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Exploring home-to-school trip mode choices in Kandy, Sri Lanka

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A R T I C L E I N F O

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A B S T R A C T

Schools are major trip generators in urban areas and school trips may largely contribute to the congestion, particularly during morning peak hours. This study investigates the home-to-school trip mode choices in Kandy city, which is a major city in Sri Lanka. The data were collected through a questionnaire survey distributed among junior, lower senior, and upper senior students of ten major schools located in Kandy city in 2015. School trip mode choices, that comprise several common travel modes in Sri Lanka, i.e., walking, public bus, school bus, school van, private vehicles (car or van), motorcycle, and three-wheeler, were modeled using multinomial logit and mixed logit frameworks. The results indicated that gender, age, household income, school type and distance play a significant role in determining the school transport mode. That is, male students were more likely to choose public buses, walking, and private vehicles relative to other transport (three-wheeler and motorcycle combined) as compared to female students. Further, older students were more likely to walk, take a school bus and public bus relative to other transport when compared to the younger students. Distance to school was found to significantly affect all the school transport modes. National or Provincial school students were more likely to use a school bus and less likely to use a private vehicle. Transport planners and policymakers could use the outcomes of this study, especially to implement congestion mitigation measures in city centers during morning peaks. Besides, some aspects of this study could be used to regulate and legalize some private transport modes, e.g., privately operated school vans, to provide a safer, reliable, and economical service to school-going children.

1. Introduction

Travel activities can be identified as a prominent and essential part of humans' daily life. People travel for accessing education, work, business, and recreational activities. Out of all these travel activities, school trips consist of a significant share of all daily trips. Schools have become substantial trip generators in local areas and cause congestion during peak hours on the streets (Lu et al. 2017; Sun et al., 2021). In addition to congestion, other negative impacts, e.g., harmful emissions, are also linked with school trips (Singleton, 2014; Wilson et al., 2007). Motorized travel modes, such as private cars, largely contribute to the congestion and emissions. Therefore, the choice of school travel modes (by parents or by students) is an important consideration from transport planners' perspective, as 'mode choice' is a key component of the four-step transportation planning process.

Active modes, e.g., bicycles and walking, are being promoted and encouraged in many cities around the world as a strategy to enhance physical activities and reduce childhood obesity among school children (Sirard and Slater, 2008; Grize et al., 2010; Schoeppe et al., 2013; Ermagun and Samimi, 2015; Pavelka et al., 2017; Rojas Lopez and Wong, 2017; Lin and He, 2020). In general, shifting from motorized modes to active modes could reduce congestion and enhance economic, environmental, and health benefits (Rabl and De Nazelle, 2012; Petersen and Pedroso, 2021). However, there are some considerations, e.g.,

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weather conditions and seasons, which influence the choice of active modes to travel to schools (Müller et al., 2008; Herrador-Colmenero et al., 2018; Ma et al., 2019). Seasonal changes make mode choices remarkably different not only within but also across different countries and regions. In addition, parents' perception of safety (Fyhri and Hjorthol, 2009; Mitra, 2013; Guliani et al., 2015), and concerns about comfort (Ermagun and Levinson, 2017) also influence the choice of school travel modes. Such aspects highlight that parents' decisions play a significant role in students' school mode choices. On the other hand, parents escort children to schools owing to various reasons (Yarlagadda and Srinivasan, 2008; Scheiner, 2016; He and Giuliano, 2017). These aspects make the mode choices of school children different from the mode choices of adults.

There are remarkable differences between school trips and non-school trips, particularly in terms of the choice of the mode (Stark et al., 2018a, 2018b). Further, given the differences in weather, geographic and cultural characteristics, choices of school trip modes are likely to vary across different geographical locations (Pont et al., 2009; Larouche et al., 2015). Further, in general, the availability of suitable infrastructure also affects the choice of travel modes in different places (Pont et al., 2009; Forsyth and Krizek, 2010; Schneider, 2013). Therefore, particular travel modes suitable for a particular geographical location, e.g., city or region, might not be appropriate for another location. On the other hand, the model structures and variable and parameter combinations could be remarkably different from country to country or region to region. Most of the previous studies have not taken the heterogeneity of the population into account. In addition, there is a lack of studies that address the school travel mode choices in developing countries, particularly in the South Asian region (Singh and Vasudevan, 2018). Considering such gaps in the current knowledge, this study aims to explore the school travel mode choice behaviors among junior, lower senior, and upper senior school children in Kandy, Sri Lanka using two model structures, i.e., traditional multinomial logit and mixed logit frameworks. This study provides a detailed discussion on the key travel modes, e.g., walking, public transport (bus and train), school bus, school van, private vehicles (car or van), motorcycle, and three-wheeler, used for travelling to schools. In particular, the influencing factors on the choice of those travel modes in this particular city located in central Sri Lanka are studied using the data collected through a questionnaire survey.

This paper is organized as follows: Section 2 discusses the related previous studies on school travel mode choice. This is followed by Section 3 that presents the details of the study area, the questionnaire survey and the analysis methods. Then in Section 4, results and interpretations are presented. Finally, in Section 5, discussions, conclusions, and limitations are presented.

2. Related works

Numerous studies can be found in the literature that explored the characteristics of school trip mode choices. Table 1 summarizes some of those studies published during the past decade, i.e., from 2010 to date, considering the geographic location, age of the students, key travel modes, and the analysis methods.

Various aspects of school trip mode choices have been explored in previous studies as explained bellow.

2.1. Students' and household characteristics

Mitra and Buliung (2015) compared mode choices between children of 11 years old and youths of 14–15 years old in Toronto, Canada and concluded that male youths tend to walk to school compared to female youths. This study demonstrated that gender did not display a significant correlation with walking for 11 years old students. Another study conducted in Canada by Guliani et al. (2015) using the data collected from 5th and 6th grade students, who were approximately 10–12 years old and from 16 public schools, concluded that boys were more likely to walk to school compared to girls. In contrast, Leslie et al. (2010) reported that, Australian girls of 10–14 years old tend to walk more and bicycle less compared to boys. A study conducted in Belgium reported that walking trips are not significantly different between male and female students aged from 10 to 13 years (Zwerts et al., 2010). This study further demonstrated that compared to girls, boys tend to use bicycles to travel to school. On the other hand, girls used cars (as passengers) as the school trip mode compared to boys.

The study by Hatamzadeh et al. (2017) reported that high school girls (aged between 15 and 18) were less likely to walk to the school compared to younger or middle-aged girls who were 7 to 14 years old. However, high school boys were more likely to walk to school compared to middle-aged boys. This finding is consistent with the outcomes of Evenson et al. (2003) who established that the probability of walking to school was generally higher for high school boys. Zhang et al. (2017) explained that active modes, i.e., walking and bicycles, and public transport, i.e., bus and subway, are most famous among boys compared to girls in China. Similar findings have been reported in a study from Iran which mentioned that male students are more inclined to walk or use public transport compared to female students (Ermagun et al., 2015). As explained by Emond and Handy (2012), US male students (age varied approximately from 15 to 18) were more likely to use bicycles to travel to school compared to females. Fyhri and Hjorthol (2009) defined a "mobility index" based on the choice of active modes (walking and cycling), public transport and car. Utilizing this index, they concluded that boys are more independent in mobility compared to girls and the independence in mobility increases with age. Ermagun and Samimi (2015) disclosed that there is a positive correlation between the age of the students and the tendency to walk or to use public transport to travel to school. However, the tendency of using school bus shows a decreasing trend with increasing age. These studies indicate that the gender effect on mode choice, in particular active mode choices, is different across different countries. McDonald (2012) also mentioned that the correlation between gender and choice of walking or biking to school is inconsistent among different studies.

Li and Zhao (2015) stated that household income and car ownership are critical factors that determine school trip mode choices in China. That is, students from low income families were more likely to walk than use bicycles and students from families with a car were more likely to use cars. Similarly, as explained by Assi et al. (2018), the students from higher income families in Saudi Arabia were more likely to use passenger cars to travel to school over walking. In general, car ownership has been identified as a key influence on determining the school trip mode (Ewing et al., 2004; Wen et al., 2008; Yarlagadda and Srinivasan, 2008; Pont et al., 2009; Fyhri et al., 2011; Ermagun and Samimi, 2015; Zhang et al., 2017; Singh and Vasudevan, 2018).

2.2. Active modes and infrastructure considerations

Active walking, i.e., walking and cycling, to school has been declined, particularly in high-income countries (Jacob et al., 2021). McDonald (2007) mentioned that the distance from home to school has increased over time and that might have caused the decline in using active transportation modes to school. Distance from home to school has been identified as a key determinant of active travel to school (Dellinger and Staunton, 2002; Müller et al., 2008; Lee et al., 2013; Guliani et al., 2015; Ikeda et al., 2018; Smith et al., 2020). As stated in Emond and Handy (2012), 'perceived distance' is the hindrance to bicycling to the school than the 'actual distance'. In addition to the long distance, the danger posed by motor vehicle traffic is also one of the most common barriers to walking and cycling to school (Dellinger and Staunton, 2002).

As explained in Timperio et al. (2006), elementary school students preferred to walk or cycle to school if the distance was less than 800 m. Helbich et al. (2016) analyzed 623 trips made by Dutch children of 6–11

Table 1
Previous studies on school travel mode choice.

Reference	Country	Age (years)	Modes	Analysis methods
Cottagiri et al. (2021)	Canada	11–20	Active (walking, bicycle) Non-active (public transport, school bus, car passenger, car driver)	Multivariable logistic regression
Ozbil et al. (2021)	Turkey	12–14	Walking Car School shuttle Public transport	Nominal logistic regression
Van den Berg et al. (2020)	The Netherlands	7–12	Bicycle (including kick-bike) Walking Car Other (including public transport)	Path analysis
Lidbe et al. (2020)	US	5–18	Walking Bicycle Automobile School bus Others	Random parameters multinomial logit
Mandic et al. (2020a, 2020b)	New Zealand	13–19	Car Active	Stepwise logistic regression
Müller et al. (2020)	Germany	10–19	Car Public transport Bicycle Walking	Multinomial logit Nested logit
Barnett et al. (2019)	Hong Kong	11–18	Walking Bicycle Public transport Taxi School bus car	Multilevel logistic regression
Fitch et al. (2019)	US	14–18	Bus Walking Bicycle Car (passenger) Car (driver)	Categorical regression Multinomial logit
Ma et al. (2019)	China	12–14	Walking Bicycle Public transport Car	Multinomial logit Multinomial probit
Mehdizadeh et al. (2019)	Iran	7–9	Car walking	Norm-Activation Model Structural equation models
Scheiner et al. (2019)	Germany	6–10	Walking Bicycle/scooter Bus Car passenger Car + Active	Multinomial logit
Assi et al. (2018)	Saudi Arabia	16–18	Passenger cars driven by the parents Walking	Logistic regression Multilayer perceptron neural networks
Stark et al. (2018a)	Austria and Germany	13	Walking Transit Bicycle Car	Structural Equation Modelling
Stark et al. (2018b)	Austria	6–10	Car Public transport Bicycle Walking	Bivariate analyses/ Correlation analysis
Singh and Vasudevan (2018)	India	5–15	Non-motorized (Walking, Bicycle, Cycle-rickshaw) Motorized (School bus, Paratransit, Family vehicle)	Multinomial logit
Hatamzadeh et al. (2017)	Iran	7–18	Walking	Binary logit models
Helbich (2017)	The Netherlands	6–11	Walking Bicycle Motorized	Mixed multinomial logit Principal components
Zhang et al. (2017)	China	7–18	Walking Car Bus or subway Bicycle	Tree-based and logit-based models
Broberg and Sarjala (2015)	Finland	11, 14	Walking Cycling Motorized modes	Multinomial logit
Li and Zhao (2015)	China	13–15	Walking Bicycle Public transport Car	Logistic regression
Mitra and Buliung (2015)	Canada	11, 14, 15	Walking Transit	Multinomial logit

(continued on next page)

Table 1 (*continued*)

Reference	Country	Age (years)	Modes	Analysis methods
Guliani et al. (2015)	Canada	10–12	School bus Car Driven Walking	Structural equation models
Ermagun et al. (2015)	Iran	12–17	Escorted (private, school bus, public, walking) Unescorted (Walking, public transport)	Two-level nested logit
Kamargianni et al. (2015)	Cyprus	11–18	Car Powered two wheeler/ Motorcycle Bus Walking Bicycle	Bhat and Dubey''s (2014) new probit-kernel based Integrated Choice and Latent Variable (ICLV) model
Noland et al. (2014)	US	4–14	School bus Car Carpool Walking	Mixed logit model
Oliver et al. (2014)	New Zealand	5–14	Walking Bicycle Private motorized Public transport	Bivariate and multivariate generalized regressions
Pojani and Boussauw (2014a, 2014b)	Albania	11–13	Walking Bus Car Bicycle	Logistic regression
Emond and Handy (2012)	US	14–18	Bicycle Not-bicycle (car, walking, bus)	Binary logistic regression
D'Haese et al. (2011)	Belgium	11–12	Bicycle Walking	Two-level bivariate, logistic regression analyses
Alemu and Tsutsumi (2011)	Japan	15–18	Monorail Walking Bus Car	Multinomial logit
De Vries et al. (2010)	The Netherlands	6–11	Walking Bicycle	Multivariate linear regression analyses
Leslie et al. (2010)	Australia	10–14	Walking Bicycle Car Bus/train/tram	Binary logistic regression

years old and concluded that the commuting distance is negatively associated with active transport only when personal, traffic safety, and weather characteristics are considered. For urban landscapes, the green space and weather were not significant determinants of the choice of active mode. They further mentioned that well-connected roads and bicycle lanes are positively correlated with active transport to school in urban environments. Pont et al. (2009) also stated that the availability of walk or bicycle paths is linked with higher rates of active transport. However, as discussed in Pont et al. (2009), longer distance to school, higher household income, and car ownership are associated with lower rates of active transport among children. Timperio et al. (2006) described that the busy roads (objectively measured) negatively influence walking or cycling to schools among Melbourne children aged 5 to 6 years and 10 to 12. For younger children, objectively measured steep inclination of the road was negatively correlated with active commuting. Müller et al. (2020) also explained that the choice of certain transport modes, particularly active modes, are influenced by hilly environments.

2.3. Weather and seasonal influences

A study conducted in Germany by Müller et al. (2008) concluded that weather is among the most influential factors for shifting students from low cost school travel modes like bicycles to high cost modes. Blanchette et al. (2020) explored the influence of climate and weather conditions on the active travel to school of Canadian school children of 9–12 years old (grades 4 to 6) and concluded that the daily weather variations impacted active travel to school compared to seasonal variations. Active travel to school was positively associated with the temperature only among female students. Herrador-Colmenero et al. (2018) studied the influence of weather conditions and seasons on travel mode choice for commuting to and from school among Spanish students aged 7 to 18 years old. Their results indicated that 7 to 11 years old students (i.e., children) were less likely to commute to school using an active mode in winter. Adolescents (12–18 years old) were more likely to commute to school by active modes in spring. Further, adolescents tend to use active modes to commute from school with the increase in mean temperatures. The study by Mitra and Faulkner (2012) concluded that seasonal climate and weekly weather conditions do not play a major role in school travel mode choice by 11–12 year old children in Toronto.

2.4. Parents' perception and considerations

For the students in primary grades, school travel modes are determined mostly by their parents. As stated in several previous studies, children's active commuting to school was most strongly correlated with parental concerns (Kerr et al., 2006; Rojas Lopez and Wong, 2017; Sener et al., 2019). Parents were also concerned about few other children in the community, availability of crossings for the children to use, and busy roads (Timperio et al., 2006). In addition, the distance to school, unavailability of sidewalks, and intersection density were strongly associated with parental considerations (Guliani et al. (2015). A study conducted in Belgium demonstrated that both the actual and perceived traffic safety significantly influence parents' decisions on primary school children's school travel mode choice (Nevelsteen et al., 2012). Mandic et al. (2020a, 2020b) explained that New Zealand parents preferred walking than cycling to school by their adolescent children of 13 to 18 years old.

It can be noted that different aspects of school travel mode choice behaviors have been explored by researchers from different geographic locations. Differences in infrastructure, weather, income levels, parental perceptions, etc. make the mode choices remarkably different in different countries or regions. Thus, the outcomes of different countries or cities might not be generalized to represent the situation in a different geographical location. On the other hand, there is a lack of studies conducted in developing countries to explore the school travel mode choices. To the best of the authors' knowledge, none of the previous studies comprehensively studied the school travel mode choices in Sri Lanka. In this study, a questionnaire was designed and conducted to explore school travel mode choice among the school children in Kandy city, Sri Lanka. Details of the questionnaire survey and analysis methods are described in the following section.

3. Methods

3.1. Study area

Kandy is a major city located in the Central Province of Sri Lanka. Kandy district has a population of 1.48 million spread across a geographical area of 1940 km^2 (Department of Census and Statistics Sri Lanka, 2019). Out of the total population in Kandy district, approximately 0.28 million are school-going children (grade 1 to 13 or 6 to 18 years old). There are 161 schools with at least 500 students located within Kandy district. Out of them, twenty three are major schools with more than 2000 students in each (Ministry of Education Sri Lanka, 2016a).

Traffic surveys conducted at entry points of the Kandy municipal area indicated that private vehicles accounted for 79% of average daily traffic. However, these private vehicles conveyed only 32% of the passengers. On the other hand, buses contributed to 9% of average daily traffic, carrying 64% of passengers. In addition, rail also carried approximately 3000 passengers daily which is only 1% of the total number of arrivals (Kumarage and Bandara, 2017).

The current study covers 10 major schools located within the Kandy Municipal Council area. Locations of these schools are shown in Figure 1 and as can be noted from the map, these schools are located approximately within a 4 km × 4 km within the Kandy municipal council area close to main roads.

Several modes are available for students to travel to and from schools in Kandy, which include public bus, school bus, school van, train, school van, private vehicles (car, van), three-wheeler, motorcycle, and walking. Generally, schools buses are operated in areas where the population of school-going children is relatively high. Similar to public buses, school bus services are also operated and maintained by the Sri Lanka Transport Board, i.e., by the government, and only school-going students can use this service. School buses are operated on public bus routes and students may buy a monthly season ticket or pay cash. In some cases, school buses are designated to one or several schools depending on the gender.

School vans are mainly privately owned and offer door-to-door service. Although the service is called "school vans", in addition to 10-seater vans (e.g., Toyota Hiace, Nissan Caravan), 30-seater buses (e.g., Toyota Coaster, Mitsubishi Rosa) are also being used to transport students. There are distinct differences between school vans and school buses. School vans are privately owned and serve one or several schools. Further, school vans operate not only on main bus routes, but on local roads as well. The parents communicate with the service provider to arrange the service (and to reserve a seat). In general, the payments are made monthly. On the other hand, school buses are operated by the government and no seat reservation is required. In addition to the above modes, parents also drop off or pick up students using private modes, e.g., private cars or vans, motorcycles, and three-wheelers.

3.2. Questionnaire design

A questionnaire was designed to obtain the details of the travel modes used for travelling to schools and the influencing factors of the choice of those modes. The questionnaire forms were prepared in three languages, i.e., Sinhala, Tamil, and English. Questionnaire forms contained three main sections: (1) details of the student (grade, gender, village, and the nearest town), (2) details of family, i.e., number of family members, household income, and vehicle ownership, and (3) detail of the trip and mode of transport, i.e., travel mode, travel time, travel distance, and travel cost. In addition, respondents were asked to rate the main concerns, i.e., low cost, low travel time, safety, comfort, and reliability, that encouraged them to choose the particular travel mode they have been using. The questionnaire survey was conducted following the guidelines by University of Peradeniya, Sri Lanka. Participation in this survey was totally voluntary and personally identifiable information, e.g., name, telephone number, home address, were not collected.

3.3. Questionnaire administration

Ten schools, i.e., 5 boys' schools and 5 girls' schools, located within the Kandy municipal council area were selected (Fig. 1). Out of the five boys' schools, two schools were national schools, two were provincial schools, and one was a private school. Similarly, two girls' schools were national, two were provincial and one was private. In total, 3840 questionnaire forms were distributed (1920 among boys' schools and 1920 among girls' schools) among the students of 8 grades (from grade 6 to 13) in the selected schools. These grades represented junior (grades 6 to 8), lower senior (grades 9 to 11), and upper senior (grades 12 and 13) students. The survey was conducted in May and June of 2015. The questionnaire forms were sent to the parents through the students. In total, 1154 and 829 completed forms were collected from boys' and girls' schools, respectively. This yielded a response rate of approximately 60% and 43% from boys' and girls' schools, respectively. The completed questionnaire forms were collected via relevant class teachers.

3.4. Analysis methods

The data collected in this study was initially analyzed using traditional descriptive statistics. Continuous variables, such as travel cost and distance, were compared for different categorical variables using box plots and bar charts. Further, non-parametric tests (i.e., Kruskal-Wallis and Mann Whitney U tests) were used in this work to identify statistical differences between these categories (see Section 4.1).

To investigate the mode choice of school-going students, discrete choice modelling was used in this study. Discrete choice models are a very popular modelling solution to investigate how different factors impact the decision-making between different categorical alternatives. As such, these models represent one of the most popular solutions adopted in transportation to investigate mode choices. Several mode choice examples are proposed in Train (2009), Ortúzar and Willumsen (2011), and Greene and Hensher (2010). Discrete choice models assume that a q decision-maker ($q = 1, \ldots, Q$), who needs to choose between i alternative, assign to each alternative a U_{iq} utility function which is specified in Eq. 1.

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

where V_{iq} is a deterministic term and ε_{iq} is the random term of the utility function. V_{iq} can have different specifications; however, in this study a linear specification is used as shown in Eq. 2.

$$V_{iq} = \sum_j \beta_{ij} X_{iqj} \tag{2}$$

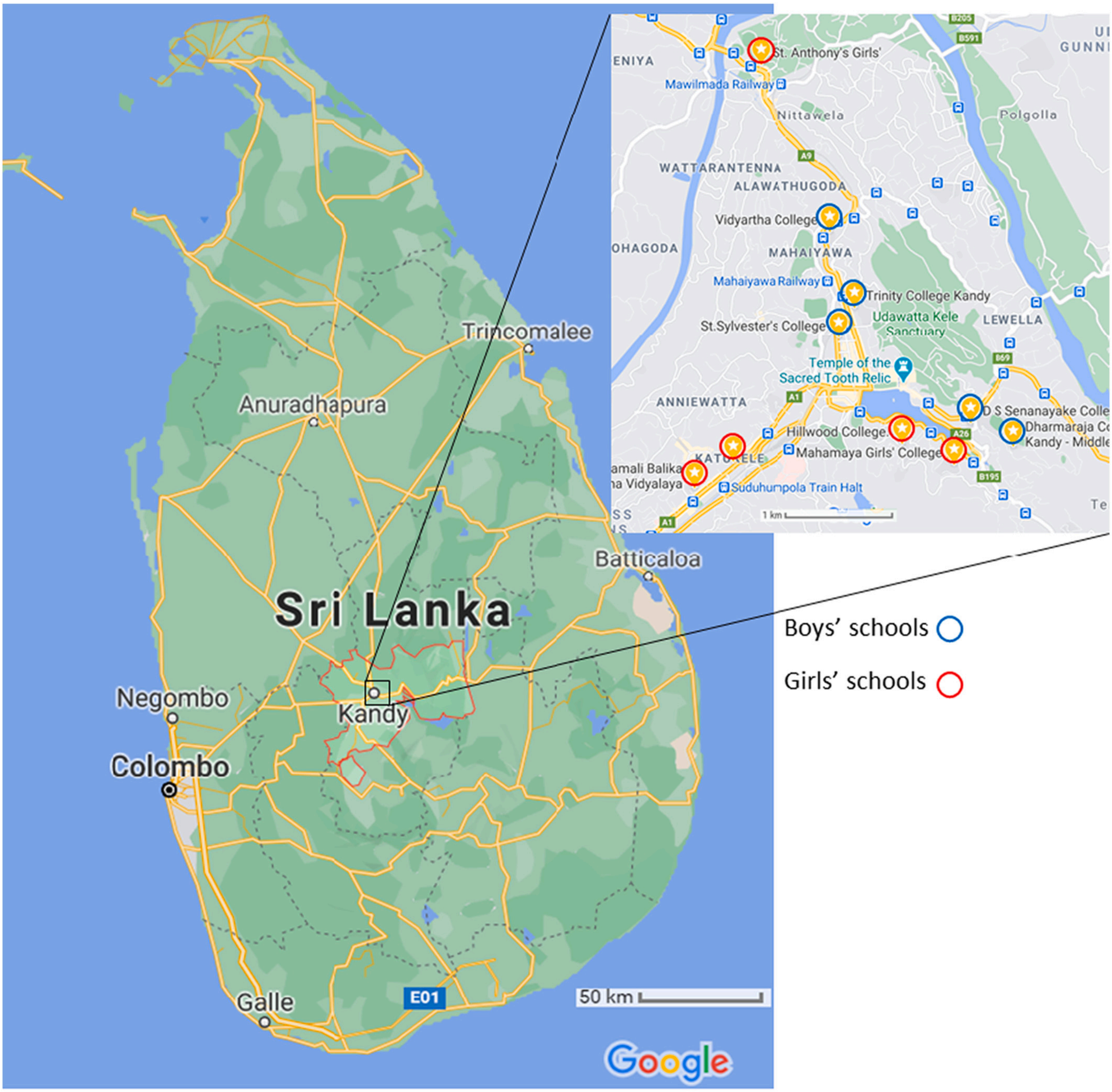

Fig. 1. Kandy district and the locations of schools considered in this study (Source: Google Maps).

where X_{iqj} are the j factors affecting the q decision-maker for the i alternative, whereas β_{ij} are parameters associated to these factors. It is possible to demonstrate that the P_{iq} probability that a q decision-maker chooses i alternative has the forms shown in Eq. 3 if assuming that that random terms in Eq. 1 follow Gumbel distributions with mean 0 and variance $\pi^2/6$ and these are independent and homoscedastic (Ortúzar and Willumsen, 2011).

$$P_{iq} = \frac{e^{Viq}}{\sum_k e^{Vik}} \tag{3}$$

Eq. 3 shows the formulation of a classic multinomial logit model. In this work, a more advanced modelling solution is used to investigate the respondents' heterogeneity assuming that β_{ij} have random distributions. These advanced models are known in the literature as mixed logit models and have been widely used to investigate how the same factors can have different impacts on several decision-makers (Train, 2009). Assuming that f is the probability density function of the β_{ij} parameters, and α_{ijz} are the z parameters defining f, the $\widetilde{P_{iq}}$ probability that a q decision-maker chooses i alternative has the formulations shown in Eq. 4 (Greene and Hensher, 2010).

$$\widetilde{P_{iq}} = \int \frac{e^{Viq}}{\sum_k e^{Vik}} f\left(\beta_{ij}|\alpha_{ijz}\right) d\beta_{ij} \tag{4}$$

Eq. 4 does not have a closed solution. As such, $\widetilde{P_{iq}}$ is estimated by using Monte Carlo techniques obtaining a simulated probability $(\widetilde{\widetilde{P_{iq}}})$. Eq. 5 shows the formulation used for $\widetilde{\widetilde{P_{iq}}}$.

$$\widetilde{\widetilde{P_{iq}}} = \frac{1}{R}\sum_{z}^{R} P_{iq}(\boldsymbol{\beta}_z) \tag{5}$$

where $\boldsymbol{\beta}_z$ are vectors of β_{ij} parameters drawn from f, and R is the number of draws. As such, Eq. 5 can be used to build a L likelihood function to estimate all the α_{ijz} unknow parameters as shown in Eq. 6.

$$L = \prod_{q=1}^{Q}\sum_{i}^{I_q} y_{iq} \bullet \widetilde{\widetilde{\mathrm{P}_{\mathrm{iq}}}} \tag{6}$$

where y_{iq} is equal to 1 if the q decision-maker selects the i alternative (i = 1, …,I_q), otherwise 0. Numerous techniques are available in the literature to solve the likelihood maximization problem to estimate the values of α_{ijz} which maximize this function.

The results from the classic multinomial logit model and the mixed logit model are also compared in this study. This comparison is done using two approaches as follows:

1. Comparing the fitting metrics such as the Log-likelihood values (LL) and the McFadden R.(Ali et al., 2020) Being these two models nested, it is also possible to run this comparison by using Likelihood Ratio Test. This test compares the goodness of fit of two competing statistical models based on the ratio of their likelihoods.
2. Comparing the elasticity of continuous variables of the two model by using the direct point elasticity proposed by Louviere et al. (2000) in Eq. 7.

$$E_{X_{iqj}}^{P_{iq}} = -\beta_{ij}X_{iqj}\left(1 - P_{iq}\right) \tag{7}$$

As such, it is possible to calculate elasticities ($E_{Xiqj}{}^{P_{iq}}$) for each individual decision-maker. We use *probability-weighted sample enumeration* method proposed in Eq. 8 to calculate sample elasticities being the more robust approach among others (Louviere et al., 2000);

$$E_{X_{iqj}}^{P_i} = \left(\sum_{q=1}^{Q}\widehat{P}_{iq}E_{X_{iqj}}^{P_{iq}}\right)\bigg/\sum_{q=1}^{Q}\widehat{P}_{iq} \tag{8}$$

where P_i is the aggregate probability of choice of alternative i and $\widehat{P}_{iq}$ is an estimated choice probability.

4. Results

4.1. Descriptive analysis

In total 1983 complete responses, i.e., 1154 and 829 responses from boys' schools and girls' schools, respectively, were received. A descriptive summary of the responses is presented in Table 2.

Out of all respondents, about 58% of the respondents were male, whereas, about 42% of the respondents were female. In terms of the grade, it can be noted that a well-distributed sample has been achieved. The distribution of responses for mode choice explains that most of the students used school van (39.2%) followed by public bus (22.1%) and private car/van (11.5%). Only 6.6% of the students walked to their school. The train was the least popular mode and only 0.7% of the students used it to commute to school. In addition, 4.3% and 3.1% of the students used motorcycles and three-wheelers, respectively.

Mean and standard deviations for the continuous variables, i.e., distance to school, the income of the family, one-way daily travel cost, and travel time, are summarized in Table 3. It can be noted that, on average, a student travelled 9.9 km from home to school. It was further noted that the travel distances ranged from 0.2 km to 71.3 km. The average travel time from home to school was around 47 min. Such travel time during morning peak hours is expected given the congestion levels in Kandy city, Sri Lanka (Kandy City Transport Study, 2011; Zimar and Sanjeevan, 2016).

Boxplots of travel distances for different modes are shown in Figure 2. It can be observed that, walking is associated with shorter distances as expected. Average walking distance (± SD) and the range were 1.47 (± 0.92) km and [0.2 km, 5.0 km], respectively. Keall et al. (2020) defined that less than 2.25 km and between 2.25 km and 4 km as walkable and cyclable distances, respectively. It was noted that only 47% of the students within the walkable distance actually walked to school in this study. On the other hand, approximately 42% of the students, who lived within walkable distance, either used a private transport mode, i.e., car, three-wheeler and motorcycle, or school van. This observation highlights the importance of improving walking facilities (to enhance the safety and connectivity) to encourage students to walk to school or to use other active modes, e.g., bicycles.

For medium distances, students used private modes, e.g., private cars, motor cycles, three-wheelers. The average distances (± SD) for the students who commuted to school by three-wheelers, motorcycles and car or van were 5.59 (± 5.50) km, 7.19 (± 6.68) km, and 8.35 (± 7.54) km, respectively. Longer travel distances are linked with public transport modes, e.g., train, public bus, school bus, or shared transport modes, e.g., school van. The average distances (± SD) for the students who commuted to school by public bus, school bus, and school van were 10.60 (± 8.34) km, 11.87 (± 8.47) km and 11.55 (± 8.37) km, respectively.

Boxplots of home-to-school travel costs are shown in Figure 3. As shown in Figure 3, travel costs considerably changed across different models. According to the Kruskal-Wallis test, the average one-way daily travel costs between different modes were statistically significant (H statistic = 969.0971, p-value <0.000).

One-way daily travel cost was the highest for school vans followed by private car or van. As confirmed with the Mann Whitney U test, the travel costs between private vehicles (car or van) and school vans were statistically significant ($Z = 10.259372$, $p < 0.000$).

As reported by the students (and parents), the train had the lowest one-way daily travel cost with an average travel cost (± standard deviation) of 15.8 (± 8.3) LKR. Mean (± SD) for other relatively inexpensive travel modes, i.e., school bus, public bus and motor cycle, were 18.42 (± 14.40) LKR, 21.39 (± 19.80) LKR, and 15.95 (± 13.96) LKR, respectively. As confirmed with the Kruskal-Wallis test, one-way travel costs between train, school bus, public bus and motor cycle were statistically insignificant (H statistic = 5.9761, p-value = 0.1128).

4.1.1. School trip mode choice and age

Mode share for different grades (or age groups) is shown in Figure 4. It can be understood that the mode share of public transport tends to increase while the mode share for school vans tends to decrease with increase in age. That is, students tend to shift from school van to public transport modes with increase in age. With age, students become more independent and some independence is needed, e.g., to buy the ticket, get down at the right stop, etc., when using public transport modes. Mitra and Buliung (2015) revealed that there are differences between mode choices of children and youth. For example, the choice of transit was associated with youths (14–15 years) compared to children (11 years). As can be understood from Figure 4, such observations reported in previous studies are consistent with the findings of the current study.

4.1.2. Gender influence on school trip mode choice.

Shares of modes corresponding to gender are shown in Figure 5, which shows that public transport modes, e.g., public bus and school bus, were famous among male students. That is, 44% of male students used such modes to travel to school. However, only 21% of the female students used public modes. School van was the most famous mode among female students and 55% of female students used school vans. Previous studies also indicated that, in general, male students tend to use public transport more than female students do (Zhang et al., 2017; Ermagun et al., 2015). Sexual harassment of women on public transport

Table 2
Summary of the survey responses.

Item	Category	N	%
Gender	Male	1154	58.2
	Female	829	41.8
Grade (mean age in years)	6 (11)	297	15.0
	7 (12)	275	13.9
	8 (13)	328	16.5
	9 (14)	222	11.2
	10 (15)	300	15.1
	11 (16)	206	10.4
	12 (17)	252	12.7
	13 (18)	103	5.2
School type	National	845	42.6
	Provincial	783	39.5
	Private	355	17.9
Travel mode	Walking	130	6.6
	Public bus	438	22.1
	School bus	195	9.8
	School van	778	39.2
	Private vehicle (car or van)	282	14.2
	Motorcycle	85	4.3
	Three wheeler	62	3.1
	Train	13	0.7

Table 3
Summary of continuous variables.

Items (unit)	Mean	Standard deviation
Distance from home to school (km)	9.91	8.29
Income (LKR) *	64,176	47,422
One-way travel cost (LKR) *	45.2	45.1
Travel time (minutes)	46.87	25.59

* 1 USD = LKR 134 (Sri Lankan Rupees) (as of June 2015).

has been identified as a critical issue in the South Asian region (Harrison, 2012; Butt et al., 2020). This could be the main reason for the less preference for travelling on public transport, especially during peak hours, by female students.

4.1.3. School type and school trip mode choice

Mode share corresponding to different school types is shown in Figure 6. It can be noted that school van is the most famous mode among students from all school types. However, the mode share for private vehicles was higher for private school students compared to the students from other school types. On the other hand, public transport mode share was higher for provincial school students compared to public and private school students. As stated in Wettewa and Bagnall (2017) and Aturupane et al. (2018), school choices by parents in Sri Lanka display some socio-cultural characteristics. That is, parents with higher socio-economic status are more likely to send their children to famous schools, e.g., private and top public schools considered in this study. Such families are more likely to own a private vehicle. This means that students who attend private schools are more likely to use private vehicles (i.e., less likely to use public transport) as compared to the students who attend national or provincial schools.

4.1.4. Influence of household income on school trip mode choice

Figure 7 shows the differences in mode share by different income groups. It is clear that with the increasing income level, share for private transport modes (private car or van) tends to increase. On the other hand, the share of public transport modes, e.g., public bus and school bus, tends to decrease with increasing income level. In general, car ownership is linked with the income level (Dargay and Gately, 1999; Nolan, 2010). Therefore, parents with higher income are inclined to use private vehicles to drop students at schools. Ali et al. (2020) also mentioned that high-income parents in Lahore, Pakistan prefer private vehicles over shared modes.

4.1.5. Main reasons behind choosing the school travel mode

Percentages of responses for the main concerns for choosing the school travel mode that they were using are summarized in Figure 8. It can be understood that students chose private vehicles and school van mainly because of the safety. That is, regardless of the higher travel cost (see Figure 3), parents are willing to choose school vans or private cars considering the safety of the children. School vans provide door-to-door

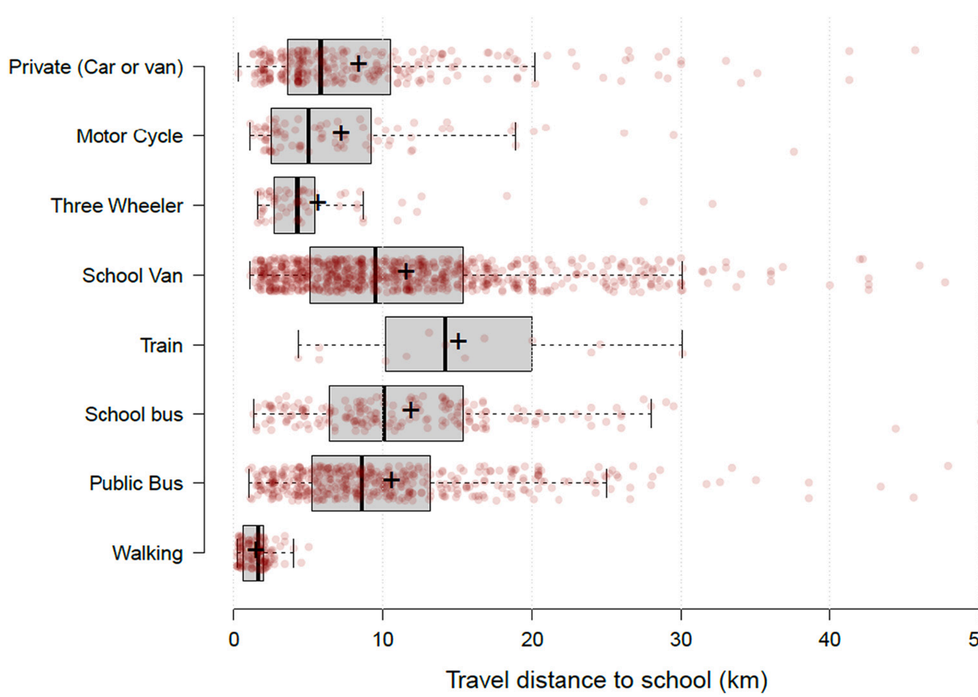

Fig. 2. Boxplots of one-way (home to school) travel distance for each mode ("+" represents the sample mean, red dots represent individual travel distances, Whiskers are based on Tukey's definition that they extend to data points that are less than 1.5 x IQR away from 1st or 3rd quartile). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

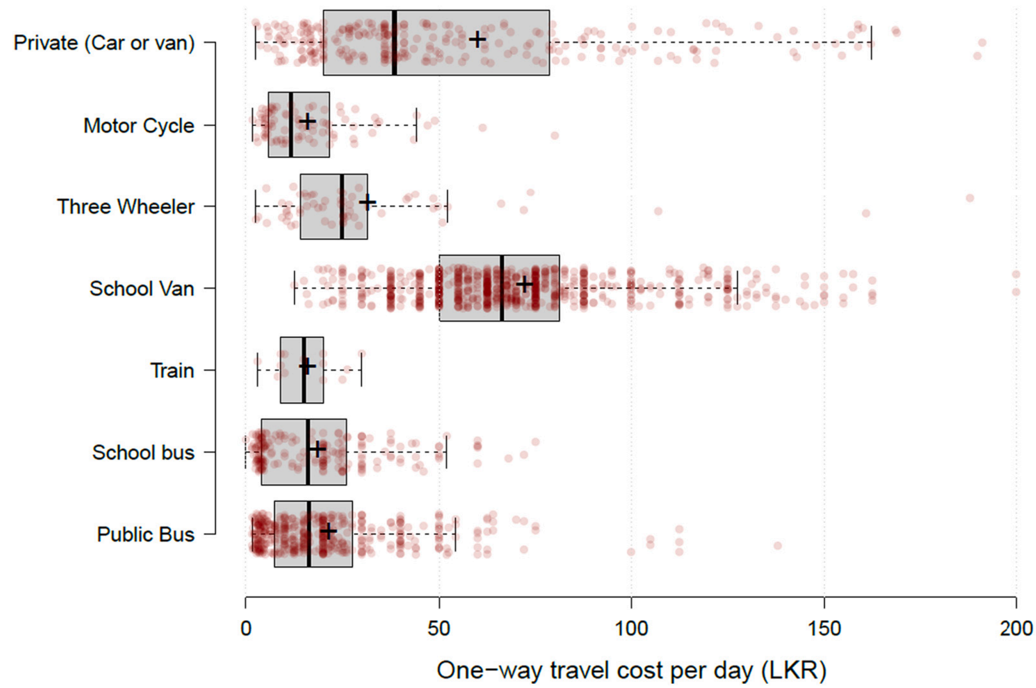

Fig. 3. Boxplots of one-way (home to school) travel cost for each mode ("+" represents the sample mean, red dots represent individual travel costs, Whiskers are based on Tukey's definition that they extend to data points that are less than 1.5 x IQR away from 1st or 3rd quartile), 1 USD = 134 LKR (as of June 2015). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

service and because of the perceived safety, younger and female students tend to travel to school by school van (see Figures 4 and 5). On the other hand, public transport modes, i.e., public bus and school bus, were chosen mainly due to the low cost. Further, as can be perceived from Figure 8, low travel time also plays a role in determining a mode to commute to school.

4.2. Mode choice modelling

The discrete choice modelling approach is used to investigate how multiple factors affected the mode choice of the school-going students who took part in the questionnaire survey. In this work, the transport mode used in the model specification are walking, public bus, school bus, school van, private vehicle (i.e., car and van), and other modes (i.e., three-wheeler and motorcycle). These modes have been identified as the main school transport modes in Kandy city (Kandy City Transport Study, 2011). The train consisted of only about 0.7% of the modal share. As such, that was removed from further analysis, and the remaining 1970 choices were used in the model estimations. In this work, two models are proposed, i.e., a multinomial logit model and a mixed logit model. In the proposed models, other modes (i.e., three-wheeler and motorcycle) are considered as the reference category. The independent variables included in the model are all the variables defining the decision-making characteristics, i.e., gender, school type, grade, income, and distance from home to school. The correlations between independent variables were computed before estimating the model to avoid multicollinearity. In the proposed mixed logit model, it was assumed that only the parameters associated with the distance follow normal random

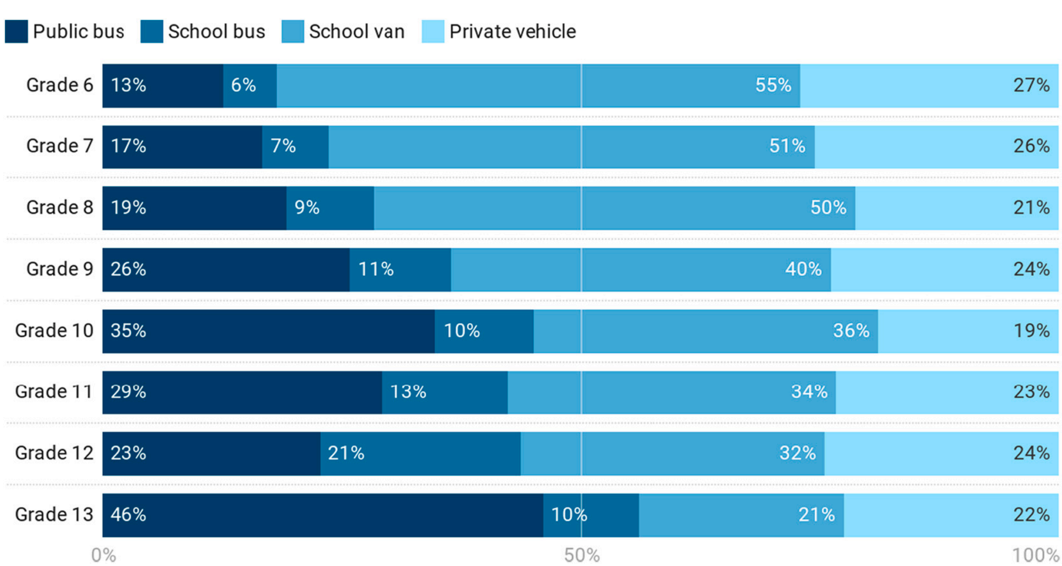

Fig. 4. Share of modes by grade.

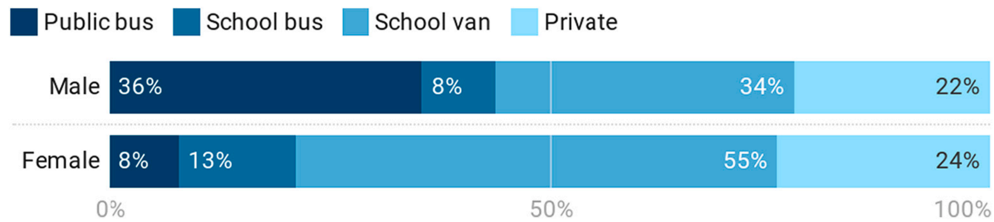

Fig. 5. Share of modes by gender.

distributions as all these parameters are statistically different from zero in the multinomial logit model. As such, this advanced model allows the investigation of the heterogeneity of how respondents perceive their distance from home to school. Both models were estimated using the *mixl* package available in R (Molloy et al., 2021). The model specifications based on the *mixl* syntax are available in Appendix A.

The estimated parameters for the multinomial logit and mixed logit models are presented in Table 4 with the fitting statistics provided by the *mixl* package. The fitting statistics show that the mixed logit model provides a higher value of likelihood. The Likelihood Ratio Test indicates that the mixed logit model fits the data significantly better than the multinomial logit using a significance level of 0.05. This is confirmed also by the comparison of the AIC (Akaike's Information Criteria), AICc (Akaike's Information Criteria with correction) and BIC (Bayesian Information Criteria) of the two models. In other words, the use of random parameters to investigate the heterogeneity in distance perception provides a better fitting with the data. As such, in the remaining part of this section only the mixed logit model results are explained.

A further comparison between the Multinomial Logit Model and Mixed Logit Model is carried out in this work by comparing the elasticities of the parameters weighting the impact of the distance in the decision-making process. In fact, while most of the parameters of the two model are comparable, there is a substantial change in the value of the distance parameter for the walking mode (See Table 4). These elasticities are calculated using the *probability weighted sample enumeration* method as described in Section 3.4 and they are shown in Table 5. The results in Table 5 highlight that the mixed logit model present an increment of elasticity in absolute value of 45% for the walking mode. As such, the distance for walking mode has a higher impact on the change of probability of using this mode in the mixed logit model.

Considering a significance level of 0.10, it is possible to observe that all the independent variables used in the mixed logit model specification have a significant impact on at least one of the mode utility functions. It is worth reminding the reader that the proposed model needs to be interpreted considering the other modes (i.e., three-wheeler and motorcycle) as the reference category. This mode is coded as mode 6 in the *mixl* syntax as explained in Appendix A. For each variable, a positive sign indicates that the variable increases the probability of a decision-maker to choose a mode while a negative sign reduces this probability.

The model shows that the gender has significant impact on the probability of a decision-maker to walk, to use a public bus and a private vehicle. The model indicates the most unlikely modes that a female decision-maker would use is a public bus followed by walking and private vehicle. As such, female decision-makers are more likely to use other modes as compared to public bus, walking and private vehicles. This is in line with the results published by Madhuwanthi et al. (2015), who also reported that adult males tend to choose private cars in Colombo, Sri Lanka. However, as reported in Singh and Vasudevan (2018), female students are more likely to use school bus compared to male students in Kanpur, India.

The type of school also has an impact on the mode choice. In fact, decision-makers going to National or Provincial schools are more likely to use a school bus and less likely to use a private vehicle. School choices in Sri Lanka have socio-cultural and socio-economic aspects (Wettewa and Bagnall, 2017; Aturupane et al., 2018). In particular, school going children who belong to families with higher socioeconomic status are more likely to attend top and famous schools, e.g., private schools considered in this study. Households with higher socio-economic status are more likely to own a private vehicle. In addition, households with children attending to private schools, which are paid, are also likely to own private vehicles. This means that students who attend to private schools are more likely to use private vehicles (i.e., less likely to use school bus that is also a type of public transport) as compared to the students who attend national or provincial schools.

Focusing on the grade variable, which is a proxy of the decision-makers' age, the model shows that the most likely mode that an older decision-maker would use is walking followed by public buses and school buses. Older students seem very unlikely to use school vans. Wilson et al. (2010) also reported that older children are more likely to travel to school by bus than the younger children in Minnesota, USA. As they mentioned, one possible reason could be that parents may believe that older children can take care of themselves while travelling using public transport. Whereas, the students studying in the higher grades are less likely to use school van relative to other transport when compared to those studying in the lower grades. School vans are door-to-door services and considering the safety of younger students, parents choose this mode both for home-to-school and school-to-home trips regardless of the higher travel cost. Students become more independent with age and they tend to shift to cheaper and more independent options. The study conducted in Iran by Ermagun and Samimi (2018) also reported that, older students are more likely to walk and use public transport compared to younger students. This finding is in line with the outcomes of the current study.

The model also illustrates that income can influence mode choice

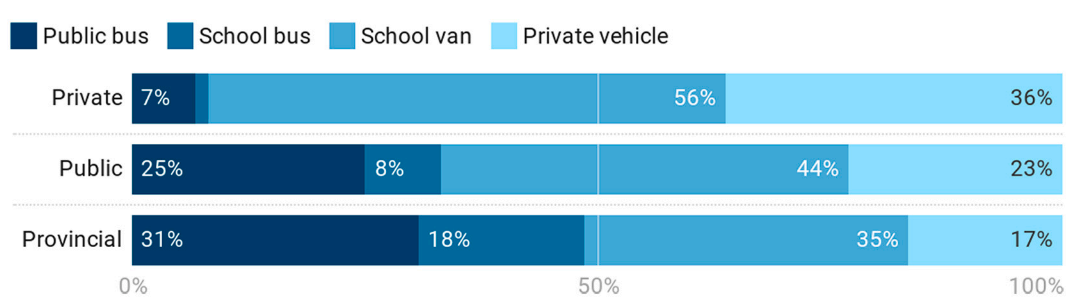

Fig. 6. Share of modes by different school types.

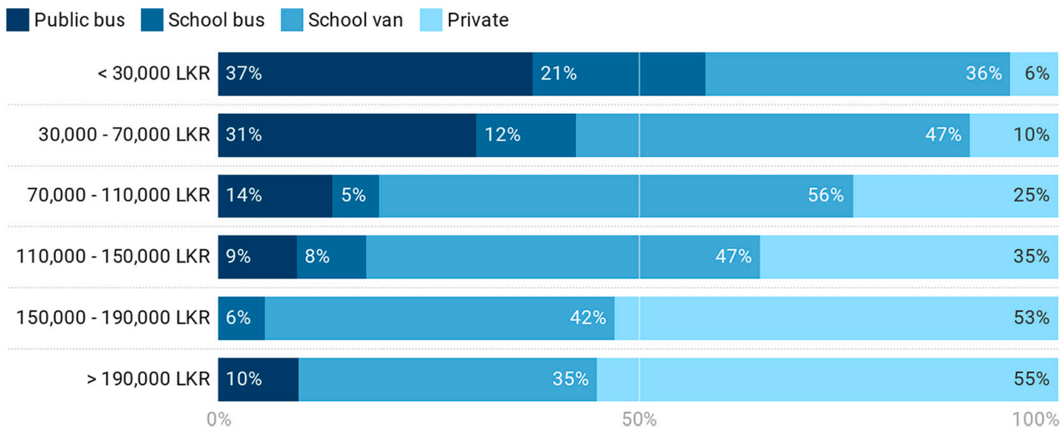

Fig. 7. Share of modes by different household income groups.

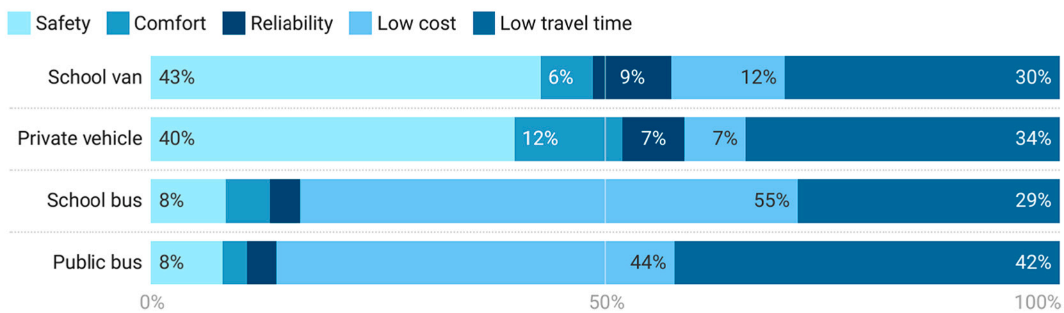

Fig. 8. Main reasons for choosing the school travel mode.

decisions. In fact, the most likely mode for students with higher household income is private vehicles followed by school vans. This finding seems in line with the results by He and Giuliano (2017), who also reported that students with lower household incomes are more likely to take the bus to school in the five-county Los Angeles region. Further, the findings of Ermagun and Samimi (2018) highlighted that students from higher household incomes are more likely to use private vehicles. Singh and Vasudevan (2018) stated that the likelihood of using faster modes increases as the income level increases in India. As private vehicles (or family vehicles) and school vans can be identified as faster modes in the current study, this finding is consistent with Singh and Vasudevan (2018).

Distance to school is the variable that significantly influenced all the modes proposed in the mixed logit model. Spinney et al. (2019) also found the distance between home and school to be the most significant neighborhood feature affecting mode choice in Canada. In addition, as reported in Singh and Vasudevan (2018), the distance was a key determinant of school mode choices in India. In particular, as the distance to school increases, students tend to use school buses and family vehicles (Singh and Vasudevan, 2018). A study conducted in Teheran, Iran by Ermagun and Samimi (2018) explained that with a 1% increase in travel distance, the probability of walking tend to reduce by 0.85%. They further mentioned that, with the increase in travel distance, students tend to shift mainly to school buses. These findings from the studies conducted in developing countries are in line with the findings of the current study. The mixed logit model developed in this study shows that the students with longer distances are more likely to use the public bus, school bus, and school van relative to private transport when compared to those with shorter distances. Wilson et al. (2010) also reported that the chances of using a bus are higher relative to walking and private cars for distances greater than 1.2 km in St. Paul and Roseville, Minnesota. The distance has finally a strong negative impact on the probability of a decision-maker to walk to school. This finding is logical and consistent with previous studies (conducted mainly in developed countries, i.e., US, Canada, Germany, New Zealand, and China) that mentioned that the distance from home to school is a key determinant of active travel to school (Dellinger and Staunton, 2002; Müller et al., 2008; Lee et al., 2013; Guliani et al., 2015; Woldeamanuel, 2016; Zhang et al., 2017; Ikeda et al., 2018; Smith et al., 2020).

The mixed logit model also allows the investigation of how different decision-makers perceived the distance and in turn how this affected their mode choice. The model shows that there is heterogeneity in distance perception for two modes, i.e., walking and private vehicles. The parameter distribution for distance for these two modes is shown in Figure 9, which highlights such heterogeneity.

5. Discussion and conclusions

Schools are major traffic attractors in city centers in many countries around the world during peak hours. School trips consist of a substantial portion of all daily trips, particularly during the morning peak, and largely contribute to the congestion. This study explored the home-to-school travel mode choices of junior, lower senior, and upper senior students, whose age ranged approximately from 11 to 18 years, in the Kandy city, Sri Lanka.

Multinomial logit and mixed logit models were estimated in this work to explore school trip mode choice behaviors. The mixed logit model is preferred over the multinomial logit model since it allows for random variation across decision-makers and relaxes the independence from irrelevant alternatives (IIA) assumption. The results indicated that demographic variables (gender, age and family income), and distance from home to school have significant influences on the choice of the school travel modes in Kandy, Sri Lanka. In addition to these factors, school type also plays a significant role in the choice of school bus and private vehicle. However, it was interesting to note that the school type was not a significant factor for choosing school vans relative to private

Table 4
Estimated Models.

		Multinomial Logit Model LL(null): −3878.876 LL(final): −2429.07 McFadden R^2: 0.373 AIC: 4928.14 AICc: 4929.44 BIC: 5123.64 Estimated parameters: 35			Mixed Logit Model LL(null): −3878.876 LL(final): −2413.907 McFadden R^2: 0.377 AIC: 4907.81 AICc: 4909.51 BIC: 5131.25 Estimated parameters: 40		
Mode	Parameters	Est.	Stad. Error	p-value	Est.	Stad. Error	p-value
Walking (mode 1)	ASC	2.710	1.069	0.010**	3.393	1.317	0.010**
	Female	−0.825	0.326	0.010**	−0.868	0.384	0.020**
	National School	0.490	0.615	0.430	0.576	0.718	0.440
	Provincial school	0.838	0.626	0.170	0.958	0.737	0.190
	Grade	0.271	0.077	0.000***	0.322	0.098	0.000***
	Income/10000	0.023	0.056	0.710	0.025	0.065	0.720
	Distance	−1.749	0.178	0.000***	−2.537	0.567	0.000***
Public bus (mode 2)	ASC	0.581	0.629	0.350	0.536	0.634	0.390
	Female	−1.741	0.229	0.000***	−1.751	0.232	0.000***
	National School	−0.084	0.384	0.830	−0.057	0.390	0.880
	Provincial school	0.320	0.392	0.410	0.356	0.397	0.370
	Grade	0.096	0.048	0.050*	0.099	0.048	0.040**
	Income/10000	0.027	0.038	0.490	0.023	0.038	0.570
	Distance	0.110	0.020	0.000***	0.110	0.021	0.000***
School bus (mode 3)	ASC	−3.116	0.807	0.000***	−3.127	0.809	0.000***
	Female	0.349	0.235	0.130	0.348	0.236	0.140
	National School	1.369	0.555	0.010**	1.369	0.556	0.010**
	Provincial school	2.210	0.555	0.000***	2.203	0.556	0.000***
	Grade	0.143	0.055	0.010**	0.143	0.055	0.010**
	Income/10000	0.030	0.043	0.520	0.025	0.044	0.600
	Distance	0.118	0.020	0.000***	0.123	0.021	0.000***
School van (mode 4)	ASC	2.607	0.558	0.000***	2.640	0.560	0.000***
	Female	−0.051	0.198	0.790	−0.033	0.199	0.860
	National School	−0.536	0.311	0.090*	−0.520	0.312	0.100
	Provincial school	−0.509	0.321	0.120	−0.505	0.322	0.120
	Grade	−0.160	0.046	0.000***	−0.165	0.046	0.000***
	Income/10000	0.149	0.034	0.000***	0.142	0.035	0.000***
	Distance	0.126	0.019	0.000***	0.130	0.020	0.000***
Private vehicle (mode 5)	ASC	0.904	0.631	0.150	1.249	0.700	0.070*
	Female	−0.457	0.228	0.040**	−0.584	0.255	0.020**
	National School	−0.725	0.337	0.040**	−0.827	0.365	0.030**
	Provincial school	−0.768	0.357	0.030**	−0.907	0.392	0.020**
	Grade	−0.081	0.053	0.140	−0.071	0.058	0.240
	Income/10000	0.255	0.036	0.000***	0.300	0.040	0.000***
	Distance	0.071	0.021	0.010**	−0.105	0.064	0.080*
	Random parameters						
	SIGMA_Dist1				0.596	0.231	0.000***
	SIGMA_Dist2				0.020	0.021	0.270
	SIGMA_Dist3				0.000	0.015	0.690
	SIGMA_Dist4				0.001	0.017	0.580
	SIGMA_Dist5				0.178	0.046	0.000***

* significant at the 0.1 level, ** significant at the 0.05 level, *** significant at the 0.01 level
ASC means the alternative specific constant
Female = 1 if the respondent is female and 0 otherwise
National School = 1 if the respondent's school is a National School and 0 otherwise
Provincial School = 1 if the respondent's school is a Provincial School and 0 otherwise
Income variable has been divided by 10,000 for estimation purpose (see Appendix A)

Table 5
Estimated Elasticities.

Parameter-Mode	Multinomial Logit Model	Mixed Logit Model
Distance-Walking	−1.7489	−2.537
Distance-Public bus	0.1097	0.110
Distance- School bus	0.1184	0.123
Distance- School van	0.1262	0.130
Distance- Private vehicle	0.0709	−0.105

transport. As the data and descriptive analyses showed, school van was the most famous mode in Kandy, Sri Lanka. Despite the travel cost, parents prefer school vans mainly because of the perceived safety. As school vans are high occupancy vehicles, they are better than private transport modes in terms of reducing the congestion on roads. However, parking of school vans, particularly in the vicinity of schools, have been identified as a critical issue (Kandy City Transport Study, 2011). Idle parking of school vans on streets and dropping of students nearby schools could create disruptions and congestion. Therefore, it is necessary to ensure adequate parking spaces or drop-off zones nearby schools. On the other hand, as school vans are private services, drivers might not be well-trained or qualified (to drive high occupancy vehicles carrying children). Thus, trainings and regulations are needed through government authorities to provide a safe and reliable service to the students (Van Niekerk et al., 2017).

Private schools, particularly the selected two schools in this study, are paid schools. Therefore, in general, students from high-income families attend such schools. Although both national and provincial schools are free of charge, there is a huge competition for national schools due to the quality of education and facilities. Thus, naturally, low-income groups tend to select provincial schools. This means private school students are less likely to use public transport as compared to provincial school children.

The train was the least frequently used mode for school trips in Kandy and the main reasons could be the availability and the quality of the service. Only two train stations are located approximately 200 m away from two girls' schools, i.e., one national and one provincial school, and one private boys' school. Service frequency is also low at approximately 20 trains per day (Kandy City Transport Study, 2011). However, even though the service frequency and the quality are enhanced, a connecting mode, i.e., mainly walking, is needed to travel from train station to school. Thus, significant enhancements in the rail network, e.g., locating new stations at walking distances to schools, might be necessary to increase the use of trains as a school travel mode.

Active modes, e.g., walking and bicycles, were also not predominantly used by the school children in this area. None of the students used bicycles and only 6.6% of the survey respondents (predominantly older male students) walked to their schools. Lack of suitable infrastructure and safety issues could be considered as the main barriers that prevent students from using active modes (Yeung et al., 2008). On the other hand, considering the quality of education and other facilities, parents tend to choose major schools. As the data indicated, on average, a student commuted 9.91 (± 8.29) km from home to school and motorized modes are necessary for travelling such distance. Some national level projects, e.g., "the nearest school is the best school" concept, are underway to improve the closest secondary and provincial schools (Ministry of Education Sri Lanka, 2016b). Through such policy interventions, there might be a possibility to encourage parents and students to choose the nearest school to home. However, it is important to improve the walking and bicycling infrastructure and solve other issues, e.g., exposure to road traffic. Müller et al. (2020) suggested that concepts like "walking buses" could be promoted to encourage younger students, who live nearby schools, to walk to the school. Although walking school buses (WSB) are famous in countries like Japan and Canada, safety is a critical issue associated with WSB (Waygood et al., 2015). Therefore, building suitable and safe walking facilities, which preferably separate walkers from motorists, is required before implementing such concepts, particularly in developing countries where accident rates are high.

The results also indicated that females are more likely to use school bus relative to other modes. Whereas they were found to be less likely to use public bus, walking and private vehicle relative to other modes (i.e., three-wheelers and motorcycles). It is worth mentioning here that the use of motorcycle among South Asian female population is very low (Krishnapriya and Soosan George, 2020). Hence, it can be deduced that females prefer three-wheelers over public bus, walking and private vehicle. The less frequent use of public transport buses by female students may also be associated with the safety and security issues as reported by several past studies conducted in the South Asian context (Tripathi et al., 2017) and therefore, parents have been reported to have more protective attitude towards girls resulting in restricted active mobility for female students (Guliani et al., 2015). This often results in females students being more likely to be escorted to school (Pojani and Boussauw, 2014a, 2014b) or use safer alternatives such as school buses. Nonetheless, more research is needed to explore what exactly affects the mode choice differences between male and female students in the study area. If the parental protective attitude, as mentioned in the existing literature, limits girls' independent mobility especially walking, then "walking school buses" can play role in reducing gender differences in mode choice behavior. Under "walking school buses" programs, designated parental groups escort school children to their respective schools particularly by walking. However, if mode choice differences occur due to girls' and boys' own mode preferences, then educational programs can be launched to educate the students about the importance of active modes.

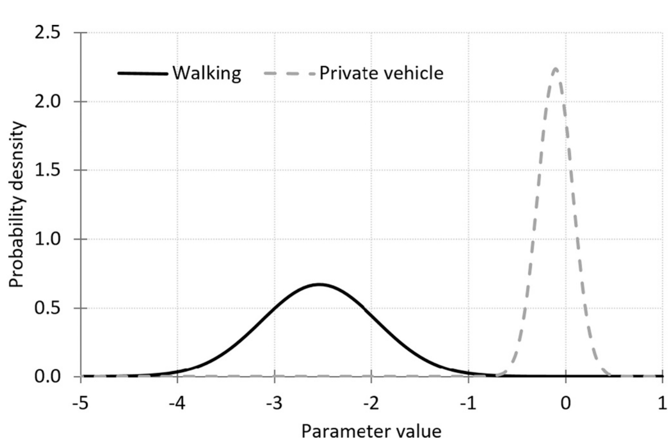

Fig. 9. Random distribution of the distance parameters for walking and private vehicle modes.

This study provides a further opportunity to compare a classic multinomial logit model and a mixed logit model with the new data presented in this work. The results show that the mixed model allowed us to highlight the heterogeneity of the parameters associated with the distance (see the distributions in Figure 9). From a fitting perspective, the two models have a close value of the Log-Likelihood (LL) and McFadden R^2 (Table 4). However, the Likelihood Ratio Test supports the hypothesis that the mixed model provides a better fitting. On the other hand, the elasticity results in Table 5 highlight that the mixed logit model provides a substantial change in the model sensitivity to the distance when focusing on the walking mode. As such, we believe that the proposed mixed logit model is more suitable to achieve more accurate forecasting based on the distance of the decision-makers from the schools.

Several previous studies highlighted that travel mode and distance from home to school are significantly inter-related (Ermagun and Samimi, 2018). Therefore, such joint models or copula-based models (Bhat and Eluru, 2009) perform better as compared to the single models (Ermagun et al., 2015; Ermagun et al., 2016). In particular, as explained in Ermagun et al. (2015), and Ermagun and Samimi (2018), the coefficient of travel distance differed between traditional discrete choice models and copula-based approaches. As a result, model interpretations in such different modelling approaches may be remarkably different. Although the heterogeneity in the distance variable was taken into account in the mixed logit model presented in this study, considering joint models (as a future study) may further provide an improvement over the home-to-school travel mode choice model presented in this study.

This study had some methodological limitations. Although a representative cross-section (in terms of social-economic characteristics and key modes) was obtained, data were collected only from 10 major schools (i.e., 4 national, 4 provincial and 2 private) with more than 2000 students in each. School trip characteristics of the students studying at other schools, i.e., smaller schools, might be remarkably different. On the other hand, given the differences in socio-economic and weather characteristics, the school trip mode choices and contributing factors of other cities in Sri Lanka could be significantly different. For example, in northern Sri Lanka bicycles have been identified as a famous school travel mode among students (Tamil Engineers Foundation, 2018). Further, parental concerns, weather, and infrastructure-related influences were not considered in this study and future studies could focus on such aspects of school trip mode choices.

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Appendix A. *mixl* model specifications

This appendix provides the model specification for the Multinomial Logit and Mixed Logit models proposed in Section 4.2. The mode coding used in the model specification is;

1. Walking;
2. Public bus;
3. School bus,
4. School van,
5. Private vehicle (i.e., car and van)
6. Other modes (i.e., three-wheeler and motorcycle)

In the *mixl* syntax @ represents parameters while $ represents variables.

Multinomial Logit Specification:

U_1 = @ASC_1+ @B_Female_1 * $Female+ @B_ST1_1 * $ST1+ @B_ST2_1 * $ST2+ @B_Grade_1 * $Grade + @B_Income_1 * $Income/ 10000+ @B_Distance_1 * $Distance;

U_2 = @ASC_2+ @B_Female_2 * $Female+ @B_ST1_2 * $ST1+ @B_ST2_2 * $ST2+ @B_Grade_2 * $Grade + @B_Income_2 * $Income/ 10000+ @B_Distance_2 * $Distance;

U_3 = @ASC_3+ @B_Female_3 * $Female+ @B_ST1_3 * $ST1+ @B_ST2_3 * $ST2+ @B_Grade_3 * $Grade + @B_Income_3 * $Income/ 10000+ @B_Distance_3 * $Distance;

U_4 = @ASC_4+ @B_Female_4 * $Female+ @B_ST1_4 * $ST1+ @B_ST2_4 * $ST2+ @B_Grade_4 * $Grade + @B_Income_4 * $Income/ 10000+ @B_Distance_4 * $Distance;

U_5 = @ASC_5+ @B_Female_5 * $Female+ @B_ST1_5 * $ST1+ @B_ST2_5 * $ST2+ @B_Grade_5 * $Grade + @B_Income_5 * $Income/ 10000+ @B_Distance_5 * $Distance;

U_6 = 0;

Mixed Logit Specification:

B_Distance_1_RND = @B_Distance_1 + draw_1 * @SIGMA_B_Dist1;

B_Distance_2_RND = @B_Distance_2 + draw_2 * @SIGMA_B_Dist2;

B_Distance_3_RND = @B_Distance_3 + draw_3 * @SIGMA_B_Dist3;

B_Distance_4_RND = @B_Distance_4 + draw_4 * @SIGMA_B_Dist4;

B_Distance_5_RND = @B_Distance_5 + draw_5 * @SIGMA_B_Dist5;

U_1 = @ASC_1+ @B_Female_1 * $Female+ @B_ST1_1 * $ST1+ @B_ST2_1 * $ST2+ @B_Grade_1 * $Grade + @B_Income_1 * $Income/ 10000+ B_Distance_1_RND * $Distance;

U_2 = @ASC_2+ @B_Female_2 * $Female+ @B_ST1_2 * $ST1+ @B_ST2_2 * $ST2+ @B_Grade_2 * $Grade + @B_Income_2 * $Income/ 10000+ B_Distance_2_RND * $Distance;

U_3 = @ASC_3+ @B_Female_3 * $Female+ @B_ST1_3 * $ST1+ @B_ST2_3 * $ST2+ @B_Grade_3 * $Grade + @B_Income_3 * $Income/ 10000+ B_Distance_3_RND * $Distance;

U_4 = @ASC_4+ @B_Female_4 * $Female+ @B_ST1_4 * $ST1+ @B_ST2_4 * $ST2+ @B_Grade_4 * $Grade + @B_Income_4 * $Income/ 10000+ B_Distance_4_RND * $Distance;

U_5 = @ASC_5+ @B_Female_5 * $Female+ @B_ST1_5 * $ST1+ @B_ST2_5 * $ST2+ @B_Grade_5 * $Grade + @B_Income_5 * $Income/ 10000+ B_Distance_5_RND * $Distance;

U_6 = 0;

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