanen 2007; Yoon et al. 2011). A total of 42.5% of the respondents lived in a single-family dwelling, 92% had access to a private vehicle and 30.71% had an income of less than €1,100 per month.

4.2. Relationship between mode choice and Travel Time Levels

In order to analyse the effect of TTL on the decision to escort children to and from school on foot or by car, a cross-tabulation analysis was carried out (Table 3). To analyse the statistical independence between the chosen travel mode and TTL, a chi-square test was performed ($\chi^2 = 9.363$, df = 2, $p = 0.009$). The test showed a significant dependence between mode choice and TTL because the null hypothesis that the two categorical variables are independent was rejected.

Table 3. Travel mode choice and travel time levels

	TTL1 (t ≤ 5)	TTL2 (t > 5 to t ≤ 15)	TTL3 (t > 15)	Total
Walking	223	258	59	540
%	48.0	47.2	64.1	
Chi-sq. test	0.087	0.341	4.356	
Driving	242	289	33	564
%	52.0	52.8	35.9	
Chi-sq. test	0.083	0.327	4.170	
Total	465	547	92	1104
%	100.0	100.0	100.0	

Table 3 shows the relationship between mode choice and TTL. As the data indicate, more people travel by car than on foot in short to medium trips ($t \leq 5$ min; $t > 5$ to ≤ 15 min). However, when travel time is longer ($t > 15$) more people travel on foot (64.1% vs. 35.9%, respectively). This paradoxical result contrasts with some of the studies referred to in the literature review. Furthermore, for short travel times (TTL1) the percentages for accompanying children on foot (48.0%) and by car (52.0%) are very similar to those for medium travel times (TTL2; 47.2% and 52.8%, respectively). However, for long travel times (TTL3) the figures for driving and walking (64.1% and 35.9%, respectively) differ largely from short and medium travel times. The chi-squared corresponding to TTL3 ($\chi^2 = 9.363$) is much higher than that of TTL1 and TTL2, thus indicating a differential behaviour in travel mode choice with respect to the TTL. Hence, in addition to distance, travel times should also be considered when analysing the school travel mode choice.

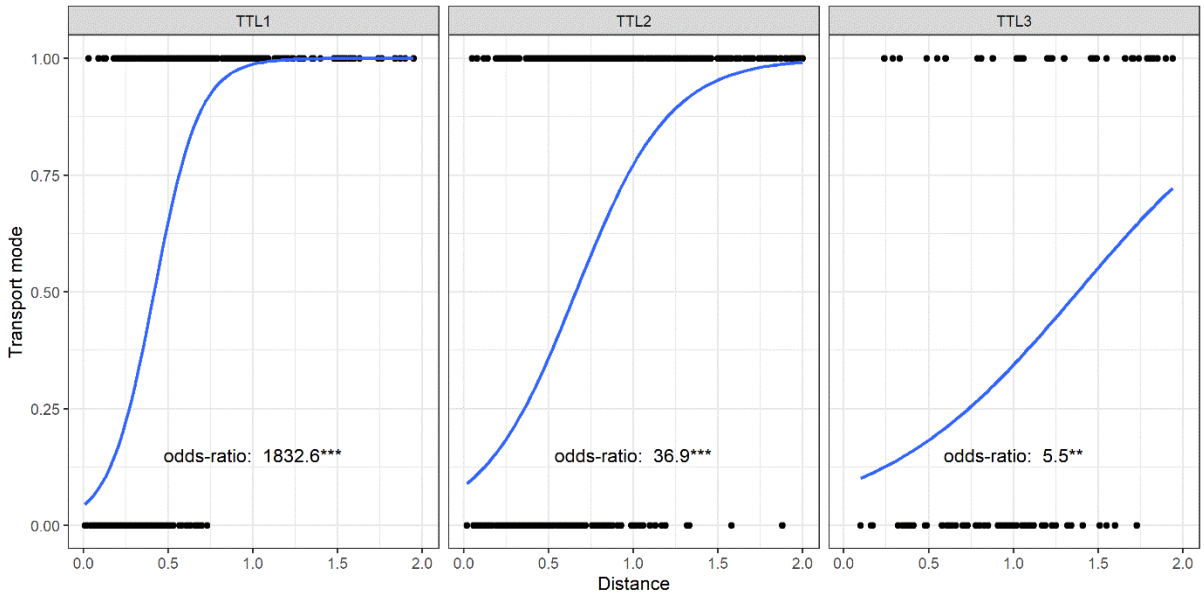
4.3. Distance-time interaction

Figure 1 shows the effect of distance on travel mode choice for each TTL. The dots represent trips made by car (transport mode = 1) and on foot (transport mode = 0) and the curve represents an adjusted logistic function. The results show that there is a direct and significant

correlation between distance and travel mode choice, given that the odds ratio values in all three cases are significant and greater than 1.

This implies that the greater the distance from home to school, the greater the likelihood that parents will drive their children to school, which is in line with other studies. However, it can also be observed that the odds ratio corresponding to short travel times (TTL1) is higher than that of medium (TTL2) and long (TTL3) travel times. This indicates that the greater the TTL, the less effect a change in distance has on the decision to travel by car. Therefore, distance does not impact all travel times in the same way. This highlights the interaction between distance and time.

Figure 1. Effect of distance on travel mode choice for each TTL



Note. Significance shown as *p*-values <: *** 0.001, ** 0.01

Figure 1 also shows that the self-reported maximum distance travelled on short trips made on foot (TTL1) is less than 0.75 km. However, for medium (TTL2) and long travel times (TTL3)

to school the dots are more scattered, indicating that some individuals are willing to walk even when distances are greater.

4.4. Logit-Multilevel models

The findings in Figure 1 justify including both distance and TTL in the regression model. As it was pointed above, it was deemed more appropriate to specify use a two-level binary logit model with random intercept to consider the binary structure of the dependent variable. Table 4 shows the results of the three logit-multilevel random effects models estimated in the study, which take into account not only the difference in the independent factors, but also the interaction between distance and travel times (TTL). Three nested models were specified to consider the cumulative effect of each group of variables. Thus, in the first model (Mod1) only the variables for the built environment group were included; in the second model (Mod2) the variables related to socioeconomic characteristics were added, and in the third model (Mod3) household characteristics were included. All the models include the interaction between distance and time. As can be observed, Mod3 is the preferred model, as it yielded the lowest Akaike information criterion (AIC) value of the three models. Furthermore, it can also be observed that the goodness-of-fit of the models can be improved by adding new variables. Thus, R2m, which represents the variance explained by the fixed factors, and R2c, which includes the previous factors and the random factors, were both improved. It should be noted that the inclusion of the interaction between distance and time improves the explanatory capacity of all three models. For example, Mod3 improved by 38.4% (0.721–0.521)/0.521). Moreover, most of the signs of the coefficients for the variables included in the models were significant.

Table 4. Logit-Multilevel models

	Mod1	Mod2	Mod3
Const.	-1.800***	-2.775***	-5.437***
Built environment			
Distance	4.174** (64.974)	4.162** (64.200)	4.263*** (71.022)
Population density	-0.907*** (0.404)	-1.010*** (0.364)	-0.852*** (0.427)
Socioeconomic characteristics			
Gender	--	0.547** (1.728)	0.455** (1.576)
Age	--	-0.016+ (0.984)	-0.016* (0.984)
Nationality	--	1.565*** (4.783)	1.571*** (4.811)
Educational level	--	-0.093 (0.911)	-0.406** (0.666)
Employment	--	0.530** (1.699)	0.503** (1.654)
Unpaid domestic and care work	--	-0.048 (0.953)	-0.293 (0.746)
Household characteristics			
Income level	--	--	-0.266 (0.766)
Type of housing	--	--	0.698*** (2.010)
Car availability	--	--	2.656*** (14.239)
Random effect (variance)			
Intercept	0.166	0.181	0.280
Slope	5.732	5.223	5.351
Model fit			
AIC	1021.3	993.1	938.9
R2m	0.420	0.460	0.521
R2c	0.690	0.695	0.721
Distance-time interaction % increase	64.2%	51.0%	38.4%
logLik	-504.6	-484.5	-454.5

Note: Significance shown in *p*-value <: *** 0.001, ** 0.01, * 0.05, " " not significant.

Parameter estimates shown with odds-ratio in parentheses

4.4.1. Built environment

The coefficients for the built environment variables are significant in all three models. As expected, the sign of the coefficient for the variable *Distance* is positive, and it can also be observed how the odds ratio for this variable is greater than 1 in all three models. This indicates the significant impact of distance on the probability of escorting by car. As explained in the literature review, distance has an impact on reducing the probability of choosing a physically active travel mode, as has been corroborated in studies for North America (McDonald 2008a; McMillan 2007; Rothman et al. 2018; Schlossberg et al. 2006), Australia (Timperio et al. 2006), England (Black et al. 2001) and Germany (Scheiner 2016). As regards the variable *Population density*, the sign of the coefficient is negative, thus indicating that the probability of escorting by car is lower in compact areas, in line with other studies (Braza et al. 2004; Ding et al. 2011; Kerr et al. 2006; Sener et al. 2019). However, this contrasts with some studies that have not found population density to be a significant variable affecting mode choice of travel to school (Ewing et al. 2004).

4.4.2. Socioeconomic characteristics

As regards socioeconomic characteristics, the variables *Gender*, *Employment* and *Nationality* are significant in all three models. However, the variable *Unpaid domestic and care work* is not, and the variables *Age* and *Educational level* are not significant in Mod2 but are significant in Mod3. With regard to the variable *Gender*, the task of escorting children to school was found to fall mainly on females, which has also been demonstrated in studies for Utrecht, Netherlands (Schwanen 2007), Germany (Scheiner 2016), the UK (Barker 2011), France (Motte-Baumvol et al. 2017) and Norway (Hjorthol and Vågane 2014). In addition, females are more likely to escort on foot, while males are more likely to escort by car. This result is similar to that obtained in a study for Germany, where males travel by car for longer

trips, while females tend to escort children to and from school on foot (Scheiner 2016). The sign of the coefficient for the variable *Employment* shows that longer working hours increase the likelihood of escorting by car, as confirmed in other studies (McDonald 2008b; Yarlagadda and Srinivasan 2008). However, the variable *Unpaid domestic and care work*, which has been related to less car travel in Atlanta, Georgia (Vovsha and Petersen 2005), is not significant in the case of Andalusia. The variable *Nationality* shows that when the escort is a Spanish national the probability of escorting by car is higher (Scheiner 2016). In addition, this variable has a greater effect on the decision to drive than the other four binary variables given its higher odds ratio. Furthermore, in Mod3, the variables *Age* and *Educational level* decrease the probability of escorting by car. Therefore, with respect to the socioeconomic characteristics, a young Spanish male in full-time employment without higher education would be more likely to chauffeur children to school in urban areas of Andalusia.

4.4.3. Household characteristics

The coefficients for the household variables *Type of housing* and *car availability* are significant, while the variable *Income level* is not. The variable *Car availability* is positive, which indicates that families who have access to a car are more likely to drive their children to school rather than go on foot (Pont et al. 2009; Yoon et al. 2011). In the case of California and Atlanta, vehicle ownership has been related to household income level given that parents who are less well off do not have access to a car (McDonald and Aalborg 2009; Vovsha and Petersen 2005). Other studies have also found income level to be a significant variable in choosing a private car for travel to school (Daisy and Habib 2014; Sener et al. 2019). In this study, however, the availability of a car has a significant impact on the escort's travel mode choice, but household income level does not.

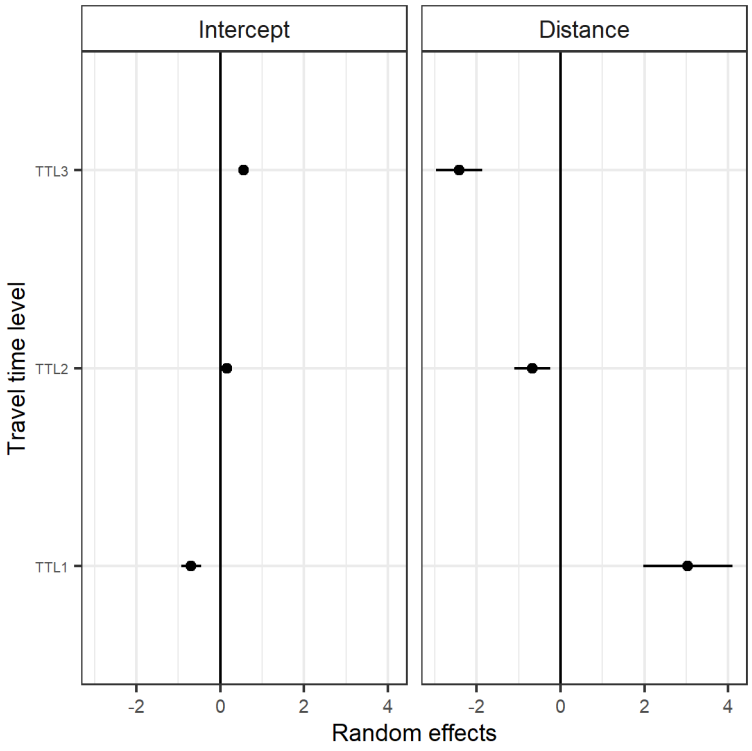
The variable *Type of housing* is significant, which coincides with other studies. Thus, for single-family dwellings, the probability of travelling to school by car increases and the

probability of walking decreases, while residential blocks in high density zones are related to more walking (Mitra 2013). However, in the case of Finland, single-family dwellings increase the probability of escorts travelling on foot or cycling (Broberg and Sarjala 2015).

4.5. Walking vs. driving: the interaction between distance and time

As mentioned, including the interaction between distance and time improves the explanatory capacity of all three models. Figure 1 shows that longer distances have a greater effect on the probability of travelling by car for short travel times (TTL1) than for long travel times (TTL3). The results of the preferred model (Table 4, Mod3) confirm this finding. The independent factors and *Distance* coefficients were calculated for each of the three TTLs for Mod3 (see Figure 2). Figure 2 shows that the fixed effect (intercept) and the coefficient of the variable *Distance* are different for each TTL. Thus, it can be observed that the constant factor for TTL3 is greater than for the other two TTLs, thus indicating that escorts are more likely to travel by car for longer travel times, although no significant differences were observed between the three TTLs. The highest coefficient for the variable *Distance* corresponds to TTL1. This confirms that individuals who travel for short times are more likely to change the travel mode when there are small changes in the distances travelled. In other words, when the time spent on travel is short, increasing the distance increases the likelihood of escorting by car. This may be due to time constraints, as noted in other studies (McDonald 2008b; McMillan 2007; Sener et al. 2019; Westman et al. 2017). In turn, individuals who travel long times are more willing to walk when faced with an increase in distance. This behaviour is probably due to the fact that individuals with less time constraints escort for longer travel times.

Figure 2. Intercepts and coefficients of the random effects



Note. Horizontal lines represent the confidence interval (95%). The intercepts and distance coefficients show deviations from the mean values.

5. Conclusions

This study analysed factors that influence adults' transport mode choice when escorting children to school in metropolitan areas of Andalusia, Spain. For this purpose, the interaction between travel time and distance in a maximum reported distance of 2 km was modelled. A total of 50.9% of the trips to and from school for distances equal to or less than 2 km were made by car. The effect of distance was considered for three travel time levels (TTL), less than 5 minutes (TTL1), 5 to 15 minutes (TTL2) and more than 15 minutes (TTL3).

In this study, we examined the effect of variables commonly used in other studies on travel mode choice for escorting children to and from school. Three groups of variables were considered: built environment, socioeconomic characteristics and household characteristics. The results indicated that the variables *Distance*, *Population density*, *Gender*, *Age*,

Educational level, *Type of housing* and *Car availability* are significant and influence travel mode choice when escorting children to school. In line with other studies, it was confirmed that distance has a strong influence on the travel mode used to escort children to and from school. Specifically, if the school is close to home, the likelihood of walking increases. According to the results, young Spanish males in full-time employment living in a single-family home in a non-compact area and who have a car are more likely to escort children by car than on foot.

It was also found that the decision to escort by car or on foot is not independent of the TTL; an aspect that has been underinvestigated in the literature. The main novelty of this study is the use of logit-multilevel random effects models, which enabled us to contrast the effect of the interaction between distance and time on the decision to escort children to and from school by car or on foot. The incorporation of this aspect considerably improved the explanatory capacity of the models, achieving an improvement of 38.4% in the preferred model (Mod3). The study has shown that, on the one hand, individuals who travel for short times are more likely to change their travel mode when there is a change in the distance travelled. In other words, when the travel time is short, an increase in distance increases the probability of travelling by car. In contrast, when travel time is longer, escorts are more likely to walk when distances increase. This behaviour is probably due to the fact that individuals with less time constraints escort for longer travel times. In addition, it has been found that gendered escorting on foot reflects patterns of gendered division and differences in time use. Females not only escort children to and from school more, but also walk more, thus confirming that they provide healthier childcare.

In view of the results, not only is it necessary to promote school assignment policies based on home-to-school distance criteria if more walking is to be encouraged, but the distance-time interaction should also be taken into account. The results suggest that in order to promote the

escorting of children to and from school on foot, measures need to be implemented with two main aims: a) to increase the time dedicated to escorting and b) to improve the socialisation of escorting time. In order to increase the time spent walking with children to school, escorts should be offered incentives for going on foot and discouraged from chauffeuring. Moreover, initiatives such as the creation of dedicated school routes need to be implemented to allow parents to collectivise the time dedicated to escorting on foot and provide them more opportunities for socialising. In short, time policies are required to ensure that those who escort children have enough time to walk to and from school provided they live a short or medium distance from the school and/or escorting is done collectively.

As a future line of research, the analysis of the spatial distribution of data should be considered to study the effect of spatial dependence on adults' decisions to escort children to and from school.

Data Availability Statement

Some or all data used during the study are online in accordance with funder data retention policies (https://www.juntadeandalucia.es/institutodeestadisticaycartografia/encsocial/2011/). Some or all data, models or code generated or used during the study (R software) are available from the corresponding author by request.

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