Modelling factors that impact the use of child safety seats for nursery school travel

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Abstract: Children, as one of the most vulnerable road user groups, are exposed to a high risk of traffic crash-related injuries and fatalities. Children's incomplete physical and cognitive development leads to inaccurate detection of traffic hazards and inadequate road crossing decisions. When young children travel as car occupants, their body structures are immature, and restraint over larger and sometimes different body areas is necessary. Therefore, children's vulnerability as car occupants is subject to their age and physical development. This research investigates factors influencing child car seat usage, particularly child restraint systems or booster seats, for commuting to nursery schools. An experimental study was conducted in three suburbs of Athens, Greece, with distinctive socioeconomic status (SES) and built environment characteristics. For this purpose, a self-administered parental questionnaire was completed for 734 children attending municipality nursery schools, exploring the traffic safety practices for preschool children, child-parent interactions, the parent's risk perception, behaviour, and knowledge of traffic safety. Responses reveal that the surveyed children—irrespective of the residence area—travel to the nursery school mainly as car occupants (89.6% overall, ranging between 84.8% for the area with the lowest SES and 96.1% for the area with the highest SES). In addition, the results indicate that three-quarters of the children are often placed in a car seat, while almost one-quarter are never restrained. Regression and structural equation models are estimated and used to examine factors affecting the usage of child safety seats. Finally, conclusions are drawn, along with suggestions to overcome the limitations and complete this research with ongoing and future data collection and analyses.

Keywords: child car seats, child restraint systems, preschool children, socioeconomic status

1 Introduction

Child passengers of motorized vehicles are exposed to a significant risk of crash-related fatalities, and road traffic injuries tend to be more severe in children than adults (Schwebel 2017). In 2016, the European Transport Safety Council (ETSC) reported 630 child (< 14 years old) fatalities, accounting for 48% of the total fatal crashes of children (Adminaite *et al.* 2018). Among the reported fatalities, almost 35% of children were under five years old. The fatality rate of child passengers (< 14 years old) is even higher in Greece and accounts for

approximately 58% of deaths from road crashes in the age group (ELSTAT 2017). One effective measure towards reducing child-related death and the injuries' severity is using child restraint systems (CRS) in vehicles. If used correctly, the CRS can reduce the risk of death in children by 28% compared to using seatbelts alone (Elliott *et al.* 2006). Therefore, in many countries, including Greece, children younger than seven must be restrained with CRS in a motorized vehicle. Currently, the height of 1.35 m (roughly refers to a 12-year-old) is the recommendation of the European Union for the transition from the CRS to the standard seatbelt (WHO 2018), executed in most membered countries. However, there are still some insouciances regarding the usage and implementation of CRS in vehicles. In the case of Greece, the compliance rates are relatively low, as an observational study revealed that only 57% of drivers use a child restraint, with no significant difference within the urban and rural areas (Yannis 2009).

1.1   CRS and booster seat use

Several studies investigated child safety seats by exploring the factors that might impact the use and misuse of such safety systems in the vehicles, such as the parent's knowledge of road safety and the effect of CRS on children's safety (Ling *et al.* 2021; Hunter *et al.* 2020; Koppel *et al.* 2013). Ramsey *et al.* (2000) argued that the common knowledge concerning the safety and size of restraint equipment is insufficient among some parents, resulting in inappropriately restraining children in vehicles (Ramsey *et al.* 2000). Nevertheless, there is a higher usage among the parent, as a driver, using the seat belt with CRS for the children travelling with them (Roynard *et al.* 2014). Another study found a reduction in child restraint use when more than two passengers are in a vehicle (Ramsey *et al.* 2000). Besides, the frequency of CRS usage is associated with the driver's socioeconomic status (SES) (e.g. education and income level) and family size, i.e., smaller families with higher SES tend to use CRS more often (Durbin 2003). In contradiction, large and low-income families are less likely to use an age-appropriate restraint system, indicating the economic and logistic barriers to child restraint use (Keay *et al.* 2013). Furthermore, parental perceptions of the hazard—associated with trip types—may also influence CRS usage. This suggests that parents may identify certain trip types to be safer (e.g. short trips) and, thus, change the usual pattern of CRS use (Emery & Faries 2008; Simpson *et al.* 2002).

1.2   Nursery school travel

School travel research has shown that childcare and child chauffeuring as household activities lead to a higher probability of commuting during morning peak hours (Oakil *et al.* 2016). The environmental factors (e.g. distance to the school) or personal factors (e.g. work-related issues of parents) can affect the travel choices of parents and school travel behaviour accordingly (Waygood & Friman 2015; Yu & Zhu 2013). The built environment characteristics might be less influential than the attitudes and psychosocial parameters when the distance to the school is shorter (Zuniga 2012). Roynard *et al.* (2014) indicated that children travelling by vehicle to school are less likely to be restrained than those travelling for other purposes.

Regarding nursery school travel, this trip type has received less attention than school travel. However, there are some similarities and differences between them. For instance, nursery travellers cannot travel unaccompanied to the nursery school, while school travellers can walk/bike independently. In the case of walking or biking to the nursery school, children's age, distance to the nursery school, and weather seem to predict active travel (Oxford & Pollock 2015). Some independent travel commitments, such as weather and the distance to the school/preschool, might be similar parameters influencing the travel behaviour for both nursery and school travel.

1.3   Paper contributions

While several studies examined different aspects of school travel, only a few focused on pre-school children. Hence, this study aims to identify the factors associated with using child safety seats for daily nursery school trips. Besides, this paper examines whether factors affecting CRS and booster seat use in other studies worldwide also apply in Athens—as the case study—or if there are area-specific factors. Furthermore, in this study, specific attention is given to socioeconomic factors known from the literature to determine road safety behaviour and car seat use. Finally, the identified parameters can be practical to drive policies for the increased use of the CRS.

2   Methodology

2.1   Study sites and data collection

A questionnaire was developed and administered to a sample of parents living in three suburbs of Athens, Greece, and having at least one child attending the municipality nursery schools. The target age group was defined as children between nine months to five years old. In addition, the following main elements were specified to be examined through the collected data:

- The family travel patterns
- The trip characteristics of nursery schools
- The child-parent interactions
- The traffic safety climate
- The family structure and SES.

2.1.1   *Questionnaire design*

The questionnaire comprised a general section where parents could provide surveyors with information about the number of children in the family, their gender and age, and the nursery schools they attend. In addition, three main sections were allocated to the questions regarding (*i*) travel to and from nursery schools, (*ii*) child-parent interactions and traffic safety, and (*iii*) parent demographics.

The SES is used in the social sciences to describe an individual or a household's economic and social position relative to the rest of the society and is evaluated using various indicators, such as the educational level, the occupation of the residents, and the property zone price. In this study, the SES of the family is defined using a set of suitable indicators: the level of education of both parents and the annual family income found in the parent demographics section. Further, traffic safety climate refers to the individual attitudes and perceptions of the traffic in a context (e.g. country or area) and is a surface component of safety culture (Gehlert *et al.* 2014). Previous research showed a correlation between traffic safety climate, secondary driving tasks and traffic violations. The questionnaires defined the traffic safety climate for pre-schoolers' parents using six items in the first two sections. Participants were asked to indicate on a five-point scale (from 1 = 'not at all' to 5 = 'certain/absolutely') how safe their children are during the commute, how safe is the route they follow, and the possibility of being involved in a traffic crash during the commute. One question was allocated to the parent estimation of the number of annual traffic fatalities in the country using several intervals (ranging from 1 = 100–500 to 7 = 2500+). Another question examined the level of difficulty parents would face if they walked to nursery school (on a scale of eight). The last question—regarding traffic safety climate—asked participants to select the most concerning danger children face daily, among six possible options, with traffic crashes being one of them. In this last question, parents tended to give more than one answer.

The questionnaire was piloted with three parents for clarity assessment and took approximately 10 minutes to complete. Therefore, it was suitable for distribution regarding the length and effort required for completion. Approval was requested and given by each local authority to distribute the questionnaires. Subsequently, the principal of each nursery school was contacted by an experienced researcher (the first author of this paper in this case). The researcher explained the aims of this study and the procedure to be followed. The schoolteachers provided all parents with a package, including an invitation letter, the questionnaires, and an envelope. Teachers informed the parents that the participation is voluntary, documentation of the collected data is anonymous, and the filled questionnaires are sealed in envelopes. The number of packages prepared was equal to the number of children attending the municipality nursery schools.

2.1.2 Selection of study areas

Fyli, Ilioupoli, and Kifissia are suburban municipalities of Athens (Figure 1). Fyli is in the west, Ilioupoli in the southeast, and Kifissia in the north part of the Athens metropolitan area. These municipalities were selected since they have socioeconomic and built environment characteristics of a typical low, medium, and high SES suburb of Athens, respectively. In terms of property values, the price zone for Fyli spans between 650 and 800 Euro/m^2, 1400 to 1900 Euro/m^2 in Ilioupoli, while the range for Kifissia is 1250 to 4000 Euro/m^2. To determine the educational level, we considered the percentage of residents over 19 years old and with tertiary education. For Fyli this percentage is 11.0%, 28.8% for Ilioupoli, and 48.3% for Kifissia. Also, in these three areas, there are differences regarding the built environment and the road network types used to find a possible link between the road type and the use of CRS.
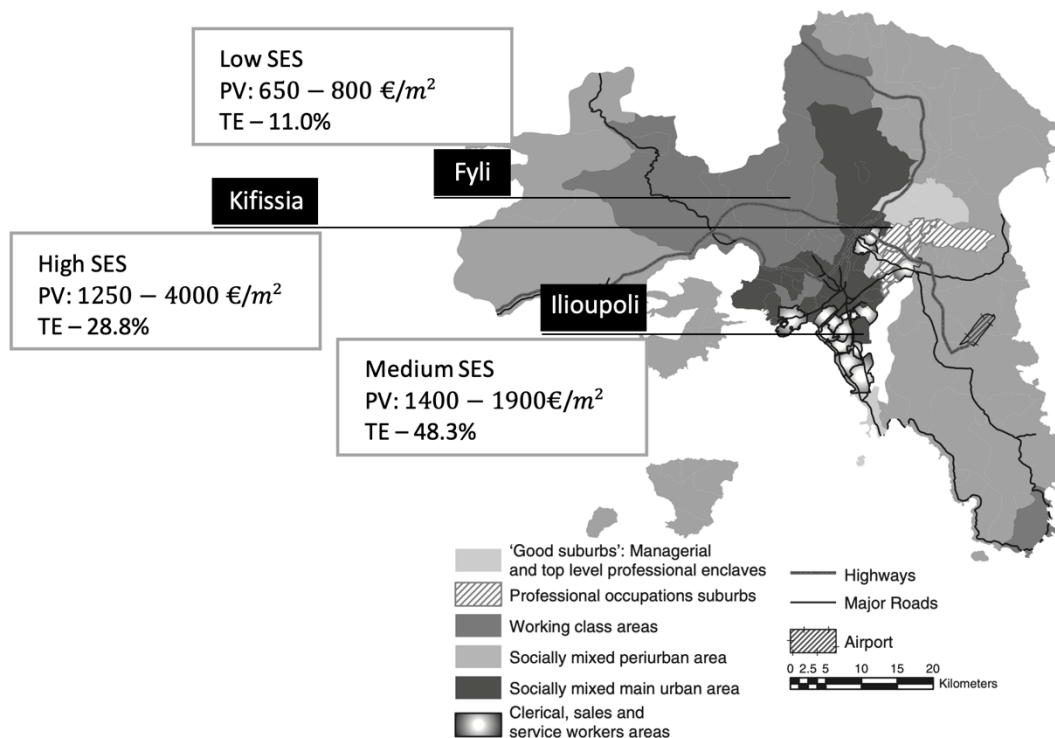

Figure 1 The occupational structure of Athens (Arapoglou & Sayas 2009)

2.1.3 Recruitment and participation rate

All municipality nursery schools in Fyli (10 nursery schools), Ilioupoli (7 nursery schools), and Kifissia (7 nursery schools) agreed to disseminate the survey to a total of 24 participating schools. There was no financial incentive for the parents to undertake the surveys. The questionnaires were distributed and collected in 2014, and we received complete and usable replies

from 734 children attending these nursery schools. The response rate by the municipality was 20% for Fyli, 55% for Ilioupoli, and 45% for Kifissia.

2.2   Overview of the data

In total, responses of 734 children were considered eligible for analysis and used as the basis for all subsequent results. Figure 2 shows children's age and gender distributions in the selected samples. Although municipality nursery schools accept children as young as nine months old in all locations, most children attending the nursery schools were between 3 and 5 years old. This age group is particularly interesting as many children graduate from forward-facing CRS to booster seats and often move to larger size restraints too early (Vesentini & Willems 2007). Figure 3 and Figure 4 illustrate the participant's demographic characteristics, household size, and income levels. Most parents were between 26 and 45 years old, and the most popular family size was four persons. In addition, the income distribution and percentage of parents with tertiary education followed the expected pattern, i.e., increases from Fyli to Ilioupoli and Kifissia. Figure 5 provides statistics for four main variables collected through the questionnaire and used in the model estimation.
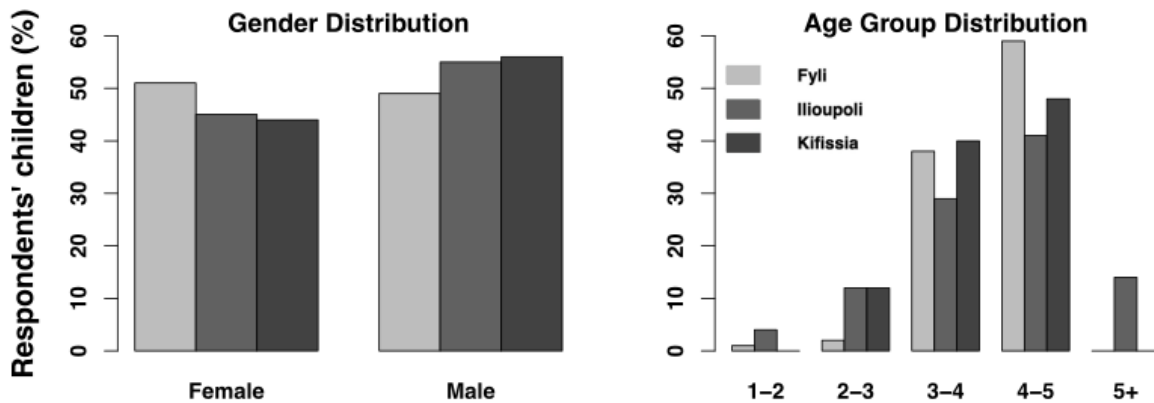

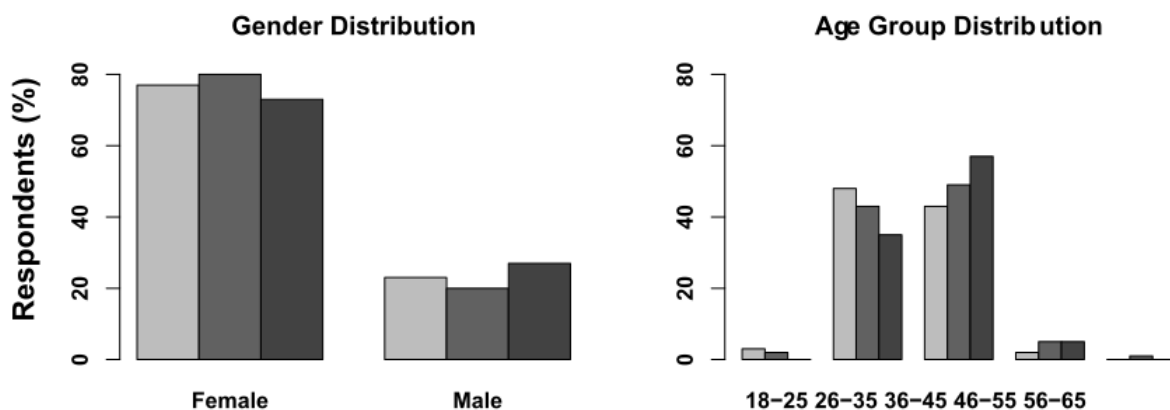Figure 2 Demographic characteristics of respondents' children

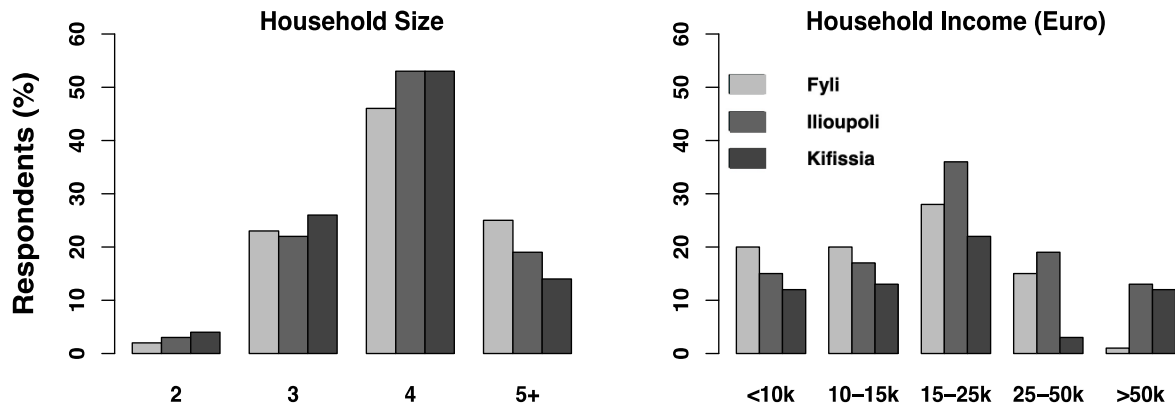Figure 3 Demographic characteristics of respondents (parents)

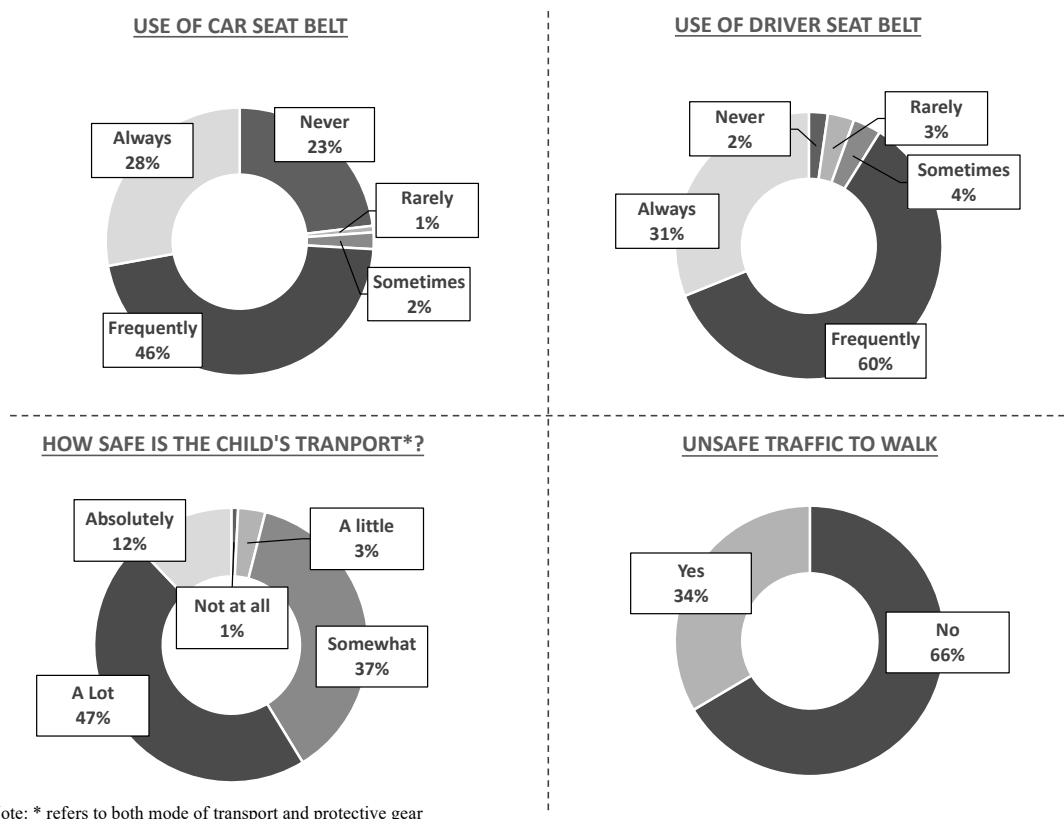Figure 4 Data of respondents (parents) in each area

Note: * refers to both mode of transport and protective gear

Figure 5 Statistics of key variables extracted from the collected data

2.3 Modelling framework

While several factors affect the road safety attitudes of parents with respect to their children, this study focuses on investigating the most relevant parameters influencing the use of child safety seats for daily commutes to nursery school. For this purpose, the information collected through the questionnaire and participants' responses were used to extract the variable influencing the use of child safety seats, and a modelling framework was built upon two layers:

I.   a generalized linear model to capture the degree of child car seat usage, and
II. a structural equation modelling approach to estimate the safety perception of the participants and quantify it as a latent variable in the model.

The employed modelling framework aims to examine various factors influencing the usage of child car seats while identifying the concept of safety perception. The latter factor is particularly significant in parents' attitudes towards restraining their children by CRS; however, it is almost impossible to measure with a single observed indicator. Hence, the structural equation modelling approach was proposed to handle the parents' safety perception concept and investigate various influencing factors in using CRS.

2.3.1 Generalized linear model

The generalized linear model allows building a linear relationship between the response (Y) and predictors (e.g. $x_1, x_2, \ldots, x_i$), even though their underlying relationship is not linear. Besides, the generalized linear model permits the magnitude of each measurement variance to be a function of its predicted value. The generalized linear relationship can be formed as Equation (1), where Y is the dependent variable, x_i is the logarithm base, β_i are model parameters, and α is the population Y intercept:

$$Y = \alpha + \beta_1 x_1 + \cdots + \beta_i x_i.$$

(1)

In this study, a generalized linear model was formulated to link the degree of child car seat use as the response and the collected variables through the questionnaires as the model predictors (e.g. demographic characteristics of parents and children, and parents' educations). In the next step, a structural equation model was formulated to explore the factors that affect the usage of child safety seats for the nursery school trip.

2.3.2 Structural equation model

As a multivariate statistical analysis technique, the structural equation model can simultaneously unite factor analysis and multiple regression analysis. The structural equation model aims to analyse the causal relationships among observed variables and latent constructs or between multiple latent variables.

In this research, a latent variable was utilised to elucidate the safety perception concept among the participants (i.e. parents) regarding the usage of child safety seats for traveling to nursery school. The latent variable of 'traffic safety climate' was constructed by using four observed indicators to explain the safety perception concept:

- **Father's tertiary education**.
- **Use of driver seat belt:** high use of driver seat belt as a binary dummy variable taking the value one for those that responded in the top, two options of the five-point Likert scale.
- **Safety level of children's commute**: the stated perception of the parents regarding their children's safety using the current transport characteristics.
- **Unsafe traffic to walk:** the (un)safety perception of the parents regarding the route for commuting on foot.

The following section discusses the model estimation and results.

3   Model estimation and results

As explained in the previous section, a generalized linear model was developed to assess the use of child safety seats through a set of predictors. Initially, the residuals were analysed, showing no major violations of the Gauss-Markov assumptions; then, the linear model was developed. Table 1 summarises the estimation results of the model. If more than one child is in the

car, the dependent variable refers to the child in the relevant age group. Most model estimates are statistically significant at the 95% confidence interval. The variable reflects parents' gender accompanying the child is marginally insignificant at the 95% level. The involvement of parents in traffic collisions is only significant at the 90% confidence interval, and the father tertiary education dummy is marginally insignificant at the 90% confidence interval.

The heterogeneity of the areas was captured with network-related characteristics of each municipality extracted from the OpenStreetMap database. The use of transportation network infrastructure variables (*i*) relates the difference across the areas with particular features, and (*ii*) is presumably transferable to other regions with the same data type. In particular, the model utilised the number of motorways and pedestrian paths in each municipality. The network-based measures can assist in generalising these findings by proposing that more pedestrian ways and motorways contribute to higher car seat usage. Indeed, this finding is intuitive for the motorways, as more motorways allow for the commute from longer distances and facilitate the use of cars. However, the intuition of a higher percentage of pedestrian paths correlated with higher vehicle use is unclear. As model results suggest, car seat increased use was observed when male and female drivers escorted the children to school. Besides, children restrained with car seats were less frequent when more than two female children older than the examined age bracket were in the same car. Socioeconomic factors were also correlated with child car use. For example, a father's tertiary education was positively associated with child seat use, while nuclear families with one child tended to use car seats more than other family structures. Safer attitudes were also reflected in increased child car seat use, as manifested by the correlation between frequent driver seat belts and car seat use. Similarly, parents involved in traffic collisions tended to put their children in car seats more often.

Table 1 Generalized linear model estimation results

Parameter	Estimated value	t-value
Intercept	0.169	1.411[*]
Pedestrian path length / area	2.464	3.644
Motorway length / area	1.509	2.429
Driver gender: male / female	0.075	1.945[*]
No. of children in car > 2	-0.207	-3.245
Child gender dummy: female	-0.076	-2.292
Child age	-0.044	-2.084
Father tertiary education dummy	0.058	1.612[*]
Family size dummy: couple with one child	0.083	2.098
Use of driver seat belt: frequently	0.499	8.227
Use of driver seat belt: always	0.598	9.311
Parent involved in traffic crashes dummy	0.060	1.797[*]
Null deviance	**91.93**	**(512 d.o.f)**
Residual deviance	**68.778**	**(501 d.o.f)**
AIC	**451.02**	

Note: [*] Insignificant at the 95% confidence interval

Table 2 summarizes the results of the structural equation model specification. The interpretation of the model estimation results is similar to the previous model. For identification reasons, the coefficient of one variable was normalized to 1 (in this case, the father's education level), and other variables were estimated through the model. The latent variable was added as an explanatory variable in the regression equation, as shown in Table 2. The regression equation related the use of a car seat with the latent variable (with which it was positively correlated) and several other characteristics. Infrastructure elements, including the length of motorways and pedestrian paths (by area), were positively correlated with the usage of child car seats. The characteristics of the children (gender and age), the driver's gender, and the family structure behaved similarly to the previous models.

Table 2 Structural equation model estimation results

Latent variables	Estimate	Std. Err.
Traffic safety climate	~	
Father tertiary education dummy	1	
Use of driver seat belt: frequently or always	2.248	2.699
Safety level of children commute	2.446	2.536
Unsafe traffic to walk dummy	-0.802	-1.889
Regression	**Estimate**	**Std. Err.**
Use of child car seat	~	
Traffic safety climate	2.903	2.733
Pedestrian path length/area	2.573	3.984
Motorway length/area	1.674	2.829
Child gender dummy: female	-0.064	-1.940
Child age	-0.048	-2.255
Driver gender: male and female	0.082	2.120
Family size dummy: couple with one child	0.103	2.610
Measures of goodness of fit	**Recommended Value**	**Value**
RMSEA	< 0.08	0.059
SRMR	< 0.08	0.039
GFI	> 0.90	0.943

A crucial aspect of structural equation models is the assessment of the goodness of fit. One general guidance is not to cherry-pick individual goodness of fit measures but instead show several. Along this vein, this study presented three of the most common measures of fit for structural equation models: (*i*) the root mean square error of approximation (RMSEA), (*ii*) the standardized root mean square residual (SRMR), and (*iii*) the goodness of fit index (GFI). Regarding RMSEA, MacCallum *et al.* (1996) have used 0.01, 0.05, and 0.08 to indicate excellent, good, and mediocre fit, respectively, while others have suggested 0.10 as the cut-off for poor fitting models. Therefore, the value of 0.059 in the model is acceptable. Similarly, SRMR values of less than 0.08 are generally considered a good fit (Hu & Bentler 1999); thus, the value of 0.039 in this model indicates a good fit. Regarding the GFI, the value of 0.943 in the model shows a satisfactory fit, as Wang *et al.* (2019) suggested. It is worth mentioning that all models were estimated using the R software, and the Lavaan package was used to estimate the structural equation model (R n/d; Rosseel 2012).

Finally, the path diagram of the developed structural equation model is depicted in Figure 6, illustrating the interconnection between the variables in the model and how variables impact one another. In the path diagram, the latent variable is placed in an oval, and all independent variables have the direction of arrows towards the dependent variable (i.e., use car seat). The following section discusses the details of the structural equation model as well as the main findings of this study.

4 Discussion

4.1 Main findings

This study examined the factors influencing the usage of child safety seats for trips to nursery school. The findings of this study indicated that several factors could impact the use of CRS for everyday commutes to nursery school. These factors can be grouped into six broad categories:

1. **Socioeconomic status.** Model results show that the SES of the area, as well as the level of education of the father, had a positive influence on the use of CRS.
2. **Family travel patterns.** There was a positive influence when male and female drivers were both involved in the commute. An increasing number of children accompanied simultaneously had a negative impact.
3. **Traffic safety climate.** The father's education level – also considered an SES factor – was among the indicators used to characterize the traffic safety climate. In addition, the use of driver seat belts was positively associated with using CRS.
4. **Family structure.** One-parent families with one child and large families used the CRS less often than nuclear families with one child.
5. **Child demographics.** The parents of older girls seemed to use CRS less than those of younger girls and boys.
6. **Road network infrastructure.** A denser road infrastructure seemed to increase the use of child safety seats.

Among the influential factors identified in this study, the impact of socioeconomic status on using CRS is in accordance with the findings of previous research (Rok Simon *et al.* 2016; Brown *et al.* 2013; Schluter & Paterson 2010). However, the impact of family travel patterns on the usage of child safety seats is slightly different in the existing literature, showing a reduced odds of children being properly rear-seated when accompanied by parents and male drivers (Chen *et al.* 2014). Similar effects are found in the literature for the number of children passengers in the car reducing CRS usage (Shimony-Kanat *et al.* 2017; Chen *et al.* 2014; Bilston *et al.* 2010). In addition, the impact of traffic safety climate is similar to the findings of previous studies, where the drivers' higher education status (Chen *et al.* 2014; Keay *et al.* 2012; Pan *et al.* 2011) and seatbelt use were associated with increased use of CRS (Chen *et al.* 2014; Macy & Freed 2012; Bilston *et al.* 2010). Further, the family structure, child demographics, and road network infrastructure show similar influence on the use of child safety seats in previous studies (Lee *et al.* 2019; Hafner *et al.* 2017; Rok Simon *et al.* 2016).

Further, the study results reveal that parents may not be well-informed about the correct use of restraint systems and their lifesaving effects. They often believe that the route they follow on their everyday travel to school by car is safe; therefore, using CRS is unnecessary. On the other hand, children often experience discomfort while seated in car seats and booster seats. In addition, parental permissiveness, the perception that violations of the child restraint law are not enforced, inconvenience, and situational factors influence parents' decisions regarding CRS usage (Dunbar *et al.* 2002).
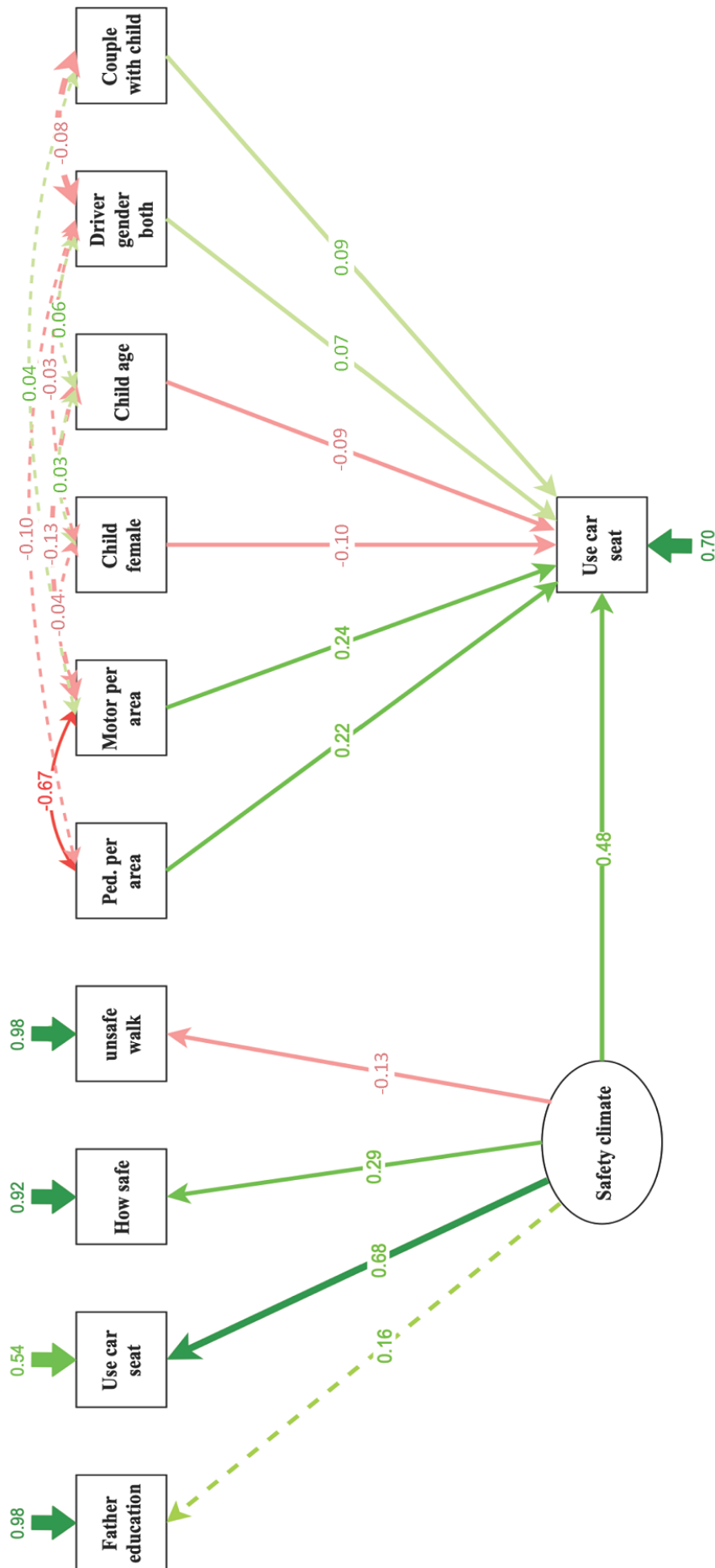
Figure 6 Path diagram for estimated structural equation model; positive coefficients shown in green and negative coefficients in red, with colour intensity and thickness of arrows reflecting the strength of the interconnections

Besides, a child restraint use law has been in place in Greece since 1997; however, it is common for parents not to use restraint systems, especially for short distances, since there is no strict enforcement. Another reason parents do not use restraint systems is that there are no road safety cameras or other means of law enforcement in these suburbs. Hence, compliance with the restraint system law is practically left to parents' beliefs alone.

4.2 Limitations and recommendations

This research utilises data collected through questionnaires. An inherent problem of surveys of this kind is that participants are more likely to be female, married, and have higher annual incomes (Koppel *et al.* 2013). Besides, as Janet Lennon (2012) demonstrated, there are differences between self-reported and observational data regarding CRS usage. Participants potentially report what they believe to be the most socially appropriate response (Lam 2001). This study tried to overcome this limitation by keeping the anonymity of the participants, but it suggests that future research should validate self-reported information with observations. Furthermore, self-selection bias in the study is likely to have resulted in the overrepresentation of more compliant parents (Janet Lennon 2012). Nevertheless, the results provide a close representation of reality since most parents believe they travel with their children safely to school; however, they do not always use restraint systems and seat belts. Since many parents do not use restraint systems, they feel that their response is socially appropriate. Further, this paper neglects the proper use of CRS. While this was not within the scope of the current study, future research could investigate the impact of socioeconomic parameters and traffic safety culture on the correct use of CRS and booster seats.

In addition, there is an economic barrier to using CRS (Keay *et al.* 2013). Since this study took place in Athens during the national economic crisis, there is an additional interest in further exploring the effect of the crisis on the use of CRS systems. Families face continuous reductions in their income, and priorities on expenses need re-evaluation. Lastly, identifying any changes in purchasing new CRS and booster seats for post-crisis time would be beneficial.

Finally, the findings of this study can be exploited for road safety purposes and to increase the usage of child safety seats. This study suggests utilising the identified factors to improve traffic law enforcement and monitoring on rural and less dense roads. Based on the study results, the lower use of CRS can be associated with the lower use of driver seat belts among parents. For parents violating the safety belt laws, additional traffic safety education and courses can improve the safety awareness of parents regarding child passenger safety issues. Besides, factors such as socioeconomic status and family structure can be considered to design safety campaigns to target parents more prone to violate child safety seat laws.

5 Conclusions

The underlying goal of this study is to explore the parameters that impact the usage of child safety seats for the daily trip to nursery school. Three suburbs of Athens with significant differences in SES are classified as low (Fyli), middle (Ilioupoli), and high SES suburb (Kifissia) and considered case studies. The study examines the traffic safety climate, parents' attitudes and behaviour, and the possible associations with CRS usage. The research presents a methodological approach for quantifying factors affecting the usage of child safety seats. Further, the concept of traffic safety culture is explicitly modelled through a latent variable and embedded as an explanatory variable in a structural equation model that captures the factors influencing the use of child safety seats. The results acquired from the developed models (as opposed to simple descriptive statistics or statistical tests, such as t-tests or χ^2-tests) can be used to drive policy decisions quantitatively. For instance, identifying the parameters—positively correlated with

traffic safety culture—can help policymakers create more targeted campaigns to improve the usage of child safety seats.

CRediT contribution statement

Ioanna Armouti: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing—original draft. **Roja Ezzati Amini:** Writing—original draft, Writing—review and editing. **Constantinos Antoniou**: Supervision, Writing—review and editing.

Declaration of competing interests

The authors report no competing interests.

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References

Adminaite, D., G. Jost, H. Stipdonk*, et al.* (2018), 'Reducing child deaths on European roads', presented at *European Transport Safety Council PIN Conference* (Brussel, Belgium), https://etsc.eu/wp-content/uploads/Reducing-child-road-deaths-on-European-roads-Dovile-Adminaite-ETSC.pdf, accessed 22 October 2022.

Arapoglou, V. P., J. Sayas (2009), 'New Facets of Urban Segregation in Southern Europe', *European Urban and Regional Studies*, 16 (4), 345-362, https://doi.org/10.1177/0969776409340187.

Bilston, L. E., W. Du, J. Brown (2010), 'Factors predicting incorrect use of restraints by children travelling in cars: a cluster randomised observational study', *Injury Prevention*, 17 (2), 91-96, https://doi.org/10.1136/ip.2010.027359.

Brown, J., L. Keay, K. Hunter*, et al.* (2013), 'Increase in best practice child car restraint use for children aged 2-5 years in low socioeconomic areas after introduction of mandatory child restraint laws', *Australian and New Zealand Journal of Public Health*, 37 (3), 272-277, https://doi.org/10.1111/1753-6405.12070.

Chen, X., J. Yang, C. Peek-Asa*, et al.* (2014), 'Parents' Knowledge, Attitude, and Use of Child Restraints, Shantou, China', *American Journal of Preventive Medicine*, 46 (1), 85-88, https://doi.org/10.1016/j.amepre.2013.08.017.

Dunbar, G., V. Lewis, R. Hill (2002), 'Parent-child interaction and road behaviour: An exploratory study', *British Journal of Developmental Psychology*, 20 (4), 601-622, https://doi.org/10.1348/026151002760390972.

Durbin, D. R. (2003), 'Belt-Positioning Booster Seats and Reduction in Risk of Injury Among Children in Vehicle Crashes', *JAMA*, 289 (21), 2835, https://doi.org/10.1001/jama.289.21.2835.

Elliott, M. R., M. J. Kallan, D. R. Durbin, F. K. Winston (2006), 'Effectiveness of Child Safety Seats vs Seat Belts in Reducing Risk for Death in Children in Passenger Vehicle Crashes', *Archives of Pediatrics & Adolescent Medicine*, 160 (6), 617, https://doi.org/10.1001/archpedi.160.6.617.

ELSTAT (2017), 'Road fatalities by age, gender, road user type' (Greece: Hellenic Statistical Authority), https://www.statistics.gr, accessed 22 October 2022.

Emery, K. D., S. G. Faries (2008), 'The Lack of Motor Vehicle Occupant Restraint Use in Children Arriving at School', *Journal of School Health*, 78 (5), 274–279, https://doi.org/10.1111/j.1746-1561.2008.00300.x.

Gehlert, T., C. Hagemeister, T. Özkan (2014), 'Traffic safety climate attitudes of road users in Germany', *Transportation Research Part F: Traffic Psychology and Behaviour*, 26, 326–336, https://doi.org/10.1016/j.trf.2013.12.011.

Hafner, J. W., S. J. Kok, H. Wang*, et al.* (2017), 'Child Passenger Restraint System Misuse in Rural Versus Urban Children', *Pediatric Emergency Care*, 33 (10), 663–669, https://doi.org/10.1097/pec.0000000000000818.

Hu, L.-t., P. M. Bentler (1999), 'Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives', *Structural Equation Modeling: A Multidisciplinary Journal*, 6 (1), 1–55, https://doi.org/10.1080/10705519909540118.

Hunter, K., A. Bestman, M. Dodd, *et al.* (2020), 'Overloaded and Unrestrained: A Qualitative Study with Local Experts Exploring Factors Affecting Child Car Restraint Use in Cape Town, South Africa', *International journal of environmental research and public health*, 17 (14), 4974, https://doi.org/10.3390/ijerph17144974.

Janet Lennon, A. (2012), 'Has increasing the age for child passengers to wear child restraints improved the extent to which they are used? Results from an Australian focus group and survey study', *Vulnerable Groups & Inclusion*, 3 (1), 14975, https://doi.org/10.3402/vgi.v3i0.14975.

Keay, L., K. Hunter, J. Brown, *et al.* (2012), 'Evaluation of an education, restraint distribution, and fitting program to promote correct use of age-appropriate child restraints for children aged 3 to 5 years: a cluster randomized trial', *American journal of public health*, 102 (12), e96–e102, https://doi.org/10.2105/AJPH.2012.301030.

Keay, L., K. Hunter, J. Brown, *et al.* (2013), 'Child restraint use in low socio-economic areas of urban Sydney during transition to new legislation', *Accident Analysis & Prevention*, 50, 984–991, https://doi.org/10.1016/j.aap.2012.08.002.

Koppel, S., C. Muir, L. Budd, *et al.* (2013), 'Parents' attitudes, knowledge and behaviours relating to safe child occupant travel', *Accident Analysis & Prevention*, 51, 18–26, https://doi.org/10.1016/j.aap.2012.10.009.

Lam, L. T. (2001), 'Factors associated with parental safe road behaviour as a pedestrian with young children in metropolitan New South Wales, Australia', *Accident Analysis & Prevention*, 33 (2), 203–210, https://doi.org/10.1016/s0001-4575(00)00033-6.

Lee, G., C. N. Pope, A. Nwosu, *et al.* (2019), 'Child passenger fatality: Child restraint system usage and contributing factors among the youngest passengers from 2011 to 2015', *Journal of Safety Research*, 70, 33–38, https://doi.org/10.1016/j.jsr.2019.04.001.

Ling, X. Y., A. J.-H. Ngeow, M. Grace Sy Tan, D. K.-L. Chan (2021), 'A survey of parental knowledge, attitude and practice of using child car seat restraints in Singapore, with a systematic review', *BMJ Paediatrics Open*, 5, https://doi.org/10.1136/bmjpo-2021-rcpch.130.

MacCallum, R. C., M. W. Browne, H. M. Sugawara (1996), 'Power analysis and determination of sample size for covariance structure modeling', *Psychological Methods*, 1 (2), 130–149, https://doi.org/10.1037/1082-989x.1.2.130.

Macy, M. L., G. L. Freed (2012), 'Child Passenger Safety Practices in the U.S', *American Journal of Preventive Medicine*, 43 (3), 272–281, https://doi.org/10.1016/j.amepre.2012.05.023.

Oakil, A. T. M., L. Nijland, M. Dijst (2016), 'Rush hour commuting in the Netherlands: Gender-specific household activities and personal attitudes towards responsibility sharing', *Travel Behaviour and Society*, 4, 79–87, https://doi.org/10.1016/j.tbs.2015.10.003.

Oxford, L., J. Pollock (2015), 'How actively do children travel to their pre-school setting?', *Journal of Transport & Health*, 2 (2), 151–159, https://doi.org/10.1016/j.jth.2015.02.002.

Pan, S., W. Du, F. Jiang, *et al.* (2011), 'Exploring child car passenger safety practices in China: experience from a parental survey in Shanghai', *Injury Prevention*, 18 (2), 133–137, https://doi.org/10.1136/injuryprev-2011-040049.

R (n/d), 'The R Project for Statistical Computing' (The R Foundation), https://www.R-project.org/, accessed 22 October 2022.

Ramsey, A., E. Simpson, F. P. Rivara (2000), 'Booster Seat Use and Reasons for Nonuse', *Pediatrics*, 106 (2), e20, https://doi.org/10.1542/peds.106.2.e20.

Rok Simon, M., A. Korošec, M. Bilban (2016), 'The influence of parental education and other socio-economic factors on child car seat use', *Slovenian Journal of Public Health*, 56 (1), 55–64, https://doi.org/10.1515/sjph-2017-0008.

Rosseel, Y. (2012), 'An R Package for Structural Equation Modeling', *Journal of Statistical Software*, 48 (2), https://doi.org/10.18637/jss.v048.i02.

Roynard, M., P. Silverans, Y. Casteels, P. Lesire (2014), 'National roadside survey of child restraint system use in Belgium', *Accident Analysis & Prevention*, 62, 369–376, https://doi.org/10.1016/j.aap.2013.08.021.

Schluter, P. J., J. Paterson (2010), 'Vehicle child restraint usage for Pacific children aged 6 weeks to 4 years: Findings from the Pacific Islands Families study', *Accident Analysis & Prevention*, 42 (6), 2075–2081, https://doi.org/10.1016/j.aap.2010.06.020.

Schwebel, D. C. (2017), 'Children Crossing Streets: The Cognitive Task of Pedestrians Across Nations', *Annals of Global Health*, 83 (2), 328–332, http://doi.org/10.1016/j.aogh.2017.04.004.

Shimony-Kanat, S., R. Gofin, A. C. Kienski Woloski Wruble, L. Mann (2017), 'Do parental decision-making patterns predict compliance with use of child booster seats?', *International Journal of Injury Control and Safety Promotion*, 25 (1), 53–57, https://doi.org/10.1080/17457300.2017.1323930.

Simpson, E. M., E. K. Moll, N. Kassam-Adams*, et al.* (2002), 'Barriers to Booster Seat Use and Strategies to Increase Their Use', *Pediatrics*, 110 (4), 729–736, https://doi.org/10.1542/peds.110.4.729.

Vesentini, L., B. Willems (2007), 'Premature graduation of children in child restraint systems: An observational study', *Accident Analysis & Prevention*, 39 (5), 867–872, https://doi.org/10.1016/j.aap.2006.08.005.

Wang, K., Y. Xu, C. Wang*, et al.* (2019), 'A Corrected Goodness-of-Fit Index (CGFI) for Model Evaluation in Structural Equation Modeling', *Structural Equation Modeling: A Multidisciplinary Journal*, 27 (5), 735–749, https://doi.org/10.1080/10705511.2019.1695213.

Waygood, E. O. D., M. Friman (2015), 'Children's travel and incidental community connections', *Travel Behaviour and Society*, 2 (3), 174–181, https://doi.org/10.1016/j.tbs.2015.03.003.

WHO (2018), 'Global status report on road safety' (Geneva, Switzerland: World Health Organization), https://apps.who.int/iris/rest/bitstreams/1164010/retrieve, accessed 22 October 2022.

Yannis, G. (2009), 'Use of child seat in Greece', presented at *Seminar for Child Safety in the car—The Greek Reality* (Athens, Greece), https://www.nrso.ntua.gr/geyannis/conf/cp47-use-of-child-seat-in-greece/, accessed 22 October 2022.

Yu, C.-Y., X. Zhu (2013), 'Impacts of Residential Self-Selection and Built Environments on Children's Walking-to-School Behaviors', *Environment and Behavior*, 47 (3), 268–287, https://doi.org/10.1177/0013916513500959.

Zuniga, K. D. (2012), 'From barrier elimination to barrier negotiation: A qualitative study of parents' attitudes about active travel for elementary school trips', *Transport Policy*, 20, 75–81, https://doi.org/10.1016/j.tranpol.2011.12.003.

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