https://doi.org/10.3311/PPtr.36538

Periodica Polytechnica Transportation Engineering, 52(4), pp. 423–436, 2024

Research on Special Phenomena of School Mobility, through the Example of Dunabogdány

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Received: 25 January 2024, Accepted: 30 July 2024, Published online: 13 August 2024

Abstract

The level of traffic safety is always a crucial issue for school-age children, as they represent one of the most vulnerable groups of road users. Problems related to school mobility primarily arise in larger urban areas, but due to the increasing motor vehicle traffic, they have also emerged in smaller communities. During the development of the mobility concept for Dunabogdány, a small settlement in the Danube Bend, we had the opportunity to assess school-related traffic behaviour. However, the results obtained did not always reflect established practices, prompting us to conduct further research to identify the underlying issues. This article presents the results of our additional research, which we compare with findings from other studies. Based on these comparisons, we formulate general suggestions, primarily aimed at enhancing the safety of active transportation for children.

Keywords

school mobility, transport safety, transport planning, transport behaviour survey

1 Introduction

In everyday life, mobility habits are significantly influenced by school traffic. Whether as students or parents participating in transportation, it is in our fundamental interest that both the journey to and from school proceed safely. In larger urban areas, this is particularly true due to greater distances, but the same holds for smaller settlements as well.

Within the framework of a project, we had the opportunity to assess the school mobility habits of a small rural community, laying the foundation for a scientific examination of the transportation situation in such settlements. Generally speaking, it can be stated that in recent decades, transportation difficulties have been increasingly observed in the immediate vicinity of schools in many communities. This often translates into congestion in vehicular traffic, as more and more children are being driven to school by car. Besides causing time loss not only for those arriving at school, this practice increases environmental pollution and compromises traffic safety. The latter may further reinforce the phenomenon since it discourages students from traveling to school independently. The question arises whether similar trends are found in a small Hungarian village, or if traditional modes of transportation, such as biking and walking, still prevail here. We consider this investigation important because it is necessary to determine whether the dominance of passenger car traffic has reached even the small rural areas and, if so, whether there are possibilities to counteract this trend, thereby re-establishing active modes of transportation as the primary means for children's school commuting.

In our article, therefore, employing the method of induction, we draw conclusions from the specific survey conducted in a small rural community and additional literary results. Based on these, we make general observations regarding the school mobility habits in small settlements and, using this information, formulate general recommendations to strengthen active mobility. Our suggestions prioritize the transportation safety of children.

2 Situation analysis

Dunabogdány is a settlement located on the Buda side of the Danube Bend, between Szentendre and Visegrád. Its main traffic route is National Road No 11, which handles the traffic of the Danube Bend's Szentendre side and the Szentendrei-sziget area with the capital. On the Szentendre side of the Danube Bend, rail transport is available only up to Szentendre; from thereon, the settlements in the region

Cite this article as: Albert, G., Lévai, Z. (2024) "Research on Special Phenomena of School Mobility, through the Example of Dunabogdány", Periodica Polytechnica Transportation Engineering, 52(4), pp. 423–436. https://doi.org/10.3311/PPtr.36538

can only be reached by road. This significantly influences the vehicular traffic in Dunabogdány. The Danube Bend has been a popular destination for those relocating from Budapest in recent years. As depicted in Fig. 1, while the population of the Szentendre district increased by 31.4% between 2000 and 2021, Dunabogdány's population grew by only 9.7% during the same period.

However, the number of vehicles increased at a much higher rate than the population. Fig. 2 illustrates that the number of passenger cars doubled over the mentioned 12 years, both in the Szentendre district and in Dunabogdány.

The growth rate of these two factors compelled the municipality of Dunabogdány to attempt to manage the increased vehicular traffic and find solutions to the challenges posed by the heightened traffic. To this end, with the authorization of the municipal council, the mayor approached KTI Hungarian Institute of Transport Science and Logistics Nonprofit Limited Liability Company (hereinafter referred to as KTI) to develop the municipality's transportation concept and provide scientifically based

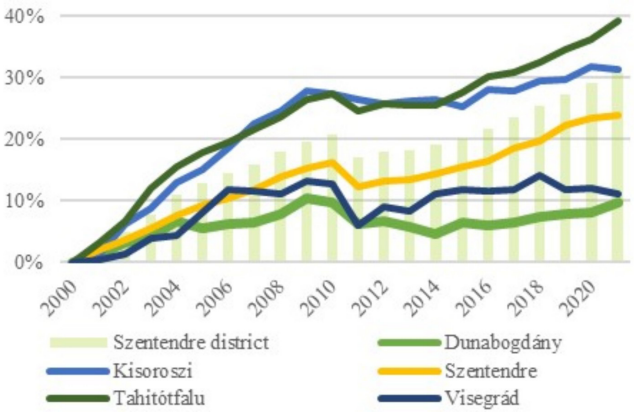

Fig. 1 Population changes in the examined settlements and areas relative to the base year (Source: Own editing based on data from the Hungarian Central Statistical Office (KSH) 2023)

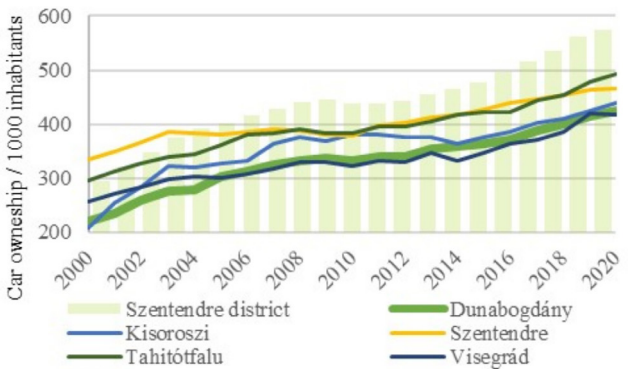

Fig. 2 Evolution of motorization level in the Szentendre district (Source: Own editing based on data from the Hungarian Central Statistical Office (KSH) 2023)

possible solutions for managing transportation challenges. According to the final agreement, KTI not only prepared a transportation concept but also a mobility concept. The goal of a mobility development concept is to ensure that future specific interventions align with a coherent train of thought within the vision for the municipality. Therefore, a concept must start from a broader perspective and take into account all areas influencing mobility.

The work was conducted in two phases, involving on-site surveys, measurements, interviews, and questionnaires. The first phase focused on identifying problems, while the second phase involved site evaluations and the development of the concept. In the following, we will address the school mobility identified in the second phase.

The elementary school and the kindergarten of the municipality play a central role in terms of mobility – justified not only by their central location within the settlement. The school can be approached from four directions, three of which are accessible by car, while the fourth direction allows access only without a car. The kindergarten is accessible both by car and on foot.

The car approach to the school from Iskola Street and Kiscuki Lane, using the established roundabout with K+R facilities, is excellently resolved. At the official main entrance of the school, cars cannot stop directly near the gate; they can only park in the church's parking lot. The fourth approach option through the municipal office courtyard primarily provides safe access for pedestrians or those arriving by public transportation. This route functions as a pedestrian path between Kossuth Lajos Street and the school, excluding car traffic.

3 Literature review

The transportation challenges around schools are not just a domestic phenomenon. Many countries around the world are addressing the issue of how to reduce car traffic to schools and redirect it towards active and public transportation modes. Therefore, before formulating our research questions, we conduct a literature analysis to identify the areas that are worth analyzing in our own primary survey based on the results, aiming to further enhance the safety of children commuting to school.

It is generally accepted that young children are entirely dependent on their parents, including every aspect of their transportation, purpose, timing, and mode. Studies support the commonly observed phenomenon that the age at which children start traveling independently has shifted in recent decades (Pooley et al., 2005), primarily on foot

and by bicycle. The main reason for this is the deteriorated sense of traffic safety due to increased vehicular traffic (Karsten et al., 2001), but the change in social trust (Carver et al., 2013; Johansson, 2005), and the growth in car ownership also play important roles. It is a peculiar phenomenon that the latter plays a dual role: besides providing more opportunities for parents to transport their children by car, it contributes to the decrease in the sense of traffic safety by increasing traffic volume. In light of these factors, studies on travel habits to school generally focus on the 8–10 age group and high school students. Considering their differing competencies, surveys of parents are usually separate from those of children.

A study by Nichols and Ryan (2023) also points to an increase in car travel to school and a decrease in active transport use over the last decade. This is confirmed by research of Guliani et al. (2015) who found a strong negative correlation between school travel distance and active transport use. A Portuguese research (2018) found that one of the disadvantages of cycling to school may be hilly streets (Arsenio et al., 2018). This may also be a reason for the higher proportion of travelling to school by car.

In their analysis, Evenson et al. (2006) examined the correlation between active modes of commuting (walking or cycling) to school and the environment, as well as other physical activities, for girls. During the study, 480 American girls in 6th and 8th grades completed a questionnaire, answering questions about the environment of their school commuting route (safety, traffic, aesthetic appearance, etc.) and home exercise opportunities. Additionally, they provided information on their independent transportation options (how much they were allowed to cycle or take the bus on their own), their exercise habits, and finally, their frequency of walking and cycling. Only a few findings were related to transportation habits, showing that in an environment providing a greater sense of safety and aesthetics, the proportion of girls walking and cycling to school is higher.

In Australia, among children aged 6–7 and 10–12 – as expected – an inverse proportionality was found between active commuting to school and the presence of a separating effect of traffic volume at intersections, similar to the younger age group with the slope of the route. Both age groups were more likely to choose active commuting modes if the school was not more than 800 meters away (Timperio et al., 2006). Three years later, the research group found that parental attitude is crucial: where they were satisfied with traffic safety, such as at pedestrian crossings on main roads, the proportion of active commuting increased within the family (Hume et al., 2008).

Wangzom et al. (2023), reviewing relevant research results between 2000 and 2020, pointed out that despite numerous campaigns and studies, the number of children walking or cycling to school is decreasing. The study confirmed that students are more likely to choose active commuting when their parents consider the route length, traffic safety, and neighborhood safety to be appropriate. A fundamental requirement for this is an obstacle-free sidewalk, the favorable effects of which – as demonstrated by a study using modern modeling techniques (Landis et al., 2001) – are strengthened by its wider physical separation from vehicular traffic, expansion, separation with trees, and barriers. This also reduces vehicle traffic speed, further improving the sense of safety. Additionally, it is evident that the slowly (if at all) changeable characteristics of the built environment are crucial in the choice of commuting mode to school.

Carver et al. (2013) focused their Australian study on understanding the motivation behind the transportation mode choices of parents who drive their children to school (and often elsewhere). The questionnaire was completed by 430 primary school and 258 high school students' parents (88% women). In 79% of families, at least one parent worked part-time, and 72% had two or more cars available. Thirty-four percent of the children were driven to school by car, with the rate being 46% for primary school students and 14% for high school students. Parents cited their concern about potential traffic accidents (45%) as the primary reason, but social trust, along with its various components (adults' helpfulness, aggressive groups of children, etc.), also played a significant role. Girls were more likely to be driven by car, as they generally had lower levels of independent mobility, and the rate of car use was higher where there was a part-time working parent.

A Flemish study aimed to explore how children evaluate their own transportation habits (Zwerts et al., 2010). To reliably uncover the main factors, three surveys were conducted: children and parents each filled out a questionnaire, and the children also completed a two-day transportation diary. Forty-four percent of the trips were related to commuting to school, with 39% being car trips among 6–11 year-olds, decreasing to 20% among 12–15 year-olds. Most other trips were made on foot or by bicycle. Independent, adult-accompanied travel was much more important for boys, while the possibility of traveling with friends was of paramount importance for girls. Girls proved to be much more sensitive to the harmful environmental effects of cars, yet they chose this mode of transportation more often than boys. Public transportation must overcome prejudices and the problem of "unknown and

unlikable" perceptions; children's judgment of it is more negative compared to other modes, although those who use it have a much more favorable perception. It is noteworthy that while 92% of children considered themselves old enough to travel alone on foot or by bicycle, this value was only 58% for buses and only 39% for trains, although this ratio increases with age. Parental responses clearly indicate that mothers are more concerned about their children than fathers, and each of them considers the immediate environment of their residence safer than the more vaguely defined "other", "distant", or "different" areas.

In their survey, Barna and Bereczky (2023) examined the actual and desired modes of transportation to school in several Hungarian primary schools. The results showed that more than half of the children travel to school by car, even though this ratio shows a continuous decrease with age. Walking, followed by public transportation, lags significantly with a relatively stable ratio. The trend indicates that some who come from farther distances for walking shift to using public transportation. The proportion of cycling was very low in the surveyed population. For lower-grade students, active transportation is the most desired mode, but for upper-grade students, this drastically decreases, and driving and motorcycling take precedence. Another survey in different areas of the country yielded similar values: 63% of students arrived by car, 25% on foot, 6% by bicycle, and 4% by public transportation (Rab and Bereczky, 2023).

Overall, it can be concluded that the main characteristics of mode choice for traveling to school have been very similar in recent decades, regardless of geographical location. The proportion of car travel is determining, with parents deciding on the mode of transportation mentioning their concerns about traffic safety and lack of social trust as the most significant factors, among many other local factors. However, it is also true that the level of traffic safety can be considered a social product (Lévai, 2019), meaning that these two factors are not independent of each other.

It is also evident that there are two significantly different streams of research approaches analyzing the motivation of traffic to school. One explicitly examines the role of active modes of transportation and the possibilities for promoting a healthy lifestyle. This involves categorizing non-active modes of transportation together, treating individual and public vehicle use together. It also means that these studies often do not examine some of the interventions that improve the traffic situation around schools.

The other stream, examining factors influencing the choice of transportation mode, seeks ways to reduce the proportion of commuting to school by car. It explores methods of redirecting transportation towards both active and public transportation. This approach may result in uncovering relationships that can assist in developing measures to improve both transportation issues and related environmental impact, i.e., sustainability. Our own research primarily focuses on mobility management; therefore, we more frequently employ the toolkit of this second approach, as we did in the case of Dunabogdány.

It is important to emphasize that local conditions and long-established traditions significantly influence transportation habits. Survey values from countries with extensive vehicle-based transportation, such as the United States or Australia, must be compared with caution to those in smaller countries with strong cycling traditions, such as Belgium. This is especially true when it comes to changes and trends.

4 Methodology

Based on the literature analysis, it can be concluded that a settlement's topology, the development of transportation infrastructure, and the volume of motorized traffic all impact children's school mobility habits. However, we have not identified studies that simultaneously examined school mobility based on topological and vehicle ownership criteria. Moreover, gender-specific analyses are scarce. Studies usually focus on a target group, either children or parents. However, we deemed it worthwhile to survey both target groups simultaneously and compare the results in terms of how parents generally transport their children to school and whether they act accordingly on an average school day.

Based on the results of our survey and the literature analysis, we formulated the following research questions:

1. The topography of the settlement can be divided into two significantly different areas: flatlands and highlands. The nearly flat areas are suitable for cycling, while the steep mountainous roads are not. Responses to questions about vehicle ownership showed that families have a very low bicycle ownership rate, only 48%, compared to the national average of 70%. This suggests that bicycle usage among adults in Dunabogdány is likely to be lower than the national average of 67%, and the rural average of 72% (Medián, 2022). We assume that this low value

in Dunabogdány is actually differentiated, being substantially lower for the highland residents and higher for those living in the flatlands.
2. Initial survey results indicate a high percentage of students commuting to school by car. Locals mention that one reason for this is their concern for their children in heavy traffic. We hypothesize that, apart from external factors like infrastructure, there are two internal components to this phenomenon: the child's gender and age. Therefore, we examine whether stereotypes hold true, such as girls and younger children being more protected than boys and older ones, and whether the latter travel to school more independently. Additionally, we analyze the influences that may affect these results.
3. While parents were asked about the typical commuting habits of their children and students about their daily mode of transportation to school, the responses regarding the mode of commuting vary significantly. We aim to uncover the reasons behind this discrepancy. Understanding this can greatly assist in the future compilation and evaluation of similar questionnaires.

As the young children of the settlement primarily attend one of the local educational institutions, we deemed it necessary to assess the traffic and mobility conditions of these institutions, with a specific focus on the school. To understand these conditions, beyond conducting traffic observations, we had the opportunity to gather the opinions of students and parents through a questionnaire survey.

Therefore, as a primary element of our research, we conducted a questionnaire survey among the students of the Dunabogdány Elementary School. The survey date was set for April 19, 2023, a Wednesday – an average school day with no special events planned at the school. The survey among the school's students was conducted on paper and with the assistance of teachers. Separate questionnaires were prepared for students in the lower and upper grades. Our goal was to gain insight into how students arrived at school on that particular day. We processed the responses and presented our findings in the mobility concept. As part of the primary research, we also surveyed the parents of the school online about their children's commuting habits. Parents were given two weeks to fill out the online questionnaires.

Our secondary research involved reviewing literature related to the research hypotheses to understand whether the results from Dunabogdány correlate with findings from other similar studies.

By employing the inductive method in the analysis of our primary and secondary research results, we draw general conclusions about the school mobility in small settlements. Additionally, we provide general recommendations to promote the reintroduction of active modes of transportation in the context of school mobility.

5 Discussion

5.1 Results

To answer our first research question, we utilize spatial delineation regarding what qualifies as an area difficult to navigate by bicycle, namely, a hill. For this purpose, we rely on a map created by KTI based on data from Lechner Knowledge Centre (Fig. 3). The markings on the streets indicate their steepness, providing a basis for delineating the hilly areas.

To conduct the study, we rely on the responses from the resident questionnaire in Dunabogdány. Based on the statements of the respondents, 48.1% own a bicycle, of which only 28.4% live in the hills, while 71.6% reside in the flat areas. According to the results, the ownership rates of bicycles for respondents living in flat and hilly areas barely differ (48.8% and 46.3%, respectively), both significantly below the national average (67%) and even more so below the rural average (72%). These measured values include children who own and ride bicycles.

The flat area is divided by National Road No. 11, which handles heavy motor vehicle traffic, and locals, according to their statements, do not like to cycle there. Thus, the most bike-friendly part of the settlement is the area between National Road No. 11 and the hills, where only the primary school and kindergarten are located. The main facilities (such as the town hall, post office, medical office, cultural centre), as well as the beach and shops, are located along National Road No. 11 or can be reached by crossing it. Therefore, it can be stated that the settlement is not an ideal area for cycling, and this situation is not significantly improved by the Danube-side bike path, as most of the daily destinations are not directly accessible from it. This may explain the below-average rates of bicycle ownership and usage.

From the survey, it can be concluded for all residents and those living in the hills that they primarily use bicycles instead of cars where parking is problematic (e.g., visiting the beach, 63.6% from flat areas, 68% from hilly areas). For destinations with an adequate number of parking spaces or those need to be reached regardless of weather conditions, car usage is stronger. It is important to highlight

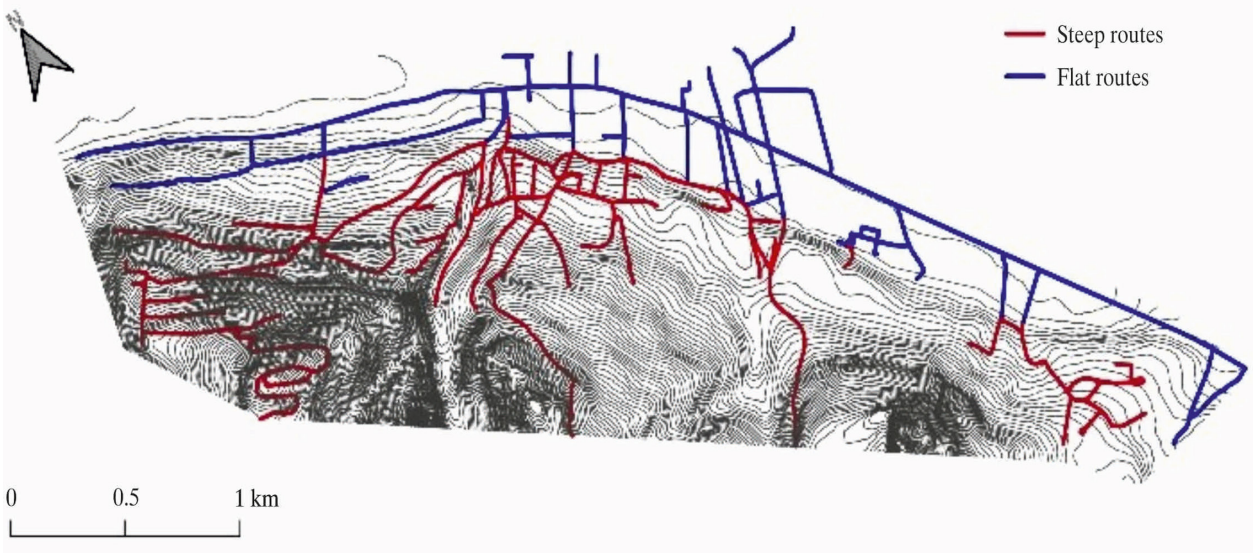

Fig. 3 Slope of the streets in Dunabogdány (Source: own editing)

that these destinations are located in the flat area of the settlement. Among flat area respondents who own a bicycle, 57.6% use it to go to Heim Bakery, and 45.5% to go to the Coop store, while for those in hilly areas, these figures are 52.0% and 40.0%, respectively. Therefore, the trend identified earlier applies to the use of bicycles in these places.

When examining the school cycling habits, it can be observed that on the day of the survey, 16.1% of Dunabogdány students arrived by bike, of which only 10.5% live in the hilly area. School data also confirm the validity of the above trend because the school is excellently accessible by car with sufficient parking spaces available, ensuring the safe exit of children through the K+R system, and consequently, the transportation time to school is predictable.

Our research, relying on a more detailed analysis of the questionnaires, did not confirm our initial hypothesis that the ownership rate of bicycles is lower among residents living in the hilly area compared to those in the flat area. The expected difference in bicycle usage is slightly detectable, but these values fall far below the national average. Moreover, we have shown that bicycle usage is primarily evident where car usage faces limitations (e.g., lack of parking spaces), and the school is no exception. Therefore, in our view, bicycles serve not as a means of regular transportation but rather for sports, occasional leisure, and spending free time. This also implies that the deterrent effect of National Road No. 11 is roughly equivalent to the topographical deterrent effect, with the difference that the former is easier to change. All of this should be considered in the development of strategies aimed at promoting active transportation.

To answer our second research question, we first analyse the students' responses regarding how they came to school on the day of the survey.

Nearly half of the students arrived at the institution by car (48%). In the case of locals, this ratio is 42%, while for those coming from the surrounding areas, 70% were brought by their parents by car. Public transportation is used locally by 2% and in the surrounding areas by 30%. Other modes of transportation can only be interpreted at the local level. The second most common mode of transportation for local students is walking (38%), followed by cycling (16%), and finally, scootering (2%) — these results are illustrated by the diagrams in Figs. 4–6.

We summarized the composition of local students arriving by car in Table 1 which reveals the following results:

- More than half of the primary school students arrive at school by car.

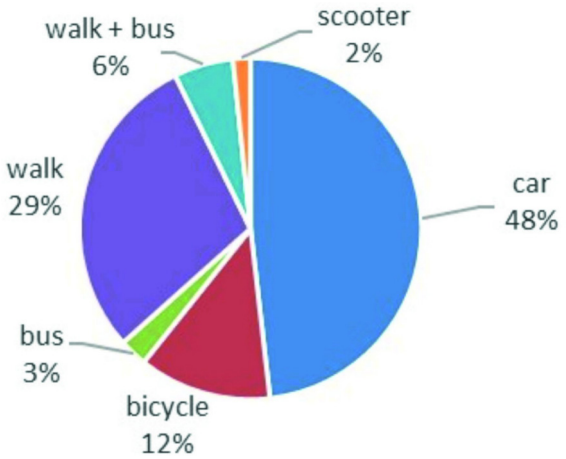

Fig. 4 Mode of arrival to school for students based on the questionnaire (Source: Own editing)

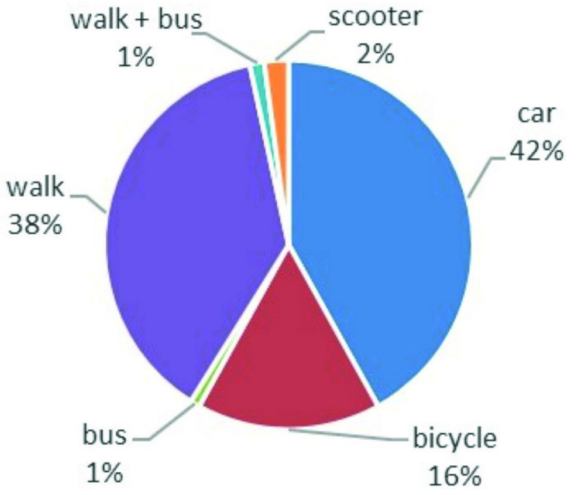

Fig. 5 Mode of arrival to school for students living in Dunabogdány based on the questionnaire (Source: Own editing)

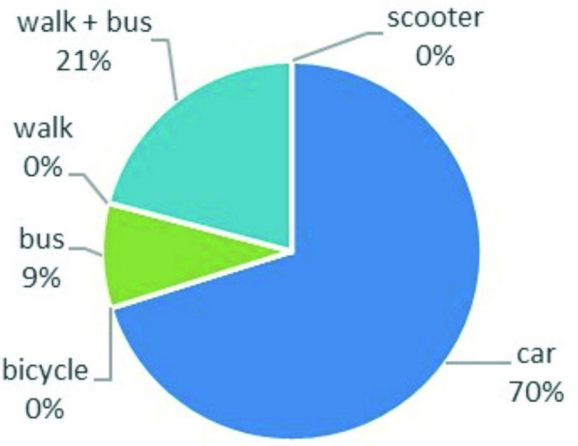

Fig. 6 Mode of arrival to school for students commuting from the surrounding area based on the questionnaire (Source: Own editing)

Table 1 Composition of students arriving at school by car (Source: Own editing)

	Arrivals	Arrivals with car	Car modal share
School Sum	303	146	48.2%
Arrivals outside Dunabogdány	67	47	70.1%
Local children (boy/girl)	236 (130/106)	99 (57/42)	41.9% (43.8%/39.6%)
Local lower class children (boy/girl)	116 (63/53)	59 (34/25)	50.9% (54.0% / 47.2%)
Local upper class children (boy/girl)	120 (67/53)	40 (23/17)	33.3% (34.3%/32.1%)

- In the case of secondary school students, this ratio decreases to 33%.
- In both lower and upper grades, the proportion of boys among those arriving at school by car is higher.

Among upper-grade students, the commuting habits to school are almost evenly divided between car and walking. Local residents around Dunabogdány, in this case, naturally use either a car (70%) or a bus (30%).

Based on the children's responses, the first stereotype that parents are more protective of younger children can be justified, as there is indeed a higher proportion of primary school students arriving at school by car. The autonomy of secondary school students is greater, with only a third arriving at school by car. This trend is similar to international experiences; however, the percentage of those arriving by car is relatively high (Carver et al., 2013), especially when compared to Flanders with a flat terrain and a strong cycling tradition (Zwerts et al., 2010). However, in the Hungarian context, this does not appear to be an outlier (see Barna and Bereczky (2023) and Rab and Bereczky (2023)).

The second stereotype of our hypothesis (which corresponds to Flemish experiences as well (Zwerts et al., 2010)), namely that girls are more protected and are therefore brought to school by car in larger numbers, is not supported by the survey. From the children's responses, it can be inferred that arriving at school by car is higher for boys in both the lower and upper grades. The difference in this ratio is greater in the lower grades (6.8%) and smaller in the upper grades (2.2%).

Our further research direction aimed to explore why parents prefer to bring boys to school by car rather than girls, contrary to our hypothesis. In their conference paper from 2023, Maráczi Rodrigó and Bihariné Németh (2023) identify traffic accidents involved children, stating that under the age of 15, boys cause twice as many accidents as girls. Based on the literature, they attribute this gender difference, particularly during adolescence, to the maturity of girls. Parents are likely aware of this issue, leading them to decide to bring boys to school by car rather than exposing them to the risk of accidents with their more risk-taking behaviour. In this regard, our research hypothesis was not confirmed; however, we were able to substantiate parental reactions based on behavioural differences arising from the children's gender.

Continuing in this direction, it is worth extending the analysis to explore whether children arrive at school alone or with an escort.

For primary school students, parents accompany them most of the time (72%). While this is self-evident when traveling by car, it is also substantiated when walking or

cycling, with the presence of an adult or at least an older sibling. This result provides a foundation for our recommendation to introduce a "bike bus" system for group cycling to school.

In the upper grades, the proportion of students traveling to school alone approaches that of those arriving with an adult (35% and 40%, respectively). From the responses, it can be inferred that three-quarters of the students (76%) do not come to school alone; instead, they arrive with classmates or siblings, as illustrated in Fig. 7.

Among the lower-grade students, 18 arrived by bike on the day of the survey, with six accompanied by parents, seven alone, and five with a sibling or classmate. Thirty-seven students walked, with 15 having adult accompaniment, 12 arriving alone, and nine with a classmate or sibling. Among those who arrived alone, those coming from the farthest, Bem József Street, were twice as many boys (8) as girls (4), as shown in Fig. 8.

Among the upper-grade students, a total of 19 arrived at school by bike, the majority alone (12 students), two with an adult, and six with either a classmate or a sibling. 52 students arrived on foot, with 63% (33 students) coming alone, three with a parent, and 16 with a classmate or sibling. The upper-grade students came on foot and alone from all parts of the settlement, with boys constituting nearly two-thirds (63%) of the total. The results are shown in Fig. 9.

The analysis of the questionnaires filled out by parents begins with the examination of available vehicles. In this regard, the majority owns two passenger cars (46%), and only about 3% of families do not have a personal car at all. Another important means of transportation is bicycles, which are not available in only 2% of families; most families can use up to four bicycles (40%). However, electric bicycles are only owned by 5% of families. The detailed results are illustrated in Fig. 10.

Based on parents' responses, the majority of children go to school or kindergarten by car (67.7%), which is significantly higher than the ratio indicated by the students themselves (48%). However, the difference may be due to the multiple-choice nature of the alternatives. The percentage of cycling and walking is the same in both surveys (12% and 29%, respectively), but there is a difference in bus usage (9% for students and 19% for parents).

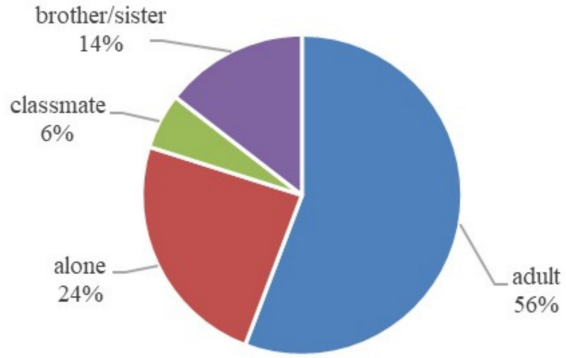

Fig. 7 Students' commuting habits to school broken down by accompanying person (Source: Own editing)

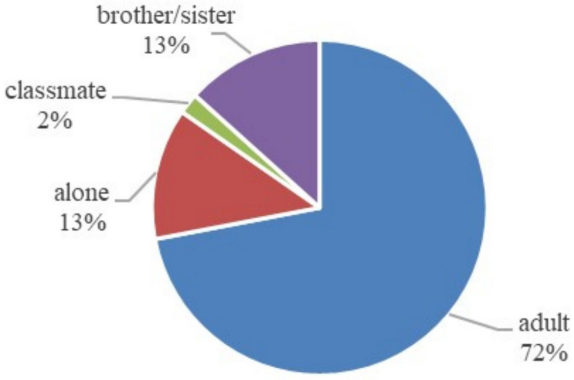

Fig. 8 Travel habits of lower-grade students to school broken down by accompanying person (Source: Own editing)

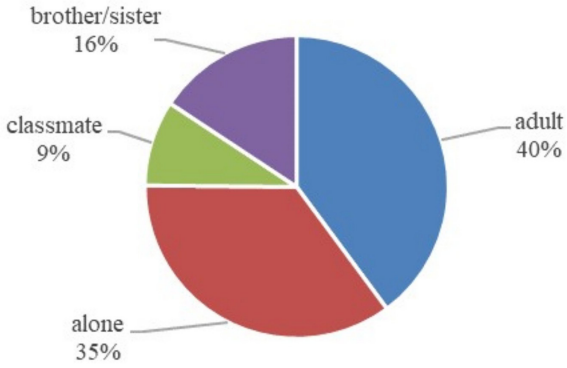

Fig. 9 Transportation habits of upper-grade students to school broken down by accompanying person (Source: Own editing)

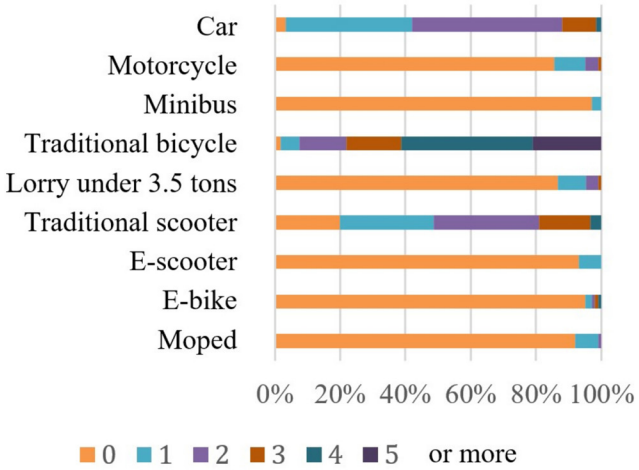

Fig. 10 Vehicle ownership of parents (Source: Own editing)

Parents accompany their children to the educational institution in 71% of cases, while students reported adult accompaniment in only 56% of cases. Nevertheless, according to parents, 38% of children travel alone, whereas students indicated solo travel in only 24% of cases. From parents' responses, it can also be concluded that less than half of the children regularly use bicycles or scooters (Fig. 11).

In the vast majority of cases (approximately 80%), siblings traveling in the same car attend the same educational institution (Fig. 12).

Answering the important question of what substitutes the primary means of transportation when it is not available, the ratios shown in Fig. 13 indicate that primarily, households resort to using a second car. Only after this, alternative modes of transportation (such as bus or bicycle) or walking come into consideration. It is noteworthy that parents primarily attempt to address transportation within their "own authority", and seeking help from acquaintances or relatives only arises as a last resort.

The diagram of Fig. 14 illustrates that nearly half of the children do not commute to school by car when the school start time differs from the usual or due to morning exercise.

It is also important to know which factors most influence parents in choosing alternative modes of transportation, other than a car, for their child to go to school or kindergarten. As shown in Fig. 15, it is evident that the primary considerations are a sense and awareness of safety, as well as the presence and quality of sidewalks. The latter can be associated with safety, as parents feel their child is secure on the sidewalk, and the necessity of walking on the road surface certainly does not reduce the percentage of commuting to school by car. Of course, age is also a decisive influencing factor, as seen in the walking ratio of older students. The importance of other factors does not reach 50%, but each of them plays a role in the child primarily using a car to reach the educational institution rather than opting for alternative means.

Our third research question investigates the background of the divergent responses from children and parents regarding school transportation habits. The question primarily arises from the parents' side to understand why a child goes to school in a different way than usual on a

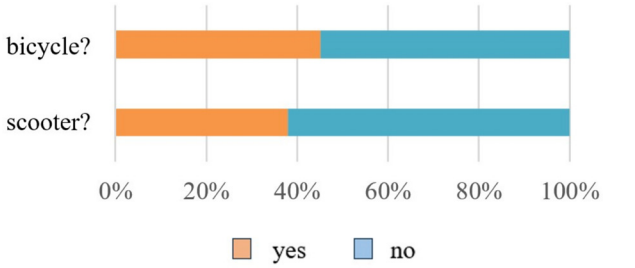

Fig. 11 According to parents, does the child regularly use … (Source: Own editing)

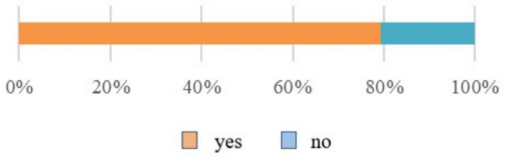

Fig. 12 Do siblings traveling by car attend the same institution? (Source: Own editing)

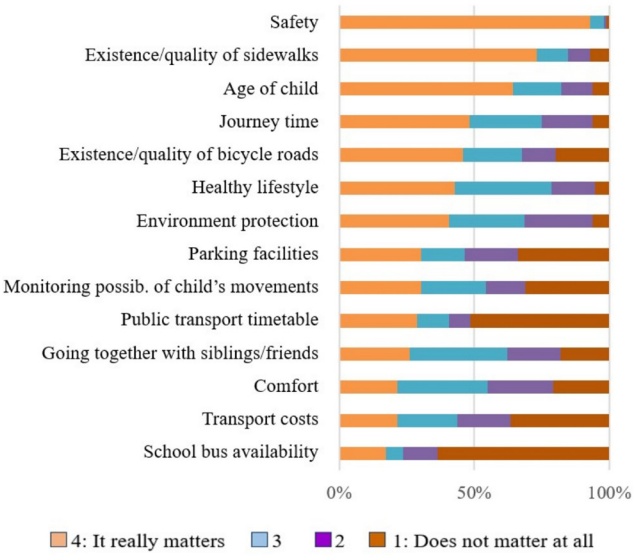

Fig. 13 Mode of transportation used in case of the primary means of transportation being unavailable (Source: Own editing)

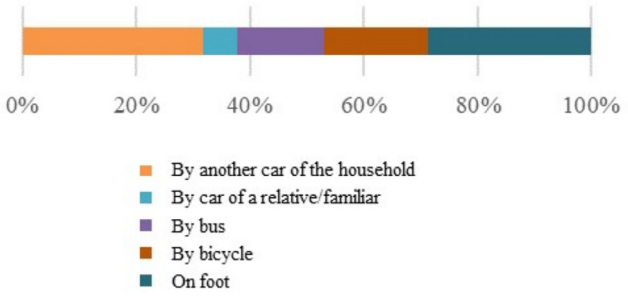

Fig. 14 The child does not go to school by car due to different school start times (Source: Own editing)

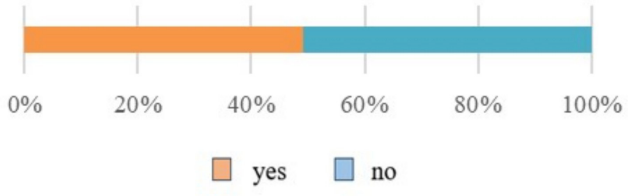

Fig. 15 Factors influencing parents choosing the mode of transportation for taking their child to school by car (Source: Own editing)

completely average school day. Since there is no reason to assume intentional distortion, we must first examine whether there are any peculiarities in the survey or the surveyed journeys that provide an explanation for the difference, meaning that the obtained values are not actually in substantial contradiction with each other.

During the research, we examined the responses of school-age children, but in many households, there are also preschool-aged children who are driven to the educational institution by their parents. When parents respond regarding the mode of transportation for their children, they likely handle all the children's travels together, and thus, the transportation of preschoolers is also classified among the general car transport.

Analysing the parental questionnaires, it can be observed that only 52.3% of Dunabogdány residents claim that their child regularly goes to school by car. This ratio is approaching the children's responses about the mode of transportation (42%). Parents could provide multiple answers regarding the general mode of transportation, so the percentage of those who did not specify another mode of transportation besides the car is 30.6%. From this, it can be inferred that only and exclusively 30.6% of Dunabogdány children are taken to school by their parents in a car. In comparison, it is worth examining the 42% response given by the children. It can be seen that the value measured on April 19, 2023, falls between 52.3% and 30.6%, indicating that we actually obtained an average school commuting value on the survey day

However, it must be noted that among those indicating alternative modes of transportation, many chose the car on that particular day. When investigating the reasons for this, it is advisable to examine the cause of traveling by car. We addressed this indirectly in the parental questionnaire, inquiring about the factors that, if available, would lead them not to take their child to school by car. Parents assigned the greatest weight to safety in their responses to this question, indicating that they do not perceive the route to school as safe. A fundamental principle of traffic safety is that young children are one of the most vulnerable groups of road users, a perception shared by parents. Numerous possibilities exist to enhance the safety of the route to school, and among our recommendations, we formulate some solutions related to active transportation. Next, we examine the positions parents took regarding other modes of transportation.

In Dunabogdány, walking and cycling can be fundamental modes of transportation. From parental responses, it can be inferred that they interpret the existence and quality of sidewalks as essential prerequisites for walking, ensuring they are suitable for pedestrians. Parents primarily emphasize this in a qualitative sense, yet in our view, leaving sidewalks unobstructed is another fundamental condition for walking. Regarding cycling, parents consider the presence of designated bike paths less crucial than the existence of sidewalks. While the quality of bike infrastructure is also important, parents prioritize it less compared to walking. The prioritization of bike lanes indicates that parents do not perceive cycling on the road in Dunabogdány as significantly more dangerous than walking on the road.

The third – theoretical – option is the use of public transportation. Public bus transportation within the town is not prevalent, although instances were reported during the survey. Therefore, the schedule and reliability of public transportation do not constitute alternatives to using a car.

Our response to the third research hypothesis is that locally, the responses of children and parents regarding school transportation do not significantly differ. Consequently, a significant portion of non-local parents (including those living in Bogonhát major) may state that they drive their child to school because using bicycles or public transportation is not a realistic alternative for them. Another explanation is that the parental questionnaire allowed for the selection of multiple general commuting options, and parents tend to mark car transportation as a general option if they have a car in the family, even when other alternatives are available.

5.2 Findings

A fundamental conclusion drawn from the examination of our research hypotheses is that a significant percentage of parents consider it an appropriate and safe solution to drive their child to school by car. This can be inferred from the results of our investigation into the third research hypothesis, which posits that safety is a fundamental consideration on the route to school for children. Parents feel this is achievable only when they personally ensure their child's supervision during the journey. Therefore, they attempt to align school commuting habits with work commuting, meaning they take their child to school at the same time as going to work, thus achieving both travel objectives in a single trip. The parental survey strengthens this idea through a question about the next destination of parents driving their child to school or kindergarten by car. More than three-quarters of respondents (75.5%) continue to their workplace, completing both the journey to school and work in one go. Additionally, Fig. 16 contains another crucial piece of information: 22.5% of parents head home

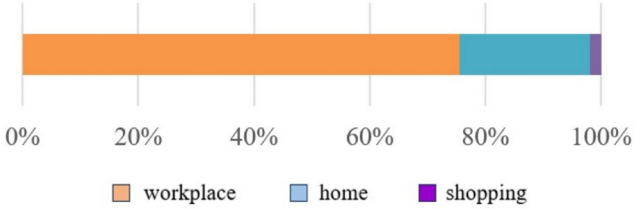

Fig. 16 Next destination of parents driving their child to school by car (Source: Own editing)

after dropping off their child at school. This group's sole purpose of commuting is to transport their child to the educational institution. Knowing the next destination is crucial because, in light of this information, it could be reasonably suggested that parents traveling nearby (e.g., within the town or immediately heading home) should not use the car for such purposes but instead take advantage of the opportunities offered by active transportation.

Another conclusion is that parents generally respond well to life situations arising from their children's age and gender, and accordingly, they organize the journey to school. The results of our second research hypothesis support this conclusion. However, within the parent group, we asked how they think children can be best educated for safe transportation. Parents primarily see the school as an opportunity, followed by internet video sharing platforms, in line with contemporary trends. They place themselves only in third place, which can be surprising, as parental role modeling is considered one of the primary tools for raising children (Fig. 17).

We consider this finding extremely important because parents place their trust in educators, making traffic safety education in public education particularly crucial. Several studies have explored this area (Maráczi Rodrigó and Bihariné Németh, 2023; Ötvös, 2023; Ötvös and Krizsik, 2023), and here we emphasize the significance of education. However, it should be noted that although parents rank themselves

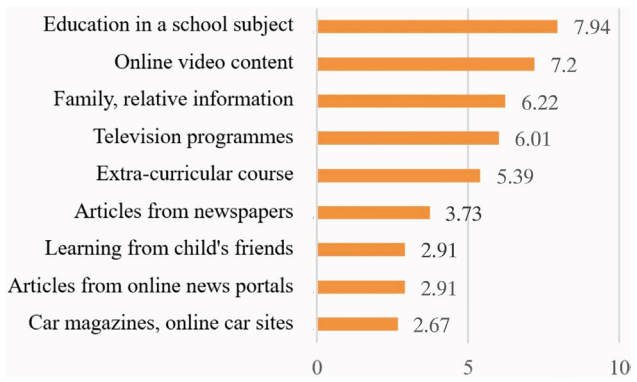

Fig. 17 Ideal channels for educating children on safe transportation according to parents' perception (Source: Own editing)

third in passing on safe transportation education, the excessive use of motor vehicles indicates their preference for controlling their children's transportation.

Therefore, we find it necessary to present recommendations that enhance children's traffic safety, increase parents' sense of security, and promote the use of active transportation modes. Our suggestions have also been articulated in the mobility concept for Dunabogdány.

5.3 Recommendations

Our research results primarily indicate the increasing trend of commuting to school by car; however, active modes of transportation are still present. Nevertheless, we see areas where recommendations can be made regarding school mobility based on our results and further literary analyses.

We consider it necessary to strengthen cycling, so we propose the establishment of dedicated cycling axes leading to the school from the main directions, especially in places where this can be realized without separate investments or with minimal investment. To implement this, the starting points of these axes need to be determined. These are gathering points in a given settlement where children already cycle in groups towards the school. We recommend adopting a radial system for creating cycling axes, as already known from public transport, i.e., guiding the axes in front of the school. Of course, these axes can serve not only school commuting but also connect points within the settlement where children willingly go.

Similarly to cyclists, pedestrian axes can be created for those arriving on foot around the school. The most suitable form for this is the transformation of the street in front of the school into a pedestrian street. If this is not possible, a suitable solution could be the introduction of the "school street" system, i.e., closing the street to motor traffic during the arrival period at the school, usually between 7:00 and 8:00 in the morning. This method can only be effective if it does not increase traffic in the surrounding streets and does not cause congestion. As an enhanced version of this, the establishment of a Kiss & Ride (K+R) traffic system at both ends of the closed section is proposed. This requires a roundabout-style road layout, and the cross-route is not a prerequisite. When there is no closure, the circular track forces cars to slow down, so they approach the school at a reduced speed. When closed, drivers can easily turn around by dropping off the children in the roundabout.

Furthermore, pedestrian traffic can be facilitated by making pedestrians "equal" to drivers by raising the road surface at pedestrian crossings around the school, thereby forcing cars to reduce speed.

Our above suggestions are generally applicable and have been incorporated into the Dunabogdány mobility concept. The proposed measures are summarized in Fig. 18.

The known method of cycling to school is the "bike bus" system, where adults accompany children on the road. The system operates on a voluntary basis, and the responsibility lies with the parent releasing the child. However, an exact description of the system was not identifiable in the literature, meaning there is no specification of how many adults are needed for the system to operate, and there are no regulations regarding the formation of the group. We consider this to be a problem because without this knowledge, parents may be hesitant to allow their children to commute to school using the "bike bus". While the required number of educators (escorts) for the transportation of school classes is determined by legislation, and these educators have the professional competence and job duty to supervise children, this is not the case in the "bike bus" system.

To address this issue, we propose defining the operation of the "bike bus" system as shown in Fig. 19.

An adult leads and closes the line, and one adult cycles for every five children in the line. In our opinion, one adult can supervise the movement of the five children in front of them, and beyond this number, we consider it more challenging. At this point, the voices of adults are still audible to the children. The basic principle of the system's operation is the presence of the appropriate number of adult escorts. If the number of children reaches the maximum number that adults can supervise, then the "bus" will no longer stop, meaning children cannot join this "route". Therefore, we strongly recommend organizing the route according

Fig. 18 Proposed active transportation axes in Dunabogdány (Source: own editing)

Fig. 19 Operational scheme of the Bike Bus System (Source: own editing)

to a pre-prepared "schedule", where parents can know in advance how many adults to expect on a given day, i.e., the "bus capacity". The school could provide great assistance in coordinating this, even just by keeping and sending the list to parents. Another question to consider is the immediate replacement of an adult (in case of illness, for example), as this affects the number of accommodated children.

We consider it extremely important to implement school action programs to familiarize children with active modes of transportation and traffic rules. Therefore, we propose incorporating the "school walk" into the educational program. This is a walk around the school with pedagogical and law enforcement/police escort, where primary school children get to know the traffic environment and challenges around the school and are shown the correct behaviour. Similarly, primary school students are addressed by educational programs that promote the practical application of traffic regulations. These programs involve children practicing applying traffic rules on tracks with scooters and bicycles (the theoretical training is expected to be included in the basic curriculum of primary schools). Further incentives for the use of sustainable modes of transportation can be realized through rewarding campaigns organized for preschoolers and primary school students who walk or cycle to kindergarten and school. Children arriving by foot or bicycle can receive some form of reward.

The examination of our third research hypothesis highlights the need to create harmony between questions posed to different target groups on the same topic. The obtained results can significantly differ from each other, and the reasons for this can only be revealed through deeper analysis, which requires additional resources. Therefore, it is advisable to coordinate questions posed to different target groups on the same topic.

6 Conclusions

Child traffic safety is always one of the most crucial topics for transportation experts. The safety of commuting to school is of paramount importance for parents, influenced significantly by the topology of individual settlements and the school environment. To appropriately design the school's traffic environment, it is necessary and essential to understand the habits of commuting to school.

In this article, we examined the results of a survey conducted in the small settlement of Dunabogdány, focusing on commuting habits to school. The goal was to analyse these results, compare them with further research findings, and make general conclusions and recommendations, primarily aimed at improving the safety of commuting to school, especially in small settlements.

Based on the unexpected results obtained during the primary research, we formulated hypotheses, which were then examined through secondary research and comparative literary analysis. Using the induction method, we derived general conclusions and recommendations from our study.

During the investigation, we found that, alongside the topology of a settlement, the accessibility of the school by car (including parking) and the time required for this has a significant impact on the mode of reaching the school. Under favourable conditions, parents prefer using cars over active modes of transportation. We also observed that stereotypes based on age influence the results of commuting to school by car, while gender stereotypes do not. According to our survey, parents are more likely to drive boys to school by car than girls. We found an explanation for this using other literature (different maturity levels between genders). We confirmed our third hypothesis that, based on the responses given by parents and children, there is no significant difference in the answers regarding commuting to school by car. For validation purposes, we compared our results with similar studies on school mobility.

Building on the conclusions drawn from the examination of our research hypotheses, we made recommendations to promote active transportation and enhance the safety of school mobility. We believe that implementing our suggestions can improve the safety of children's transportation.

We consider research that contributes to increasing the level of traffic safety to be of utmost importance. Therefore, we recommend our findings as the basis for further research, and as part of the first small settlement mobility concept, we propose using them to develop additional traffic strategies for small and medium-sized settlements.

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