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Research paper

Comparing children and parental preferences for active commuting to school. A focus on Italian middle-school students

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ABSTRACT

Active commuting to school has significant positive health and environmental impacts; however, the increasing use of private vehicles has transformed school commuting from an active to a passive activity. Our research is aimed at analyzing which factors influence the choice on how to commute to school with a special focus on the role played by the Covid-19 health emergency.

We carried out an online survey involving a sample of 193 students of a middle school of Trieste (Italy) and 217 parents. We find that attitudes and perceptions of children and parents significantly differ with respect to both the risks and benefits of different means of transportation and with respect to the policies that should be implemented to support active commuting to school.

Our study is innovative with respect to the age range we focused on, since most of the literature deals with young children (elementary school) or with adolescents (high school) whose modal choice are taken either by their parents or by the students themselves. With reference to middle school students, instead, it is expected that children and parents jointly take the choice on how to commute and it is relevant to detect the role played by each family member in the decision-making process.

Our results will be useful to local administrators, policy-makers and decision-makers in order to design, implement and support transport and demand management policies that are effective in shifting the mobility habits of middle school students toward healthier and more sustainable means of transportation.

1. Introduction

Active mobility (i.e., walking and cycling) is a crucial aspect of a healthy lifestyle especially for young people as active mobility in childhood and adolescence has a very long-lasting impact on adult health (Gunter et al., 2012). Active school travel improves cardiorespiratory fitness (Gaya et al., 2009; Leary et al., 2008; Sugiyama et al., 2007; Voss & Sandercock, 2010), reduces metabolic syndrome (Hansen et al., 2018), and maintains a healthy weight (Lee et al., 2008). It enhances perceived self-efficacy (Rutberg & Lindqvist, 2018), reduces feelings of loneliness through the mediation of a stronger sense of community (Pacilli et al., 2013), and improves mental health and wellbeing (Herrero et al., 2021; Ramanathan et al., 2014; Ruiz-Ariza et al., 2015; Stark et al., 2018 b; Yang et al., 2014). It also increases the overall levels of physical activity (Larouche et al., 2012), supports neighborhood social cohesion (du Toit et al., 2007), and encourages children's autonomy in the use and exploration of public spaces (Prezza et al., 2009).

A large proportion of intra-EU travel (20%) relates to the mobility of children and young people, mainly due to movement to and from schools (Casadó et al., 2020). Therefore, additional positive externalities of active commuting to school include the reduction of traffic, congestion, crashes, noise, energy consumption, and harmful gas emissions (Brand et al., 2021; Ferretto et al., 2021; Lozzi & Monachino, 2021; Qiu & He, 2018; Temjanovski et al., 2019). Moreover, it is beneficial for organizing family time (Prezza, 2007).

Despite the undoubted health and environmental benefits of active commuting to school, active child transport and independent mobility (i.e., the freedom to actively travel without adult supervision) have largely declined in recent decades. Many countries have recorded negative trends including Canada (Rothman et al., 2021), the Czech Republic (Pavelka et al., 2017), France (Fillon et al., 2021), Germany (Schmidt et al., 2017), New Zealand (Ikeda et al., 2018), Spain (Chillón et al., 2013), the UK (Macdonald et al., 2019; Nikitas et al., 2019), and

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the USA (Kontou et al., 2020).

In Italy, the percentage of middle-school students going to school in an active manner decreased from 49% in 2001 to 43% in 2020. In 2020, children aged 11–13 were by far the student segment most frequently walking or cycling to school, 39.6% and 3.5%, respectively. The Italian National Institute of Statistics (http://dati.istat.it) reports a sharp decline of active commuters as students get older, reaching the lowest number (17%) among students aged 18–19 (last year of high school). In fact, up to middle school, children usually attend a school close to home and can safely walk or cycle the short distance from home to school. Once they start attending high school, they begin to travel independently. Indeed, according to Italian law, parents must accompany their children to school until they are 14 years old. Moreover, the density of high schools is much lower than the density of primary and middle schools, implying greater travel distances and requiring faster motorized means of transport.

In the literature, there are several articles analyzing which factors prevent (or favor) children's active travel to school. However, only few studies analyzed the barriers towards active commuting to/from school as perceived by both parents and children (remarkable exceptions being Aranda-Balboa et al., 2021, and Wilson et al., 2018). In addition, no research attempted to detect whether parents' rather than children's concerns prevail in determining the transport mode used. In fact, although in the literature the usual approach is to assume that young people are passive agents adapting their behavior to their parents' decisions; Casadó et al. (2020) proved that children's mobility habits are also shaped by their own needs and perceptions. Only adopting this broader view, which considers both children's and adults' views and preferences, will policy makers and local administrators be able to design and implement policies and initiatives that are effective in promoting and supporting active commuting among young people and their families.

This research will advance the understanding of the factors driving the choice of active commuting to school by examining the following research questions:

- which barriers to active commuting are separately and jointly perceived as important by parents and children;
- which policies supporting active commuting to school are preferred by parents and children;
- which impacts the Covid-19 pandemic had on the commuting behavior of middle school students.

To the best of our knowledge, this is the first article focused on an Italian case study that analyzes the full range of factors that influence children's independent travel to school, including trip, child, and parents' characteristics, and that jointly considers the subjective concerns, attitudes, and perceptions of both parents and children. As a case study, we have selected the city of Trieste, a medium-sized city located in the northeastern part of Italy. In Trieste the percentage of residents commuting on foot (30%) is in line with the values recorded at the national level (31.5%), while the percentage of residents travelling by bicycle (1%) is significantly lower than the national value (7.1%) mostly due to the hilly nature of some parts of the city.

The article is structured as follows. Section 2 reviews the literature on active commuting to school. Section 3 describes the geographical context of the research and the methodology we used to collect the data. Section 4 reports the descriptive statistics, the modelling framework, and the econometric results. Section 5 discusses and compares the results obtained with the evidence presented in the literature and draws some policy implications.

2. Literature review

The research literature on children's active commuting to school is highly heterogeneous in terms of motivation, scope, methodology, and target variables. The complexity of the existing literature is due to the large number of factors influencing children's travel choice and the multifaceted health implications of the transport mode chosen. Indeed, the main research fields are travel mode choice studies and children health (both physical and psychological) studies. Our review is focused on the first stream of literature.

2.1. Built and natural environment

Several articles have focused on the role of the built and natural environment in promoting active mobility among children and young people. According to this literature, school proximity to residential homes is the most important determinant of active commuting among children (Barnett et al., 2019; Buliung et al., 2017; Chica-Olmo et al., 2018; Curtis et al., 2015; Mitra et al., 2010; Pizarro et al., 2016; Schicketanz et al., 2021; Solana et al., 2018; Yeung et al., 2008).[1]

Additionally, Broberg et al. (2013) found that single family housing allows independent mobility and the use of active transport modes, while dense urban residential living allows for independent mobility but does not promote active transport. Street block size, public transit facilities and sport/leisure venues such as sport and recreation facilities, parks and playgrounds, are important factors associated with active travel to school (Leung & Loo, 2020). However, the built environment around a child's residence has a stronger association with mode choice than the built environment around the school (Mitra et al., 2010).

Exposure to major roads and high dwelling density have a significant negative correlation with active commuting to school, while cycling path availability (Helbich et al., 2016) and intersection density (Ikeda et al., 2018) have a positive relationship. Traffic calming is associated with higher levels of independent travel, while routes characterized by high-speed roads with lower levels of independent travel (Scheiner et al., 2019; Stark, Meschik, Singleton, & Schützhofer, 2018 b) does not. Land-use mix, instead, does not affect children's active mobility. In fact, unlike adults, children's prime motive is commuting to/from school rather than performing chaining trips.

According to the literature focused on Italian case studies, small urban context and availability of protected blocks, courtyards and condominium gardens used by children for outdoor playing activities are important driving factors supporting active commuting. In addition, active commuting to school is more frequent in new suburbs of large cities with large arteries for fast-moving traffic and Limited Traffic Zones and inner street networks with less traffic for walking and cycling (Prezza, 2007).

2.2. Parents' attitudes and perceptions

Many children both in urban and rural areas lack mobility license (i.e. parental allowance for travelling or being outside without supervision) and independent mobility (Carver et al., 2012). Risk of being injured, poor neighborhood safety related to traffic and strangers, and lack of social trust are parents' most important concerns (Alparone & Pacilli, 2012; Carver et al., 2013; Foster et al., 2015; Lopes et al., 2014; Mammen et al., 2012; Prezza et al., 2005; Schicketanz et al., 2021; Scheiner et al., 2019; Sener et al., 2019; Smith et al., 2020; Stark, Frühwirth, & Aschauer, 2018; van de Craats et al., 2019; Zuniga, 2012).

Additional factors emerging from studies conducted in Italy include bad maintenance conditions of roads, intensity and speed of traffic, drivers' lack of respect for pedestrians and road rules, as well as air pollution (Prezza et al., 2005). Parents of children walking to school have more positive perceptions of "walkability", while parents who drive their children have more safety concerns related to traffic (Lee

[1] none of the articles we have reviewed analyzed the role played by the level-of-service characteristics (e.g. travel time and travel cost) of the mode alternatives.

et al., 2013; Park et al., 2013).

Individual and social characteristics such as age (van den Berg et al., 2020), gender, income, and occupational status can also affect parents' attitudes and perceptions. In fact, parents of girls report greater concerns about stranger danger, while fathers report greater concerns about strangers than mothers (Larsen et al., 2018). In addition, parental fear of strangers is lower in higher income neighborhoods (Foster et al., 2015).

Besides safety considerations, parents decisions are based also on what they consider easiest and quickest (Buliung et al., 2017; Larsen et al., 2018; Park et al., 2013; Sener et al., 2019; Stark, Frühwirth, & Aschauer, 2018), and driving children to school is the preferred choice if parents have to commute to work or perform other activities. Indeed, escorting parents are more likely to agree that walking requires too much planning and that driving is easier/faster (Lee et al., 2013). However, as mothers work longer hours further away from home, children are less likely to be chauffeured to school and more frequently actively commute to school or take the bus (He & Giuliano, 2017; Stark, Frühwirth, & Aschauer, 2018).

Finally, the more parents engage in walking activities, the more likely their children are to actively go to school (Henne et al., 2014; Park et al., 2013; van de Craats et al., 2019).

2.3. Children's attitudes and perceptions

Driving factors for children's active commuting to school are the willingness to socialize with schoolmates (Hinckson, 2016; van den Berg et al., 2020) and to interact with the surrounding environment (Smith et al., 2015). Distance and traffic related concerns, instead, are negative factors preventing children from actively going to school (Smith et al., 2020). Moreover, children's perception of living in an area where walking alone is safe increases the probability of walking to school (Buliung et al., 2017). Children perceive the home-school journey as being easier if there are traffic lights or pedestrian crossings where they have to cross the roads, if roads are one-way or there is a speed limit, if the road and sidewalk maintenance condition is good and vehicles are not (illegally) parked on sidewalks (Prezza, 2007).

2.4. Comparison of children's and parents' attitudes and perceptions

Children and adolescents perceive higher physical and motivational barriers and social support barriers towards active commuting to school than their parents. On the contrary, parents perceive distance, traffic safety, convenience, built environment, crime-related safety, and weather as higher barriers than their children do. In both cases, higher perception of barriers are related to lower active journeys to school (Aranda-Balboa et al., 2021; Chillón et al., 2017; Huertas-Delgado et al., 2018, 2019; Miller et al., 2013; Segura-Díaz et al., 2020). The attitudes and perceptions of parents and children, however, tend to be intertwined. Children who actively commute to school prefer to be more autonomous and have parents who allow them to be independent, while children who prefer to be driven have parents fearing that commuting alone is too dangerous (Curtis et al., 2015).

2.5. Children's and household demographic factors

Children are more likely to make active journeys to school if they are male, older, and have siblings (Leung & Loo, 2020; Pacilli et al., 2013; Prezza, 2007; Prezza et al., 2009; van de Craats et al., 2019). Children living in high-status households – measured by income, parental education, and home ownership– travel less independently. Finally, household car ownership, being a key resource for travel, increases the chance of children being driven (Scheiner et al., 2019).

3. Data and methods

We carried out a survey in February 2021 at the middle school "G. Corsi" in Trieste, the regional capital of Friuli-Venezia Giulia, an Italian region on the border with Austria and Slovenia. The city lies on a hilly area with an altitude ranging from 0 to 458 m above the sea level. The school catchment area includes a densely inhabited neighborhood characterized by extremely steep streets (with a maximum gradient of 16.2%) (Fig. 1). The average height difference of the home-school route recorded for our sample is 85 m, with values between 2 and 422 m.

Trieste has a dense public transport service, with 61 daytime urban lines, 15 evening-lines, 10 night-lines, a tramway and two maritime lines (www.triestetrasporti.it). The middle school "G. Corsi" is not far from the city center of Trieste (1.4 km away from the main square), is close to the train station (4 min on foot) and is served by 26 bus lines, with stops within 5 min on foot. In Trieste there are two cycle paths (Rive - Passeggio Sant'Andrea and Miramare, Fig. 2), however they are not connected and are both far from the school, moreover the school has no parking facilities for bicycles. The city hosts a bike sharing service that can be used, however, only by adults. Although the city of Trieste has no pedestrian lanes, most of the streets in the school's catchment area are equipped with sidewalks, their size and maintenance conditions, however, are highly heterogeneous. According to a survey conducted in 2019 by the local administration (http://mobilitasostenibile.comune.trieste.it) 37% of the residents travel by car, 30% walk, 20% travel by bus, 9% by scooter and only 1% use a bicycle.

With reference to the period in which we collected the data, it is worth mentioning that we conducted the survey after the first lockdown experienced in Italy between March and May 2020 as a response to the Covid-19 pandemic during which people worked from home and distance learning replaced in-person classes. In the second half of 2020, middle schools fully re-opened and, at the time of the survey, children attended all classes in person. The restrictions became stricter in March 2021, when the schools were closed again, although in Friuli-Venezia Giulia middle schools were able to reopen as early as April 2021.

We administered an online questionnaire to both parents and students.[2] We differentiated the questionnaire based on the status of the respondent: being a student rather than a student's parent. The principal of the middle school provided us with the institutional email address of each student and with the email address of the parents of each student. We sent a link to the questionnaire designed for students to each of the 348 students enrolled in the middle school where we carried out the survey. We also sent a link to the questionnaire designed for parents to the parents of each student. We instructed parents and students to independently complete the questionnaire. We surveyed a total of 193 children and 217 parents. Our sample size is similar to the size of the sample studied by Huertas-Delgado et al. (2018) in Riobamba (150,000 inhabitants), surveying 172 pairs of children and parents living, by Huertas-Delgado et al. (2019) in Granada (232,000 inhabitants), surveying 207 pairs living, and by Curtis et al. (2015) in Brisbane (2.28 million inhabitants), surveying 254 pairs living. Children over 12 years were the largest segment of the student sample (40%), children aged 12 and children under 12 were 36% and 24%, respectively. The student sample was equally distributed between females (54%) and males (46%). Adults aged 45 to 49 represented the largest segment of the parental sample (43%), followed by adults over 49 years of age (29%) and adults up to 44 years of age (28%). Females represented the majority of the parents' sample (66%).

We structured the questionnaire in four parts. In the first part, we asked to describe the transport mode used to go to school (round trip) either by the respondent, if the respondent was a student, or by the respondent's child, if the respondent was a parent. Then we asked if and why the respondent or the respondent's child had changed her/his commuting habits from the previous school year, and, if relevant, why s/he did not travel on foot or by bicycle. In the second part, we asked the

[2] in the remaining of the text we interchangeably use the terms student/students and child/children.

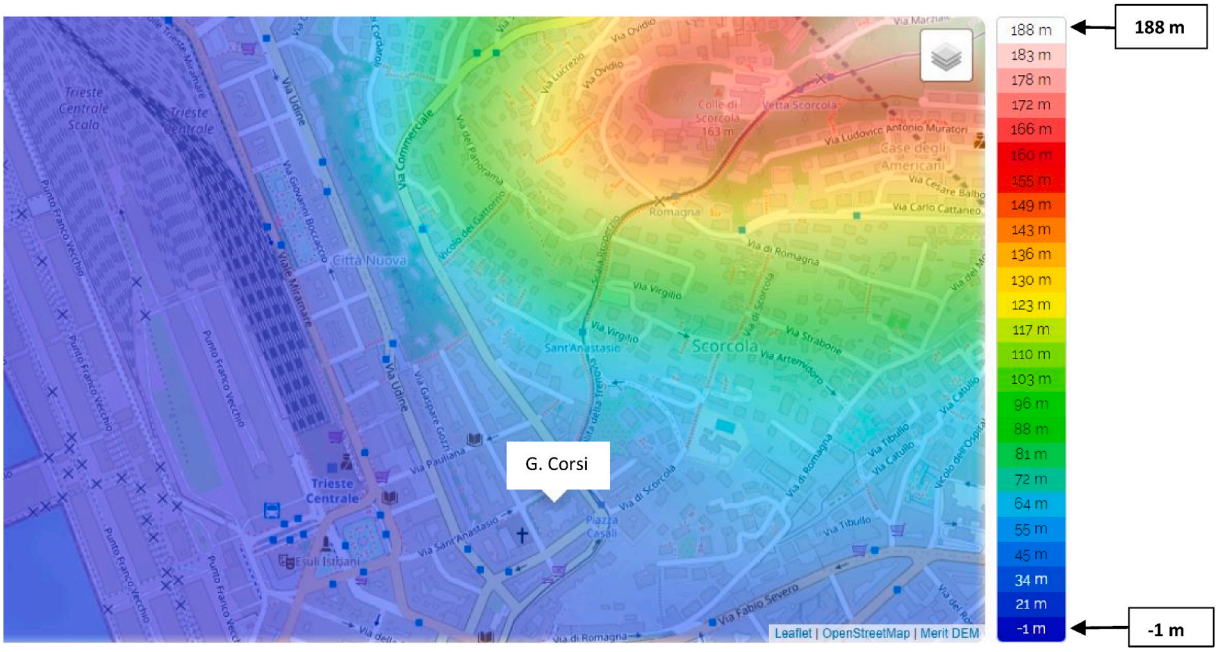

Fig. 1. Catchment area of the "G. Corsi" middle school in Trieste
Source: https://it-ch.topographic-map.com/maps/f65v/Friuli-Venezia-Giulia/.

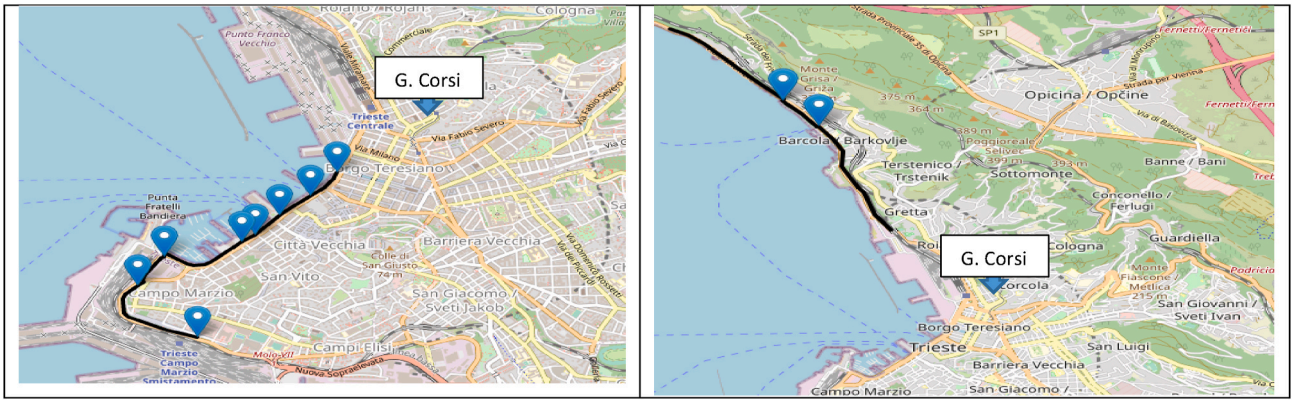

Fig. 2. Bicycle lanes in Trieste
Source: www.piste-ciclabili.com.

respondent to indicate which means of transport would be preferable in his/her opinion to avoid infection from Covid-19 and for health, safety (avoiding accidents and harassment) and environmental reasons. In the third part, we asked under what circumstances the respondent would travel or would allow the child to travel on foot and/or by bicycle. Finally, in the fourth part, we asked the respondent about his/her socio-demographic characteristics.

4. Results

We first computed descriptive statistics on how students go to school. Afterwards, we estimated three multinomial logistic (MNL) regression models to detect which are the most important factors influencing the travel mode choice. Given the discrete nature of the variable describing the transport mode choice, we could not use linear regression models since they might predict choice probabilities that are smaller than zero or greater than one and would estimate constant partial effects for any explanatory variable (Hensher et al., 2005; Wooldridge, 2006). Initially, we used all the data collected from both students and parents (MNL_1), then we used only the data collected from students and parents belonging to the same household (MNL_2). Finally, we estimated a joint model based on the data collected from each pair of parent and student with the aim of detecting which factors prevail in determining the travel mode choice at the household level (MNL_3). The estimation of these three models allowed us to assess the robustness of the results obtained (MNL_1 vs MNL_2) and, more importantly, enabled the investigation of the influence of household membership on travel mode choice (MNL_2 vs. MNL_3).

The dependent variable of the models we estimated is the transport mode used by the students to go to school, i.e. walking, travelling by car, or travelling by bus. Since only a small percentage of the sample used the scooter and nobody stated s/he goes to school by bicycle, we did not include these means of transport in the set of the possible outcomes of the transport mode choice. Walking is the reference category of the all models we estimated, since our research focus is on active vs. motorized mobility. We used Google Forms (www.google.com) to collect the data and Nlogit (www.limdep.com) to perform the econometric analysis.

4.1. Descriptive statistics and mobility habits

The mode share of active school travel in our sample (36%) is slightly lower than national rates for students aged between 11 and 13 (40.5%), also the percentage of students travelling to school by car or scooter (38%) is slightly smaller than national rates (41%). The mode share of travelling by bus, instead, is significantly higher in our sample (25%) compared to the national share (16%). In addition, none of the respondents said that they or their children go to school by bicycle, significantly differing from the national share, which is 3%. These differences are likely due to the dense and frequent bus services provided in the school catchment area and due to the school's steep hilly surroundings.

The mode share of walking and of travelling by bus is higher for the return trip, with car mode share decreasing by almost 10% and mode share of walking and travelling by bus increasing by 3% and 8%, respectively (Fig. 3). Both results are in line with the evidence reported in the literature (Sener et al., 2019).

Although age only marginally affects the share of active travel, ranging from 35% for 12-year-olds to 38% for older students, 11-year-olds travel significantly less frequently by bus (18% vs. 27%) and more frequently by car or scooter (46% vs. 36%) compared to older students.

Distance plays an important role in influencing the travel mode choice, as reported in most of the literature we reviewed in Section 2. Our research confirms this result. In fact, 84% of the students who go to school on foot live within 1 km to school, however the percentage decreases to 16% for those who live from 1 to 2 km to school and reduces to 5% for those who live over 2 km to school. The percentage of students travelling by car as passengers, instead, increases significantly as the distance to school increases (Fig. 4). The bus is the prevailing means of transport for students living between 1 and 2 km to school.

Another factor never studied before in the literature that however significantly influences the modal choice of our sample is the maximum height difference of the home-school path. In fact, while 60% of the respondents go to school on foot when the difference in altitude is at most 50 m, only 9% go to school on foot if the difference in altitude is greater than 50 m, preferring to use the car (53%) or the bus (34%) (Fig. 5).

To disentangle the role played by distance and elevation in Fig. 6 we depicted the transport mode share by distance travelled fixed the height difference, where *panel a* refers to maximum height differences smaller than or equal to 50 m and *panel b* refers to maximum height differences larger than to 50 m. The significant role played by both factors is confirmed, as the percentage of students walking to school decreases as the distance to be travel increase independently from the elevation difference taken into account (smaller or larger than 50 m) and vice versa.

Half of the sample (51%) is escorted to school, however the percentage decreases to 35% in the way back home. Fathers are more frequently in charge of accompanying children to school and from school than mothers, 27% vs. 21% and 16% vs. 14% respectively. Relatives, friends and schoolmates seldom escort children to and from school.

Since, according to the literature, parents' choice on how to commute to the workplace might influence children's travel habits, we deemed it important to analyze if there was any difference between mothers' and fathers' commuting choices (Fig. 7). In our case study, mothers were more frequently walking or using the bus than fathers. The percentage of mothers and fathers working from home due to the Covid-19 pandemic, instead, was similar, 8% and 6% respectively.

Almost a quarter of the students (22%) we surveyed changed the transport mode used to go to school compared to the previous school year. The most cited reasons for the transport mode change were the fear of being infected by the Covid-19 virus (44%) and the longer distance to be travelled due to the new location of either the school or the respondent's house (23%).

4.2. Perceptions

We asked the respondents to indicate which means of transportation (maximum three) are safer, healthier and less harmful to the environment. Most parents and students said that walking is preferable to improve their health, to avoid accidents, and to protect the environment. According to 50% of respondents or more, travel by car is preferable to avoid harassment and to prevent Covid-19 infection (Table 1). Parents' and students' perceptions, however, are different. We calculated the chi-square statistic for each means of transportation and source of potential risk and benefit and we found that, in percentage terms, there are more parents than students who believe that walking is safe with respect to the risk of Covid-19 and harassment. More parents than students also believe that travelling by car is safe with respect to the risk of accidents, while the opposite holds true for the risk of harassment. More students than parents, instead, hold the belief that cycling is healthier, less harmful to the environment and safer with respect to the risk of Covid-19 and that travelling by bus is safer with respect to the risk of accidents.

Most parents and students said that protecting pedestrian and cycle lanes from motorized traffic and separating pedestrian lanes from cycle paths would facilitate walking and cycling to and from school. In addition, a large percentage of students stated that both pedestrian and cycle lanes should be wide. From the parents' point of view, organizing walking buses and securing road junctions would be an effective policy to increase walking and cycling to and from school, however only a small percentage of students agreed with this view. Most students, in fact, would rather prefer to go to school with their schoolmates (Table 2). We calculated the chi-square statistic for each policy proposed and we found that the perceptions of parents and students are significantly different except for commuting to school with schoolmates.

4.3. Mode choice model

In this Section we report the estimates of three multinomial logistic (MNL) regression models highlighting the factors that influence the choice of the means of transportation used by students to go to school.

In the first model (MNL_1) we investigated whether and how the factors influencing the transport mode choice differ when we disjointedly control for the attitudes and perceptions of parents and students. To this end, we estimated six sets of segment- and alternative-specific parameters, one set for each family member (parents vs. students) and transport mode (walking, using the car, using the bus) pair. The dependent variable of this model represents the transport mode used by the child. For this first model, we excluded 10 questionnaires collected from individuals stating they use the scooter and 64 additional questionnaires that were missing some critical data. The final sample included 336 observations.

The second model (MNL_2) has the same specification as the first one; however, we estimated it using only the data collected from parents and students belonging to the same household. Since we were able to detect 115 pairs, and we excluded 1 pair using the scooter to go to school and 13 pairs that were missing some critical data, we used 202 observations, 101 collected from parents and 101 from their corresponding child.

Finally, we studied a joint model (MNL_3) with the aim of detecting which common and segment-specific factors prevailed in determining the transport mode choice at the household level. For the latter model, we used 101 observations, that is one observation for each parent-student pair.

More specifically, in model MNL_1 and MNL_2 the utility U an individual $n \in \{1, \ldots, N\}$, belonging to the parents' segment (p) or to the students' segment (s), gets from walking (w), travelling by car (c), and travelling by bus (b), is described by the following equations:

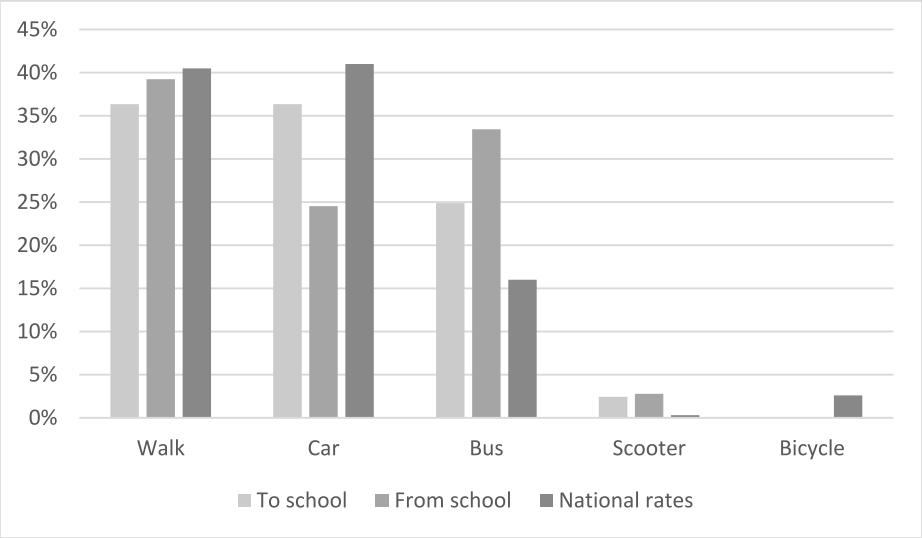

Fig. 3. Students' mode share to and from school compared to the national rates.

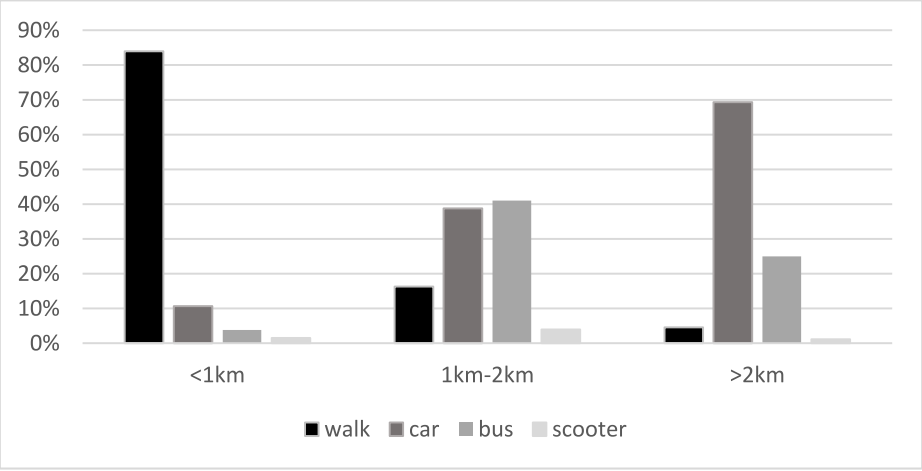

Fig. 4. Students' mode share by distance travelled.

Fig. 5. Students' mode share by height difference.

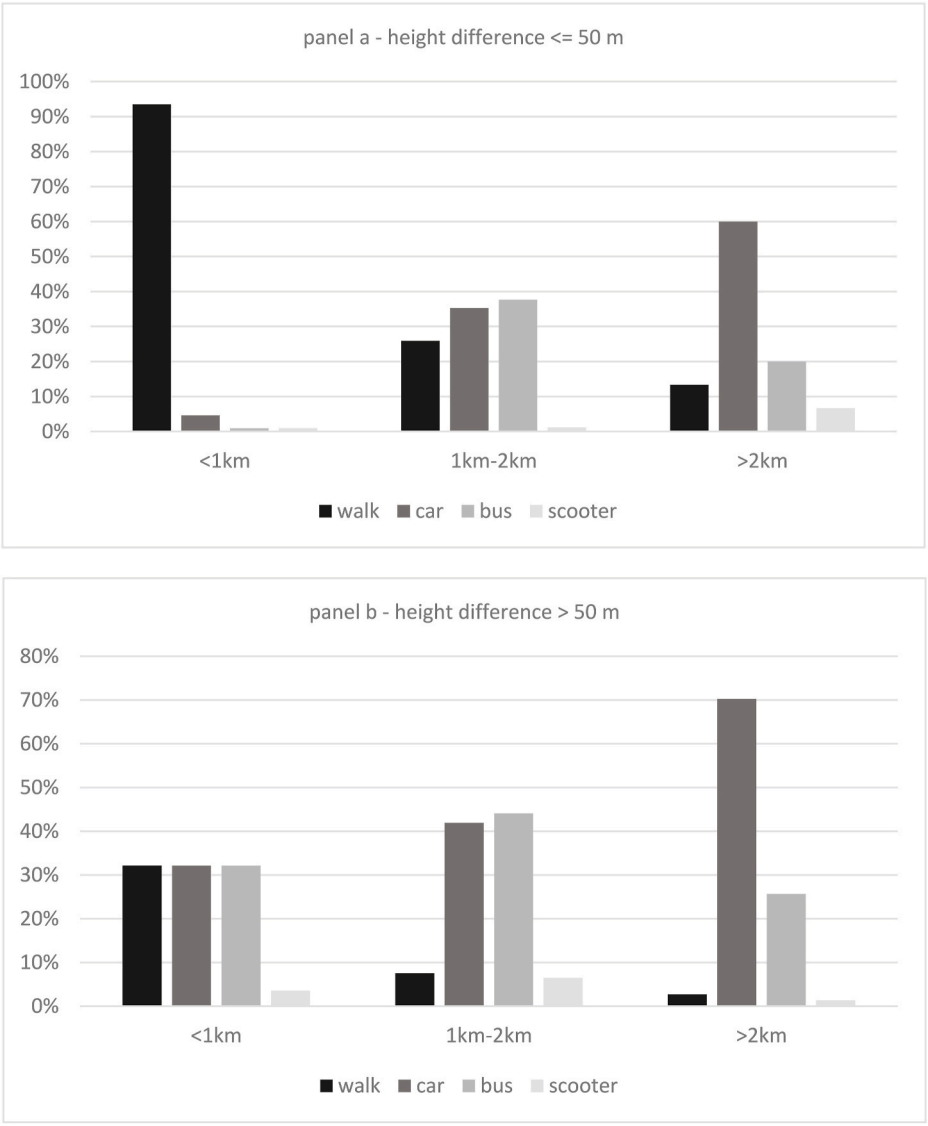

Fig. 6. Students' mode share by distance travelled and height difference.

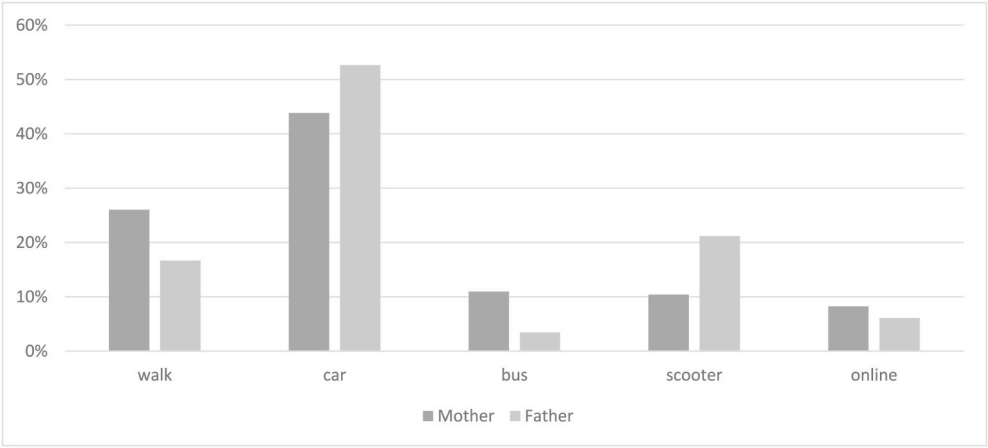

Fig. 7. Parents' mode share for commuting trips.

Table 1
Parents' and students' beliefs about transport modes' safety, security and environmental impact.

		walk	car	bicycle	bus
Preventing Covid-19 infection	Parents	73%	50%	30%	3%
	Students	56%	58%	45%	2%
	χ^2	13.0	2.6	9.9	0.4
	p	0.00	0.10	0.00	0.52
Healthier	Parents	84%	3%	57%	2%
	Students	88%	1%	78%	1%
	χ^2	1.3	2.0	20.3	1.8
	p	0.25	0.15	0.00	0.18
Avoid accidents	Parents	68%	27%	5%	38%
	Students	73%	10%	8%	30%
	χ^2	1.2	19.2	1.5	2.9
	p	0.27	0.00	0.22	0.09
Avoid harassment	Parents	19%	65%	15%	16%
	Students	7%	88%	12%	12%
	χ^2	12.7	29.5	0.8	1.3
	p	0.00	0.00	0.38	0.25
Environmental protection	Parents	92%	1%	72%	24%
	Students	94%	2%	91%	19%
	χ^2	0.6	0.7	23.9	1.5
	p	0.43	0.40	0.00	0.22

Note: percentages are calculated as the ratio of parents/students selecting the transport mode depicted in the column over the number of parents/students we interviewed. The complement to 100% of each cell represents, in percentage terms, the number of parents/students who did not select the transport mode described in the column. Since parents and students could select up to three transport modes, the percentages reported in along each row do not necessarily sum to 100%.

where RT is a vector of h explanatory variables describing the route travelled by child n when commuting to school. [3] SDC is a vector of k explanatory variables describing the respondent gender and age and how the respondent, if s/he is a parent, or the respondent's parents, if the respondent is a student, commute to work. AP is a vector of l explanatory variables describing the perceptions of respondent n with respect to the safety, security and environmental impact of each transport mode. The vectors of the parameters of each explanatory variable set are α_h, β_k and δ_l, respectively and are separately estimated for parents (p) and students (s). ε_{ni}, with i representing the three alternative transport modes (walking, travelling by car and travelling by bus), is an error term which is assumed to have a Gumbel distribution (type I extreme value) and to be independent of the estimated parameters, of the independent variables and of the N individuals. For identification purposes, the variance of the error term is set equal to 1. μ_p is an error component with a normal distribution, mean fixed at 0 and variance to be estimated. It is aimed at detecting whether the variance of the preferences of parents and students significantly differ and at rescaling the parameters estimated taking the difference of the scale parameter into account (Train, 2009).

In model MNL_3, instead, the utility U_{mi} a household $m \in \{1, \ldots, M\}$, comprising two member types, that is parent (p) and students (s), gets from walking (w), travelling by car (c), and travelling by bus (b), is given by:

$$U_{mw} = ASC_w + \lambda_h' \, RT_{mh} + \gamma_{pkw}' \, SDC_{pkw} + \gamma_{skw}' \, SDC_{skw} + \tau_{pkw} \, AP_{pkw} + \tau_{skw} \, AP_{skw} + \varepsilon_{mw} \quad [7]$$

$$U_{mc} = \gamma_{pkw}' \, SDC_{pkw} + \gamma_{skw}' \, SDC_{skw} + \tau_{pkw} \, AP_{pkw} + \tau_{skw} \, AP_{skw} + \varepsilon_{mc} \quad [8]$$

Table 2
Parents' and students' preferences for active mobility policies.

Policy		Respondent		Policy	Respondent	
Pedestrian lanes should be	protected from traffic	Parents	87%	speed limit 30 km/h	Parents	59%
		Students	74%		Students	40%
		χ^2	11.2		χ^2	14.8
		p	0.001		p	0.000
	separated from cycle paths	Parents	51%	traffic wardens	Parents	59%
		Students	65%		Students	36%
		χ^2	8.2		χ^2	21.6
		p	0.004		p	0.000
	wide	Parents	35%	guarded road intersections	Parents	63%
		Students	61%		Students	23%
		χ^2	27.7		χ^2	66.3
		p	0.000		p	0.000
Cycle paths should be	protected from traffic	Parents	92%	commuting with schoolmates	Parents	57%
		Students	77%		Students	60%
		χ^2	18.0		χ^2	0.4
		p	0.00		p	0.538
	separated from pedestrian lanes	Parents	56%	walking bus	Parents	67%
		Students	72%		Students	27%
		χ^2	11.3		χ^2	65.5
		p	0.000		p	0.000
	wide	Parents	47%			
		Students	73%			
		χ^2	28.6			
		p	0.000			

$$U_{npw} = ASC_{pw} + \alpha_{ph}' \, RT_{hn} + \beta_{pkw}' \, SDC_{npkw} + \delta_{plw} \, AP_{nplw} + \varepsilon_{nw} + \mu_p \quad [1]$$

$$U_{npc} = \beta_{pkc}' \, SDC_{npkc} + \delta_{plc} \, AP_{nplc} + \varepsilon_{nc} + \mu_p \quad [2]$$

$$U_{npb} = \beta_{pkb}' \, SDC_{npkb} + \delta_{plb} \, AP_{nplb} + \varepsilon_{nb} + \mu_p \quad [3]$$

$$U_{nsw} = ASC_{sw} + \alpha_{sh}' \, RT_{hn} + \beta_{skw}' \, SDC_{nskw} + \delta_{slw} \, AP_{nslw} + \varepsilon_{nw} \quad [4]$$

$$U_{nsc} = \beta_{skc}' \, SDC_{nskc} + \delta_{slc} \, AP_{nslc} + \varepsilon_{nc} \quad [5]$$

$$U_{nsb} = \beta_{skb}' \, SDC_{nskb} + \delta_{slb} \, AP_{nslb} + \varepsilon_{nb} \quad [6]$$

$$U_{mb} = \gamma_{pkw}' \, SDC_{pkw} + \gamma_{skw}' \, SDC_{skw} + \tau_{pkw} \, AP_{pkw} + \tau_{skw} \, AP_{skw} + \varepsilon_{mb} \quad [9]$$

where RT_{hm} is a vector of h explanatory variables describing the route travelled by the student when commuting to school, while SDC_{pkw} and SDC_{skw} are vectors of k explanatory variables describing the socio-demographic characteristics of each member type. AP_{pkw} and AP_{skw} are

[3] For identification purposes, the individual invariant variables RT are specified only in the utility function of walking.

vectors of l explanatory variables describing the perceptions of each member type with respect to the transport modes' safety, security and environmental impact. The vectors of the parameters of each explanatory variable set are λ_h, γ_k, and τ_l, respectively. ε_{mi}, with i representing the three alternative transport modes (walking, travelling by car and travelling by bus), is an error term which is assumed to have a Gumbel distribution (type I extreme value) and to be independent of the estimated parameters, of the independent variables and of the M households.

4.4. Results for the whole sample (MNL_1)

In Table 3 we report the estimates of the multinomial logistic regression model based on all the observations we collected (MNL:1). We used a stepwise procedure and controlled for the goodness of fit of the model to define which variables are to be included in the model specification. We checked the robustness of the model with respect to the selection of the explanatory variables and the specification of the error component. We tested several sociodemographic variables (e.g. age and gender of students, age of parents) and additional latent variables besides those included in the final model, but their parameters were not statistically significant and the unrestricted LL of the model did not significantly improve. Since the parameters are segment specific, we report them in two different columns, one for each household member.

Based on the parents' parameters estimates we find that, ceteris paribus, the probability that parents have children that use a motorized means of transportation (car or bus) is higher than the probability that their children walk to school, except for distances of less than 1 km and for height differences of less than 50 m. The probability that parents have children that commute on foot increases as parents think that walking is a safe means of transportation with respect to the Covid-19 pandemic. The probability that parents have children that go to school by car increases if mothers commute by car and if parents think that travelling by car is a safe means of transportation with respect to the Covid-19 pandemic. The probability that parents have children that go to school by bus increases if mothers commute by bus and if parents think that travelling by bus is a safe means of transportation with respect to the risk of harassment and the risk of accidents.

Students' parameters are similar to parents' ones with a few interesting exceptions. It is confirmed that, ceteris paribus, the probability that students use a motorized means of transportation is higher than the probability that they walk to school and that the probability of walking to school increases as distances are less than 1 km, and for height differences of less than 50 m. Moreover, in line with the results obtained for parents, students are more likely to walk to school if they think it is preferable to prevent the Covid-19 infection. However, differently from the results we obtained analyzing the data collected from parents, the probability that they commute on foot significantly increases also if they think that waking is a healthy transport mode. Similarly to the results obtained for parents, students are more likely to be taken by car if their mother commutes by car and if they think it is preferable to prevent the Covid-19 infection. However, students that believe that walking is preferable for the environment are less likely to go to school by car while parent's perceptions about the higher environmental sustainability of walking is not significantly correlated with the probability that their children go to school on foot. As for the probability that students use the bus to get to school, similarly to the results already obtained on the basis of parents' data, it increases if mothers commute to work by bus and if students believe that travelling by bus is safe with respect to the risk of harassment. Risk aversion with respect to accidents, instead, does not play a significant role when the perceptions and attitudes of students are taken into account in analyzing their choice of travelling by bus.

In addition to the evidence that some perceptions are only relevant for one of the two segments, health and environmental protection for students, risk of accidents for parents, it is interesting to note that also the relative importance of the driving factors differs. E.g. distance and height differences are relatively less important for students than for parents, while the negative *a priori* toward walking compared to using a motorized means of transportation (car or bus) is relatively smaller for parents than for students.

Table 3
Transport mode choice model based on all the data collected (MNL_1).

	Parents' alternative specific parameters (SE)	Students' alternative specific parameters (SE)
Walking		
ASC walking (relative to motorized modes)	−4.81*** (1.66)	−5.76*** (1.58)
Distance up to 1 km (dummy)	3.74*** (0.74)	2.98*** (0.59)
Max height difference up to 50 m (dummy)	2.80*** (0.77)	2.53*** (0.62)
Walking preferable to prevent Covid infection (dummy)	2.25* (1.42)	1.99*** (0.69)
Walking preferable for health (dummy)	0.92 (1.37)	2.70** (1.16)
Car		
Mother commuting by car (dummy)	0.97** (0.47)	0.73* (0.42)
Car preferable to prevent Covid infection (dummy)	1.72*** (0.45)	1.78*** (0.46)
Walking preferable for environment (dummy)	0.02 (0.43)	−1.04** (0.50)
Bus		
Mother commuting by bus (dummy)	1.39** (0.69)	1.42** (0.59)
Bus preferable to avoid harassment (dummy)	1.48***(0.54)	1.15** (0.57)
Bus preferable to avoid accidents (dummy)	1.48***(0.44)	−0.45 (0.48)
Standard Deviation Error Component (μ)	0.02 (0.72)	
N. of observations	336	
LL (0)	−602	
LL (final model)	−192	
Adj. Rho-square (0)	0.68	
AIC	429	
Estimated parameters	23	

Note: ***, **, * indicate significance at 1%, 5% and 11% respectively.

4.5. Results for paired parents and students (MNL_2)

The results we obtained using only the data collected from pairs of parents and students belonging to the same household (MNL_2, Table 4) are in line with the results we estimated for the whole sample (MNL_1) proving the robustness of our model specification also with respect to the different sample selection. [4] The only differences are that the relationship between the likelihood of going to school on foot and students' perception that walking is healthy and between the likelihood of going to school by bus and students' perception that travelling by bus is safe with respect to the risk of harassment are not statistically significant anymore.

[4] Due to the small sample size and subsequent strong correlation between the alternative specific constant and the variable describing students' positive health perception of walking, we could not enter this explanatory variable in the specification of the model.

Table 4
Transport mode choice model based on data collected from pairs of parents and students (MNL_2).

	Parents' alternative specific parameters (SE)	Students' alternative specific parameters (SE)
Walking		
ASC walking (relative to motorized modes)	−3.95** (1.86)	−6.48*** (2.22)
Distance up to 1 km (dummy)	3.79*** (0.95)	5.60*** (1.33)
Max height difference up to 50 m (dummy)	2.88*** (1.07)	4.30*** (1.45)
Walking preferable to prevent Covid infection (dummy)	2.15* (1.48)	3.98*** (1.55)
Car		
Mother commuting by car (dummy)	1.12* (0.67)	1.25* (0.68)
Car preferable to prevent Covid infection (dummy)	1.76*** (0.62)	2.94*** (0.71)
Walking preferable for environment (dummy)	0.11 (0.61)	−1.49** (0.74)
Bus		
Mother commuting by bus (dummy)	1.94** (0.92)	3.16*** (1.10)
Bus preferable to avoid harassment (dummy)	1.17** (0.71)	0.97 (0.83)
Bus preferable to avoid accidents (dummy)	1.69***(0.61)	0.63 (0.68)
Standard Deviation Error Component (μ)	0.06 (1.15)	
N. of observations	202	
LL (0)	−362	
LL (final model)	−91	
Adj. Rho-square (0)	0.75	
AIC	224	
Estimated parameters	21	

Note: ***, **, * indicate significance at 1%, 5% and 14% respectively.

4.6. Results for joined model (MNL_3)

With the third model (MNL_3, Table 5) we studied the transport mode choice at the household level. In line with the results we had already obtained, we found that, ceteris paribus, motorized means of transportation are more likely to be used than walking, except for short distances with limited height differences. The likelihood of walking to school increases when both parents and students believe that it is a safe means of transportation for preventing the Covid-19 infection. The strength of the positive relationship between the perception that walking is safe and the choice of walking, however, is stronger for students than for parents both in terms of statistical significance and in terms of the absolute value of the parameter.

It is also confirmed that the probability of using the car increases as mothers commute to work by car and if both parents and students believe that travelling by car is safe with respect to the risk of the Covid-19 infection. Students' perception that walking would be a more environmentally sustainable means of transportation, instead, does not significantly affect the likelihood of going to school by car.

As for the probability of using the bus, it is confirmed that it increases as mothers commute to work by bus and if parents believe that it is a safe transport means with respect to the risk of accidents. Parents' and students' perception that travelling by bus is safe with respect to the risk of harassment, instead, does not significantly influence the likelihood of using this transport mode to go to school.

Overall these findings, when compared to the ones provided by model MNL_2, show that at the household level the choice of transport mode seems to be affected by common preferences and, in some respects, more by parents' than students' attitudes and perceptions.

Table 5
Joint transport mode choice model (MNL_3).

	Household alternative specific parameters (SE	Parents' alternative specific parameters (SE)	Students' alternative specific parameters (SE)
Walking			
ASC walking (relative to motorized modes)	−9.16** (3.84)		
Distance up to 1 km (dummy)	5.58*** (1.58)		
Max height difference up to 50 m (dummy)	4.78*** (1.82)		
Walking preferable to prevent Covid infection (dummy)		2.79* (1.80)	4.41** (1.85)
Car			
Mother commuting by car (dummy)		0.81 (0.80)	
Car preferable to prevent Covid infection (dummy)		2.57*** (0.90)	2.66*** (0.84)
Walking preferable for environment (dummy)		- 0.24 (1.62)	- 1.24 (1.67)
Bus			
Mother commuting by bus (dummy)		3.66***(1.23)	
Bus preferable to avoid harassment (dummy)		0.80 (0.83)	0.54 (1.02)
Bus preferable to avoid accidents (dummy)		1.97*** (0.81)	1.17 (0.85)
N. of observations	101		
LL (0)	−124		
LL (final model)	−35		
Adj. Rho-square (0)	0.73		
AIC	101		
Estimated parameters	15		

Note: ***, **, * indicate significance at 1%, 5% and 12% respectively.

4.7. Parents' and students' preferences for active mobility policies

In Table 6 and in Table 7 we report the estimates of two binomial logistic (BNL) regression models describing which policies would favor the adoption of active travel modes by the students that at the time of the survey were not going to school by bike or on foot.

In model BNL_1 the dependent variable is a binary variable. It describes whether parents would allow their children to commute to school by bicycle or whether students would we willing to ride the bicycle to go to school if cycle lanes were available. Since nobody stated to use the bike to commute to school, to estimate this model we used the data collected from all the respondents (410 observations) excluding only 13 questionnaires due to important missing data.

With model BNL_2, instead, we analyzed whether parents would allow their children to commute to school on foot or whether students would be willing to walk to school if pedestrian lanes were available. Since 36% of the sample was already walking to school, to estimate this model we asked this question and we used only the data collected from the households whose children were not going to school on foot (262 observations) excluding 1 questionnaire due to important missing data.

Table 6
Policies favoring going to school by bicycle.

	Parents' specific parameters (SE)	Students' specific parameters (SE)
Other motorized transport modes	−1.03 (0.79)	1.88*** (0.51)
Speed limit 30 km/h (dummy)	0.94* (0.57)	1.64*** (0.39)
Commuting with schoolmates (dummy)	−0.18 (0.57)	1.11*** (0.37)
Cycle lanes should be protected from traffic (dummy)	0.59 (0.69)	1.00** (0.43)
Max height difference up to 50 m (dummy)	1.58* (0.55)	0.23 (0.35)
Parent's gender (dummy = 1 for female)	−0.88* (0.54)	
Standard Deviation Error Component (μ)	0.00 (0.99)	
N. of observations	397	
LL (0)	−550	
LL (final model)	−174	
Adj. Rho-square (0)	0.68	
AIC	374	
Estimated parameters	12	

Note: ***, **, * indicate significance at 1%, 5% and 11% respectively.

Table 7
Policies favoring going to school on foot.

	Parents' specific parameters (SE)	Students' specific parameters (SE)
Other motorized transport modes	0.32 (0.55)	0.54 (0.59)
Speed limit 30 km/h (dummy)	1.20** (0.61)	1.33** (0.56)
Traffic wardens (dummy)	0.70 (0.60)	1.44** (0.63)
Pedestrian lanes should be protected from traffic (dummy)	0.92* (0.58)	0.76 (0.52)
Pedestrian lanes should be separated from cycle lanes	−0.91* (0.54)	−1.17** (0.52)
Standard Deviation Error Component (μ)	0.00 (0.99)	
N. of observations	261	
LL (0)	−362	
LL (final model)	−120	
Adj. Rho-square (0)	0.67	
AIC	262	
Estimated parameters	11	

Note: ***, **, * indicate significance at 1%, 5% and 11% respectively.

More specifically, in model BNL_1 the utility U_n an individual $n \in \{1, \ldots, N\}$ who is either a parent (p) or a student (s) gets from allowing her/his child to go to school by bicycle or from going to school by bicycle (b) instead of using an alternative motorized transport mode (a) is given by:

$$U_{npa} = ASC_{pa} + \varepsilon_{na} + \mu_{np} \quad [10]$$

$$U_{npb} = \eta_{pk}' \, SDC_{npk} + \nu_{ph}' \, RT_{nh} + \zeta_{pg}' \, PO_{npg} + \varepsilon_{nb} + \mu_{np} \quad [11]$$

$$U_{nsa} = ASC_{sa} + \varepsilon_{na} \quad [12]$$

$$U_{nsb} = \eta_{sk}' \, SDC_{nsk} + \nu_{sh}' \, RT_{nh} + \zeta_{sg}' \, PO_{nsg} + \varepsilon_{nb} \quad [13]$$

where the explanatory variables describe the k sociodemographic characteristics (SDC_{nk}) of the respondent; the h characteristics of the route travelled by the student when commuting to school (RT_{nh}); the g policies that the respondent believes should be used by the local administrators to increase the adoption of this form of active mobility (PO_{ng}). The policies proposed in the survey include:

- building a network of wide cycle paths;
- building a network of cycle paths protected from traffic;
- building a network of cycle paths that are separated from pedestrian lanes;
- setting a speed limit of 30 km/h in the school surroundings;
- increasing the number of traffic wardens monitoring the surroundings of the school;
- monitoring the roads intersections;
- organizing groups of schoolmates to go to school with;
- organizing walking school buses.

The vectors of the parameters of each explanatory variable set that is the sociodemographic characteristics, characteristics of the route, and the policies to be implemented, are η_k, ν_h and ζ_g, respectively. ε_{ni} is an error term which is assumed to be IID with a Gumbel distribution.

Model BNL_2 has the same specification as model BNL_1 except that the dependent variable represents the choice between walking to school and using alternative motorized means of transportation (i.e, the car, the bus or the scooter).

We used a stepwise procedure to define the models' specification. We controlled whether the parameters of the explanatory variables we entered in each stage of the analysis were statistically significant and whether the unrestricted LL of the model substantially improved. The final models reported in Tables 6 and 7 proved to be robust with respect to the variable selection process we used. The inclusion of the additional error component we specified to control for the scale difference between parents and students did not affect the sign and value of the parameters.

With reference to model BNL_1 (Table 6) we found that the likelihood that parents allow their children to commute by bicycle increases if the maximum height difference along the route is less than 50 m. We also found that the likelihood that parents would favor the use of the bicycle to go to school is higher for those parents who believe that the local administration should implement a speed limit of 30 km/h in the surrounding of the school. However, we also found that, ceteris paribus, mothers would less likely allow their children to ride the bicycle, compared to fathers.

Students would still prefer a motorized means of transport if no additional policies were implemented beside the provision of cycle lanes. However, the willingness of riding the bicycle to go to school is higher for those students who believe that a speed limit of 30 km/h should be implemented, that cycle paths should be protected from traffic, and that groups of schoolmates commuting together should be organized. None of the variables we have included in the specification of the model to describe the sociodemographic characteristics of the respondents, the distance to be travelled, and the additional policies we proposed in the questionnaire, significantly influenced the willingness to commute (or to allow the students to commute) to school by bicycle.

As for the choice of walking to school (model BNL_2), we found that (Table 7) parents' willingness to allow their children to walk to school increases if they believe that a speed limit of 30 km/h should be introduced and that pedestrian lanes should be protected from traffic. Students' willingness to walk to school increases if they believe that a speed limit of 30 km/h should be introduced and that the number of traffic wardens should be increased. Finally, the opinion that pedestrian lanes should be separated from cycle lanes, is negatively related with the willingness of walking to school or of allowing children to walk to school.

5. Discussion and conclusions

This study examined which factors drive children and parents' choice toward active commuting to school acknowledging the role that children play in deciding the transport mode to be used. We found that a significant role is played not only by the distance to be travelled, but also

by the maximum height difference to be covered along the path, a factor never studied before in this research field. The mobility habits of parents are also important, as the likelihood of students going to school by car or by bus increases as parents, more specifically mothers, use the car or the bus to get to work. Sociodemographic characteristics of parents and students such as gender and age, instead, do not play a significant role, at least when also perceptions of the risks and benefits of active mobility compared to motorized means of transportation are taken into account. To assess their relative importance, we regressed the current choice on how to commute to school against the characteristics of the route to be travelled, the sociodemographic characteristics of the respondents, and the respondents' beliefs about the benefits and risks of walking, travelling by car, and travelling by bus. We found that both parents and students are highly influenced by the perception of the Covid-19 infection risk and that this factor favors commuting on foot or by car. The willingness to avoid the risk of harassment, instead, is significantly related with the bus use and is perceived as important by both parents and students. However, while students' choices are also driven by the perceived environmental and health benefits of walking, favoring active mobility choices, parents' choices are further conditioned by the risk of accidents. At the household level, instead, the prevailing factors driving the choice are the Covid-19 infection risk and parents' perception of the risk of accidents. Our results offer a richer picture of the travel mode preferences within families compared to the evidence provided in the literature, showing that some driving factors are relevant for both students and parents but also that significant differences exist between students' and parents' attitudes and perceptions.

This research further expands the literature by analyzing and comparing parents and students' preferences for the policies that should be implemented to support active commuting to school. We find that providing pedestrian lanes and cycle lanes will not suffice to induce a modal shift toward walking and cycling. In fact, the willingness of both parents and students of (allowing) walking or cycling is positively related to the opinion that a speed limit of 30 km/h should also be implemented. We tested several other complementing policies and we found that parents' and students' perception of which are the most important ones greatly differ. Parents deem it important to implement policies reducing the risks of accidents, such as protecting pedestrian and cycle lanes from traffic and separating pedestrian from cycle lanes, while students are also in favor of policies increasing traffic control enforcement, while enabling them to commute with schoolmates.

These results provide important insights to local administrators on how they should review urban traffic plans. Introducing a speed limit of 30 km/h within some areas of the city center is among the most discussed policies not only in Trieste but also in many other Italian cities. However, according to our results, although such an initiative would be welcome by the school community, it will not be effective until separated and protected pedestrian and bicycle paths are also provided. Moreover, the speed limit should be rigorously enforced and should be accompanied by additional interventions such as stricter controls of irregular parking and of major road intersections by traffic wardens.

We also found that the students we surveyed, contrary to their parents, would not be in favor of initiatives such as the "walking school bus", although it has proven effective in other countries and the local administration is currently analyzing its feasibility. Moreover, as already pointed out by Larouche et al. (2012), Prezza et al. (2009) and Yang et al. (2014), organizing a "walking school bus" is a highly demanding initiative whose success might be constrained by insufficient follow-up duration, incomplete implementation of planned interventions, little access to funding resources and lack of formal support from local and regional governments. According to our results and in line with the evidence reported by Nikitas et al. (2019), it would be much more effective to implement a school-level platform that connects schoolmates (and households) living in the same street or neighborhood allowing them to share the journey to school with or without adult supervision. Indeed, as already suggested by Aranda-Balboa et al. (2021), Forman et al. (2008), and Timperio et al. (2006), students need physical or motivational encouragement and social support to walk or cycle to school. In fact, in our case study we found that having someone to walk or cycle with to school would not influence parents' preferences but would significantly increase students' willingness to actively commute to school, confirming that socialization is more important for children than for adults.

According with our results and with the evidence reported by Aranda-Balboa et al. (2021), providing students and parents with short training courses on road safety and on the short- and long-term benefits of actively commuting would also help increase the willingness to walk or use the bicycle to go to school. However, our research demonstrates that both students' and parents' involvement is crucial to guarantee the effectiveness of these kinds of initiatives, as already pointed out by Buttazzoni et al. (2019), Park et al. (2013), Wilson et al. (2018) and as proved by Lawson et al. (2019) in the environmental domain. As long as students attend training courses on the environmental and health benefits of walking and cycling but their parents are not aware of it and do not believe that the commuting journey and the environment surrounding the school are safe, the household decision on how to go to school will not shift toward active transport modes. The case study analyzed in this research is emblematic with respect to this issue: although the school where we conducted the survey organized several workshops during the year with the local police to provide students with the training needed to safely commute to and from school, 85% of the parents were not aware of it. Parental education and students empowerment initiatives, as well as active mobility policies that are in line with households' preferences, would most likely reduce the existing intention-behavior gap according to which although the vast majority of parents and students surveyed were in favor active commuting to school, a high percentage of them still travel by car.

Adopting soft policies aimed at increasing awareness within the community and among other motorized transport users about parents' concerns about their children walking or cycling would also be beneficial (Macdonald et al., 2019; Scheiner et al., 2019; Yang et al., 2014), since according to our results safety concerns significantly condition the transport mode choice at the household level. In addition, as underlined by Carver et al. (2013), policies aimed at increasing community connectedness and at building social trust may be important to encourage active transport for students, since they would reduce the fear of harassment perceived both by parents and students. Indeed, the local environment and travel context heavily influence students' needs, shaping their exposure and their perceptions of both the opportunities and risks of independently commuting to school (Casadó et al., 2020). Media campaigns involving schools and the wider community promoting a physically active culture, passive surveillance, road safety and a shared sense of security could also help in achieving a more active and sustainable commuting system (Smith et al., 2020).

As pointed out by Prezza et al. (2009), the ultimate goal is to establish a virtuous circle. The greater the autonomy developed by children, the greater the confidence of parents in their children's ability to go to school actively and independently; the more children are allowed to walk or cycle to school, the more self-confident they are and the more the environment around the school becomes and is perceived as safe and suitable for pedestrians and riders.

Our research has several limitations. First, our findings depend on the cultural, geographical and social context in which we collected the data, thus they may not be fully generalizable across all school grades or to other Italian cities. In fact, we focused on middle school students; however, different outcomes might be expected and found for primary and high school students. Furthermore, the city where we carried out our research has peculiar geographic characteristics that significantly influenced our results, as shown by the importance of the maximum height difference of the route travelled for the chosen means of transportation. Our results, on the other hand, also demonstrated the importance of accounting for this factor when dealing cities

characterized by hilly areas of neighborhoods. Two additional local-specific factors have conditioned our results: the supply of public transport services, which is much wider and denser in Trieste than in most Italian cities, and the absence of cycling lanes, which are instead provided in many other Italian cities. Therefore, the degree of generalizability of our findings requires further studies to be fully established. Second, the short-term decision on how to commute to school is closely related to the long-term decision on where to live. Although we controlled for the influence of the home-school distance in choosing which transport mode to use, our results might still be affected by a self-selection bias. Third, our results are based on cross-sectional data, implying that causality effects could not be tested and that the nature of the relationships we observed should be considered with caution. Finally, the econometric models presented in this paper do not take into account the role played by the level-of-service characteristics (e.g. travel time and travel cost) of the mode alternatives on the students' choice on how to commute to school, a topic that should be further investigated to test the robustness of our results.

Future research lines include also the extension of the study to other schools located in different neighborhoods of Trieste and the collection of panel data. Other student populations and geographical contexts will also be investigated, including smaller and larger cities, and rural areas.

CRediT authorship contribution statement

Lucia Rotaris: Supervision, Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft. **Fabio Del Missier:** Conceptualization, Methodology, Writing – review & editing. **Mariangela Scorrano:** Validation, Writing – review & editing.

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