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ANALYSIS OF THE IMPACT OF THE POLISH RESIDENTS' MOBILITY ON THE ENVIRONMENT

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Resume

Environmental protection is a major task for countries around the world in the 21st century. One of the sources of pollution is the road transport. Therefore, an analysis of the impact of the mobility of Polish residents on the environment was carried out. To this end, a survey was conducted, asking questions such as: the frequency of switching from cars to public transportation, the way of moving in and out of built-up areas, the impact of transportation on the environment, the EURO standard, the purchase of an alternative-powered car and eco-driving. This research was carried out on a group of residents, taking into account: age, gender, place of residence and occupational status. Based on the research, it can be concluded that under the influence of Covid-19. the population is trying to protect itself from contagion, so it chooses individual means of transportation.

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1 Introduction

The main task for countries around the world is to protect the environment. Increasing amounts of harmful chemicals in soil, water and air will reduce the Earth's natural resources in the future. For this reason, the European Union is encouraging member countries to introduce a policy of sustainable development. This term refers to development that will meet the needs of the population, while at the same time protect the ecosystem for future generations [1].

One source of pollution is the road transport. It is the one that emits large amounts of harmful components into the environment from fuel combustion. It is a source of vibrations and human disease. The creation of linear and point infrastructure from cleared land contributes to the disruption of the proper functioning of plants and animals. The road transport is developing rapidly, so its impact on the environment is changing dynamically. Therefore, there is a need to address the issue of assessing the impact of the mobility of Polish residents on the environment [2].

Mobility is defined differently by authors of publications. Szoltysek [13], treats mobility as daily, routine movement and activities resulting from the

reorganization of personal life, which may include a change of residence or place of work. We can equate this with movement and any activities of people performed by means of transportation outside of their place of residence [4-5]. Menes [6], on the other hand, depicts mobility as mobility associated with the daily movement of residents, most often to work or school.

According to the Treaty on the Functioning of the European Union [7] and the resulting EU transport policy, mobility, understood as an element of human activity, depends on the person making the trip, the infrastructure manager and other users of the transport system for that mobility [8-9]. Closely related to mobility issues is the concept of sustainable development, which includes economic, environmental and social issues [10-13].

When analyzing the mobility of residents, it is important to keep in mind the transportation challenges, which are included in the 2011 White Paper [14] and the Urban Mobility Action Plan [15], among others. Taking into account the behavior of urban residents, a policy for sustainable transportation development in urban areas should be developed. These policies create plans for development of sustainable transportation in cities, in which the most important element is sustainable

urban mobility. This is the main goal of the 21st century transportation policy [12-13, 16-17]. Among other things, the sustainable transportation plan calls for a reduction in the daily use of cars in favor of greater use of public transportation, cycling and walking [18]. Behavior of the Polish public, in terms of choosing a mode of transportation, was also analyzed by the author of [19]. In addition, the problem of the mobility of residents was addressed in the works [20-25]. The pandemic has affected the mobility of residents [26-27].

2 Research

2.1 Subject and conditions of the study

The subject of the study was to analyze the impact of the mobility of Polish residents on the environment, in 2000-2020. The results of the survey will show the behavior of citizens in the context of the choice of means of transport versus its impact on the ecosystem. The survey is designed to determine the transport preferences of Poles and test their knowledge of environmentally friendly activities.

2.2 Methods and measures for assessing the impact of road transport on the environment

The survey was conducted in 2021 among Polish residents. Due to the limitations of the then prevailing Covid-19 pandemic, the survey was conducted via the Internet. The electronic survey was created using the Google Forms application. The link assigned to it was distributed on social networks, transportation portals and among friends. The survey was fully anonymous and consisted of 18 closed-ended questions, but with the option to enter your own answer. At the beginning of the form was a metric on gender, age, labor market status and place of residence. This was followed by questions about respondents' travel patterns in cities and outside the built-up areas, both before and during the pandemic. Respondents were asked about public transportation problems and their environmentally friendly behavior related to their choice of individual transportation. The last question asked about solutions to reduce the negative impact of road transportation on the environment. The answer to this question was partly imposed by the survey author, but respondents also had the opportunity to introduce their own ideas. Before conducting the target survey, a pilot study was conducted, which consisted of sending a form with survey questions to a selected group of people.

An important step during the implementation of the survey was the calculation of the survey sample. For Poland (population of 38151,000), assuming a confidence level of 95% and a maximum error of 5%, the required number of people taking part in the survey was 384

respondents. The survey on changes in mobility versus its impact on the environment was completed by 414 respondents [28].

The respondents' answers were also analyzed for metric questions, namely: gender, age, labor market status, place of residence and possession of a driver's license. In addition, two analyses (by gender and driver's license) were considered in the context of the Chi-square statistics. This statistical test is used to test hypotheses for random variables. One can test whether the variables are related by the common pattern of the results obtained. If the Chi-square has a greater value than the theoretical Chi-square, then there is no relationship between the variables [29]. The formula for the Chi-square test of concordance is of the form:

$$\chi^2 = \sum_r \frac{(f_i - np_i)^2}{np_i}, \quad (1)$$

where:

χ^2 - Chi-square test;

f_i - number of values in a given range;

np_i - the number of units that are in a given range.

2.3 Results

The survey included 414 participants: 211 women and 203 men. Respondents were divided into six age groups: under 18 (those without a driver's license), 18 to 25 (mainly students), 26 to 35, 36 to 45, 46 to 55 and over 55 (especially retirees). The smallest group is made up of people under the age of 18, as the questions are specifically aimed at those authorized to drive. The chart below shows the percentage distribution of respondents' ages (Figure 1).

Almost half of the respondents are employed (55.1%). The second largest group is students, 26.8%, but 2.6% both study and work. The 55+ age bracket includes 10.3% of respondents with retired status. The remaining respondents are students (3.9%) and unemployed (3.9%) (Figure 2).

Figure 3 shows a graph of the respondents' place of residence. The survey was addressed to residents of each settlement unit. The responses of respondents from different areas of permanent residence are relatively equal to each other. Respondents were then asked about having the authority to drive a vehicle with a gross vehicle weight of up to 3.5 tons. Of the 414 people who took part in the survey, as many as 349 have a Cat B driver's license and only 65 do not have driving privileges.

The next question was addressed to those with driving privileges. It should be noted that it was not mandatory for respondents to complete. The question "How long have you held a driver's license?" was answered by 316 people. The length of time that respondents have held a driver's license starts at one year and for some it is already 45 years (Figure 4).

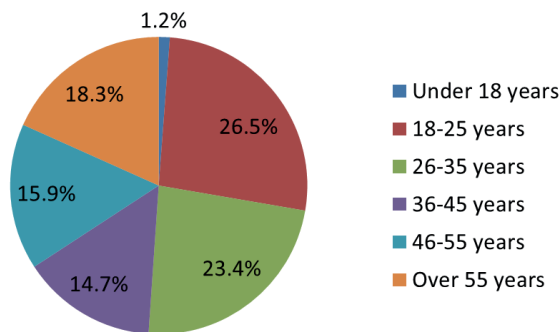


Figure 1 Age of respondents

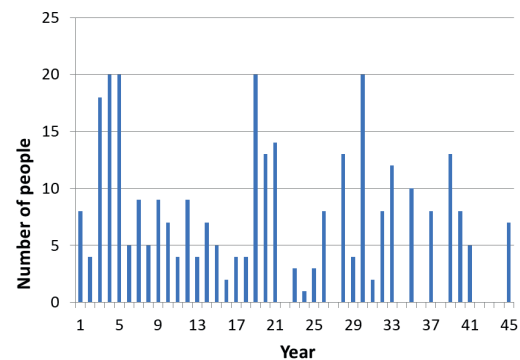


Figure 4 Length of ownership of a driver's license by respondents

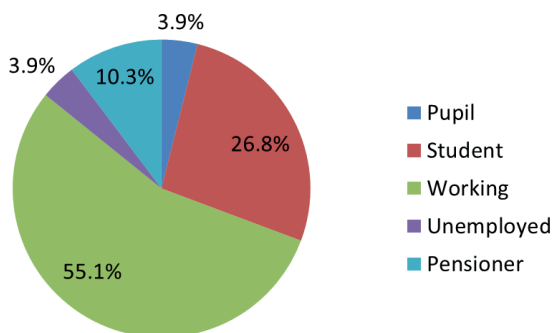


Figure 2 Respondents' labor market status

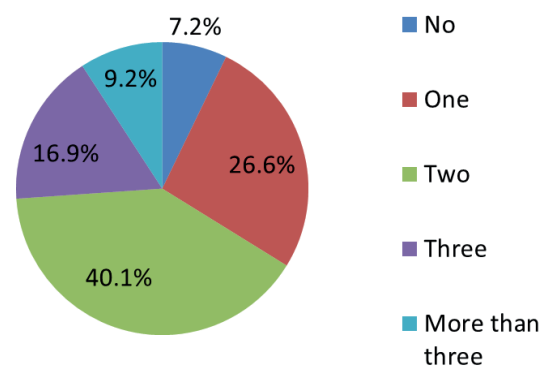


Figure 5 Number of vehicles in respondents' households

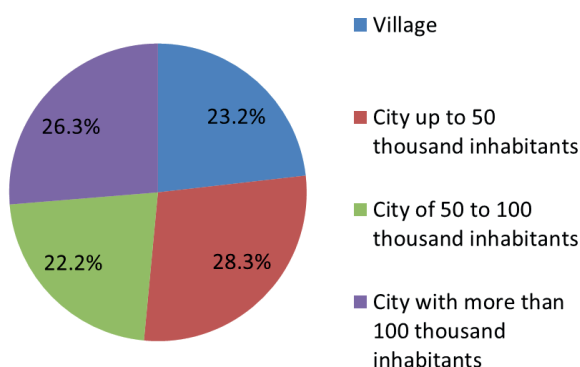


Figure 3 Respondents' place of residence

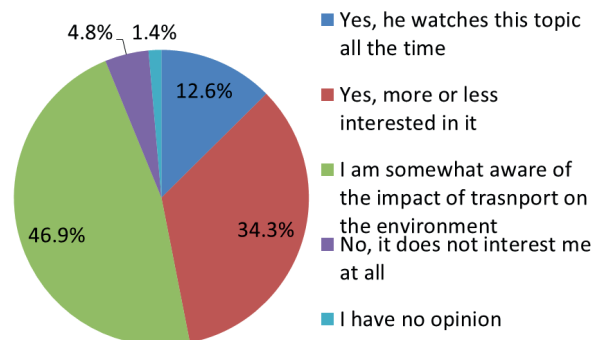


Figure 6 Awareness of Poles regarding the impact of transportation on the environment

For 40.1% of respondents, there are two vehicles in the household. The second group is made up of families with only one passenger car (26.6%). Ownership of three means of transportation was declared by 16.9% of respondents, while more than three motor vehicles were marked by 9.2% of respondents. Only 7.2% of respondents have no vehicle in their household (Figure 5).

The survey asked respondents about their general knowledge of the environmental impact of road transportation. 12.6% of people observe and analyze environmental changes caused by transportation all the time, while 34.3% of respondents are more interested in the issue. Nearly half of respondents said they are somewhat aware of how the way they travel and operate their vehicle affects the ecosystem. 4.8% said they

were not interested in the topic related to the impact of transportation on the biosphere and 6 people expressed no opinion (Figure 6).

The next step assessed Poles' awareness according to gender, age, labor market status and place of residence. In this case, taking into account gender, age and driver's license held, there are no significant differences between the responses of men and women. The Chi square test shows that there is no correlation between the responses of men and women, as the χ^2 is 10.47, where the theoretical χ^2 is 9.49. Moreover, it can be concluded that Poles are interested in this topic regardless of where they live (Table 1).

With environmental protection in mind, respondents were asked how they travel around the city most often, as well as outside the built-up area. The question was

Table 1 Awareness of Poles related to the impact of transportation on the environment (%)

	I don't have an opinion	No. it doesn't interest me at all	Yes. I watch this topic all the time	Yes. more or less interested in this	Somewhat. I am aware of the impact of transportation on the environment
Sex					
Women	2.84	3.32	11.37	31.75	50.72
Men	0.00	5.91	13.79	37.44	42.86
Age					
Under 18 years	0.00	0.00	20.00	40.00	40.00
18-25	2.41	4.35	10.63	28.99	53.62
26-35	1.69	6.78	16.95	25.42	49.16
36-45	0.00	10.87	6.52	47.83	34.78
46-55	0.00	4.08	14.28	36.73	44.91
Over 55	0.00	0.00	18.75	52.08	29.17
Status in the labor market					
Pupil	0.00	6.25	6.25	31.25	56.25
Student	1.80	3.60	13.51	31.54	49.55
Working	1.75	6.58	12.28	34.65	44.74
Unemployed	0.00	0.00	6.25	37.50	56.25
Pensioner	0.00	0.00	16.28	39.53	44.19
Place of residence					
Village	3.13	3.13	11.46	34.38	47.90
City of up to 50.000 residents	0.85	4.27	11.97	34.19	48.72
City of 50.000 to 100.000 residents	2.17	8.70	8.70	39.13	41.30
City >100.000 residents	0.00	3.67	17.43	30.28	48.62
Driver's license					
Yes	1.43	5.16	11.75	35.53	46.13
No	1.54	3.08	16.92%	27.69	50.77

Table 2 Most common way respondents travel around the city (%) - part 1

		Car	Public transport	On foot	Bike. scooter	Other (e.g.cab)
Sex						
Before the pandemic	Women	41.23	45.97	10.43	2.37	0.00
	Men	63.55	27.59	6.90	1.96	0.00
During the pandemic	Women	56.40	25.59	14.22	3.32	0.47
	Men	83.74	7.39	8.38	0.49	0.00
Age						
Before the pandemic	Under 18 years	20.00	20.00	40.00	20.00	0.00
	18-25	40.58	43.96	13.05	2.41	0.00
	26-35	64.41	28.82	5.08	1.69	0.00
	36-45	82.61	10.87	2.17	4.35	0.00
	46-55	71.53	28.47	0.00	0.00	0.00
	Over 55	41.67	52.08	6.25	0.00	0.00
During the pandemic	Under 18 years	0.00	60.00	0.00	40.00	0.00
	18-25	58.45	24.64	14.98	1.93	0.00
	26-35	74.58	13.56	8.48	1.69	1.69
	36-45	89.13	2.17	6.53	2.17	0.00
	46-55	93.88	6.12	0.00	0.00	0.00
	Over 55	77.08	6.25	16.67	0.00	0.00

Table 3 Most common way respondents travel around the city (%) - part 2

		Car	Public transport	On foot	Bike, scooter	Other (e.g.cab)
Status in the labor market						
Before the pandemic	Pupil	18.75	12.50	56.25	12.50	0.00
	Student	33.34	54.05	11.71	0.90	0.00
	Working	67.54	26.32	3.95	2.19	0.00
	Unemployed	68.75	25.00	6.25	0.00	0.00
	Pensioner	25.58	62.79	9.30	2.33	0.00
During the pandemic	Pupil	37.50	18.75	25.00	18.75	0.00
	Student	55.86	27.93	16.21	0.00	0.00
	Working	82.89	8.78	5.70	2.19	0.44
	Unemployed	75.00	18.75	6.25	0.00	0.00
	Pensioner	46.51	27.91	25.58	0.00	0.00
Place of residence						
During the pandemic	Village	69.79	21.88	8.33	0.00	0.00
	City of up to 50.000 residents	56.41	30.77	8.55	4.27	0.00
	City of 50.000 to 100.000 residents	54.35	33.69	10.87	1.09	0.00
	City >100.000 residents	30.28	59.63	7.34	2.75	0.00
During the pandemic	Village	85.42	7.29	6.25	1.04	0.00
	City of up to 50.000 residents	79.48	8.55	8.55	3.42	0.00
	City of 50.000 to 100.000 residents	68.48	17.39	14.13	0.00	0.00
	City >100.000 residents	46.79	33.03	16.51	2.75	0.92
Driver's license						
Before the pandemic	Yes	59.31	33.24	6.02	1.43	0.00
	No	77.36	12.32	8.60	1.43	0.29
During the pandemic	Yes	56.92	13.85	23.08	6.15	0.00
	No	40.00	29.23	26.15	4.62	0.00

divided into the time before and during the Covid-19 pandemic, as the restrictions introduced contributed to changes in residents' lives. By 2019, 216 respondents were using a personal car to get around the city. Another very popular mode of travel was the use of public transportation. Only 9 people indicated that they used bicycles and scooters and 36 people moved around the city on foot. The breakthrough comes as the Covid-19 pandemic continues, with as many as 289 people indicating that they mostly move around the city by individual means of transportation. The number of people traveling by public transportation decreased (by 84 people), but more respondents chose to cover urban routes on foot (by 11 people). Among all the survey participants, no one uses the services of cab companies (Figure 7).

In the next step, the way respondents get around the city was analyzed according to gender, age, labor market statute and place of residence, as well as the driver's license held, according to pandemic. It is men who are most likely to travel by car in built-up areas, while women choose public transportation for travel. During the pandemic, many people switched from the public

transportation to personal transportation. The chi-square test shows that there is no relationship between the way of urban travel and gender, as the χ^2 is 20.9, where the theoretical χ^2 is 7.81. In addition, people in the 36-45 and 46-55 age groups are most likely to use a personal car when traveling in a built-up area. Public transportation is mainly used by people over 55 and those in the 18-25 age group. In terms of choice of mode of transportation before the pandemic, students were the most likely to walk, students chose public transportation, employed and unemployed people used a personal car and retirees and pensioners traveled by public transportation. During the Covid-19 period, the share of passenger cars increased in each group of respondents. In the built-up area, the passenger car is mainly used by residents of rural areas and cities with up to 50,000 and 50-100,000 residents. The public living in larger metropolitan areas uses public transportation for this purpose. However, during the pandemic, many respondents substituted public transportation in favor of individual means of transportation. Respondents most often use a personal car to travel in built-up areas. During the Covid-19 pandemic, many people switched

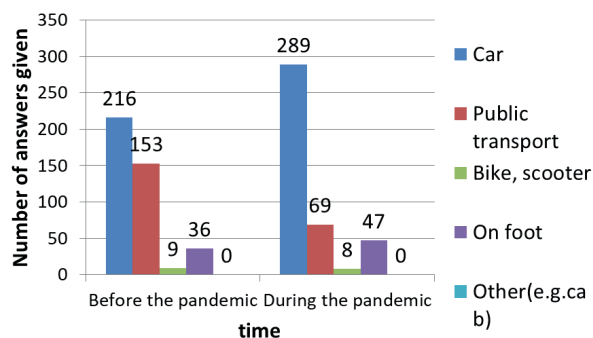


Figure 7 The most common way respondents move around the city

from the road transportation to traveling on foot (Table 2 and 3).

The timing of the Covid-19 pandemic has not drastically changed the way Poles travel outside built-up areas. Most respondents use a personal car outside urban zones. Respondents who do not have a driver's license prefer to choose the train over the bus. However, the pandemic has contributed to the public's reduction in the use of public transportation in favor of the personal car (Figure 8).

In addition, respondents were asked about the frequency of switching from cars to public transportation. Before the Covid-19 pandemic, a very large number of respondents were willing to travel by public transportation. The distribution of responses to this question is as follows: 80 respondents travel by bus/tram daily, 120 respondents several times a week, 60 respondents several times a month and as many as 83 respondents always choose personal transportation.

One of the effects of the pandemic is that the public is using public transportation less. As many as 131 people declared that they do not substitute their personal car for public transportation at all. Sixty-three respondents choose public transportation several times

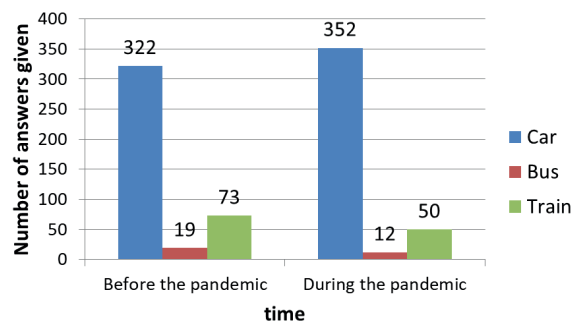


Figure 8 Respondents' responses regarding the mode of travel outside the built-up area

a month and 54 people only occasionally during the year. There was a decrease in the number of people who, before the pandemic, declared that they take public transportation every day. The above responses of respondents are shown in Figure 9.

Before the Covid-19 pandemic, the public was more likely to travel by public transportation. During this infectious disease, the percentage of people who do not substitute a personal car at all has increased. Daily passengers on public transportation are mainly people under the age of 18 and respondents in the 18-25 age range. The answer "does not replace at all" was marked by the largest number of respondents in the 26-35 and 46-55 age brackets. In addition, daily passengers of public transportation are mainly students, schoolchildren and unemployed people. Working people prefer to choose a personal car over public transportation for work-related travel. In contrast, residents of metropolitan areas travel by bus/tram. In addition, daily trips by public transportation are made mainly by people without a driver's license for motor vehicles. Among respondents who choose only a personal car is the public who own their own means of transportation (Table 4 and 5).

Public transportation is more environmentally

Table 4 Frequency of switching from personal car to public transportation among respondents (%) - part 1

		Everyday	2-3 times a week	Once a week	Several times a month	Several times a year	It does not replace at all	Not applicable
Sex								
Before the pandemic	Women	27.01	17.06	5.69	9.00	10.43	20.85	9.96
	Men	11.33	16.75	18.72	20.69	10.34	19.21	2.96
During the pandemic	Women	20.38	10.43	9.95	12.32	9.95	27.49	9.48
	Men	5.42	9.85	11.33	18.23	16.26	35.96	2.95
Age								
Before the pandemic	Under 18 years	40.00	0.00	0.00	0.00	0.00	20.00	40.00
	18-25	25.12	19.81	5.80	10.14	12.56	15.94	10.63
	26-35	18.65	18.65	8.47	11.86	10.17	28.81	3.39
	36-45	15.22	6.52	45.65	8.70	2.17	21.74	0.00
	46-55	8.16	10.21	12.25	30.61	8.16	30.61	0.00
	Over 55	8.33	20.83	12.50	29.17	12.50	14.58	2.09

Table 5 Frequency of switching from personal car to public transportation among respondents (%) - part 2

		Everyday	2-3 times a week	Once a week	Several times a month	Several times a year	It does not replace at all	Not applicable
Status in the labor market								
Before the pandemic	Pupil	25.00	12.50	0.00	6.25	12.50	18.75	25.00
	Student	26.12	27.03	7.21	9.01	9.01	11.71	9.91
	Working	14.91	11.40	16.23	17.11	10.53	25.44	4.38
	Unemployed	31.25	0.00	0.00	25.00	12.50	25.00	6.25
	Pensioner	18.60	27.90	11.63	16.28	11.63	11.63	2.33
During the pandemic	Pupil	25.00	18.75	0.00	6.25	12.50	18.75	18.75
	Student	18.92	13.51	13.51	16.22	8.11	19.82	9.91
	Working	8.77	7.89	10.96	14.04	14.47	39.92	3.95
	Unemployed	18.50	6.25	0.00	12.50	6.25	44	12.50
	Pensioner	13.95	11.63	9.30	23.26	20.93	18.60	2.33
Place of residence								
During the pandemic	Village	11.46	10.42	4.17	6.25	19.79	41.66	6.25
	City of up to 50.000 residents	11.12	15.38	17.95	25.64	9.40	16.24	4.27
	City of 50.000 to 100.000 residents	16.30	21.74	23.91	13.04	5.43	13.04	6.54
	City >100.000 residents	37.61	20.18	2.75	11.93	7.34	11.02	9.17
	Village	6.25	6.25	6.25	8.33	13.54	54.17	5.21
During the pandemic	City of up to 50.000 residents	5.98	5.98	11.12	21.37	17.09	33.33	5.13
	City of 50.000 to 100.000 residents	10.87	14.13	19.57	15.22	9.78	23.91	6.52
	City >100.000 residents	28.44	14.68	6.42	14.68	11.01	16.51	8.26
	Village	6.25	6.25	6.25	8.33	13.54	54.17	5.21
Driver's license								
Before the pandemic	Yes	16.91	15.47	12.61	16.33	11.75	22.64	4.29
	No	32.31	24.62	9.23	6.15	3.08	6.15	18.46
During the pandemic	Yes	10.32	8.31	10.03	15.76	14.61	36.68	4.29
	No	27.69	20.00	13.85	12.31	4.62	4.62	16.91

friendly than using individual transportation. As the survey above shows, it is not the most popular choice among respondents. For this reason, Poles were asked what discourages them from using public transportation. Most people declared the lack of direct connections as a problem. Travel time and delays that occur are other factors. Respondents do not pay attention to the price and possible danger. For some people, discouraging factors are the quality of public transportation, fear of contracting coronavirus, crowding and lack of seats, lack of personal hygiene of other travelers. Respondents' responses are shown in Figure 10.

Behaviors that can be considered pro- or anti-environmental are those related to actions in the context

of used car parts. The survey asked drivers what they do with used batteries and tires. 23.7% of respondents indicated that this question does not apply to them, as they do not own a passenger car. More than half of the respondents present environmentally friendly behaviors in terms of used car parts, which include: leaving them at a store (17.1 %), giving them to a recycling center (26.3%) and leaving them at a workshop (17.6 %). Only 15% of people declared actions that could endanger the environment. Among activities that do not threaten the environment, storing them in the garage or basement (10.6%) dominates, as their future fate should be decided. 3.9% use used tires or batteries for other purposes and only two people threw them in the

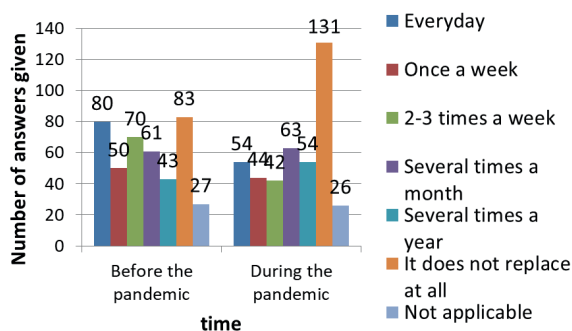


Figure 9 Frequency of switching from personal cars to public transportation among respondents

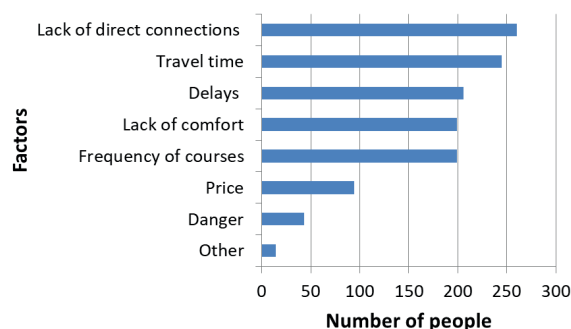


Figure 10 Distribution of respondents' answers on factors that discourage them from choosing public transportation

garbage. The percentage distribution of the number of respondents' answers is shown in Figure 11.

The next question asked about respondents' actions in the context of used car parts. Most respondents marked the answer that they give them to a recycling center. Among non-environmental behaviors among men, using batteries and tires for other purposes

dominated, while women's responses included throwing them in the garbage. Among ecological behaviors in the context of used car parts, two responses dominated: leaving them at the store and giving them to a recycling point. Among those aged 18-25 and 26-35, there are respondents who throw them in the garbage. As many as 17.39% of those in the 36-46 age bracket use used

Table 6 Drivers' behavior toward used car parts (%)

	I leave in the store when I buy new	I leave in the workshop	Surrenders to a point accepting waste tires/batteries	Stores in garage/basement	Uses for other purposes	I throw in the garbage	Not applicable
Sex							
Women	14.22	16.10	23.70	9.48	0.95	0.95	34.60
Men	20.69	19.21	29.06	11.82	6.90	0.00	12.32
Age							
Under 18 years	0.00	0.00	0.00	0.00	0.00	0.00	100.00
18-25	13.53	13.53	22.71	12.07	1.93	0.48	35.75
26-35	37.29	15.25	27.12	3.39	3.39	1.69	11.87
36-45	26.09	6.52	30.44	13.04	17.39	0.00	6.52
46-55	16.33	24.49	36.74	12.24	2.04	0.00	8.16
Over 55	4.17	43.75	29.16	10.42	2.08	0.00	10.42
Status in the labor market							
Pupil	6.25	6.25	6.25	6.25	6.25	0.00	68.75
Student	9.92	11.71	22.52	13.51	1.80	0.00	40.54
Working	24.12	19.74	28.51	10.53	5.70	0.87	10.53
Unemployed	12.50	25.00	43.75	0.00	0.00	0.00	18.75
Pensioner	6.98	23.26	25.58	9.30	0.00	0.00	34.88
Place of residence							
Village	20.83	20.83	25.00	16.67	5.21	0.00	11.46
City of up to 50.000 residents	20.51	23.93	25.64	9.40	0.85	0.00	19.67
City of 50.000 to 100.000 residents	20.65	9.78	26.09	9.78	9.78	2.18	21.74
City >100.000 residents	8.25	14.68	28.44	7.34	0.92	0.00	40.37
Driver's license							
Yes	19.48	20.34	29.51	12.32	4.30	0.29	13.76
No	6.16	3.07	9.23	1.54	1.54	1.54	76.92

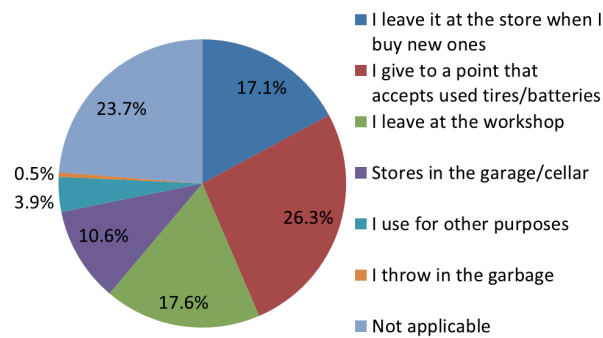


Figure 11 Drivers' behavior toward used auto parts

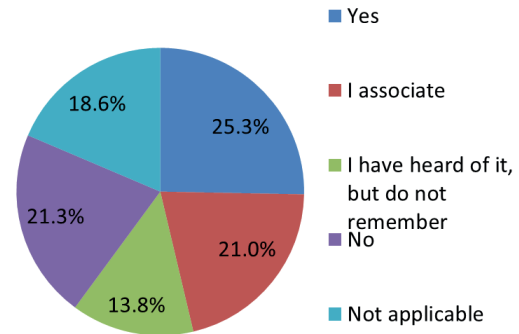


Figure 12 Drivers' knowledge of EURO standards

car parts for other purposes. In addition, there are two predominant responses: leaving them at the store and giving them to a recycling center. Among working people, there are respondents who throw them in the garbage and use them for other purposes. Respondents' place of residence has no influence on the further fate of used car parts. The answers to this question are very close to each other. Those with a driver's license have the largest share of used car parts, as they are the ones who own their own means of transportation (Table 6).

The next questions were aimed at those with

a driver's license and a passenger car. Respondents' knowledge of the European emission standard was tested. 25.4% of respondents know what the EURO standard defines. Among the 34.8% of respondents are those who associate or once heard, but cannot fully describe the meaning of the European exhaust gas standard. As many as 21.3% of respondents do not know the meaning of the EURO standards (Figure 12).

In the case of European exhaust gas standards, it is 37.44% of men and 13.74% of women who know what EURO stands for. According to the chi-square test,

Table 7 Drivers' knowledge of knowledge of EURO standards (%)

	Yes	I have heard of it. but I do not remember	I associate	No	Not applicable
Sex					
Women	13.74	17.06	14.69	27.01	27.50
Men	37.44	10.34	27.59	15.27	9.36
Age					
Under 18 years	0.00	0.00	0.00	0.00	100.00
18-25	21.26	12.07	12.56	26.09	28.02
26-35	38.98	15.25	18.64	16.95	10.18
36-45	30.43	21.74	28.26	15.22	4.35
46-55	42.86	10.20	20.41	24.49	2.04
Over 55	6.25	16.66	56.25	10.42	10.42
Status in the labor market					
Pupil	12.50	0.00	12.50	12.50	62.50
Student	12.61	16.22	9.01	30.63	31.53
Working	36.41	14.47	25.00	17.54	6.58
Unemployed	12.50	0.00	37.50	31.25	18.75
Pensioner	9.30	13.95	27.91	16.28	32.56
Place of residence					
Village	25.00	11.45	22.92	30.21	10.42
City of up to 50.000 residents	35.05	8.55	19.66	23.08	13.66
City of 50.000 to 100.000 residents	22.81	18.48	30.43	8.70	19.58
City >100.000 residents	17.43	17.43	12.84	22.02	30.28
Driver's license					
Yes	28.37	15.47	24.07	24.64	7.45
No	9.23	4.62	4.62	3.08	78.45

there is no correlation between knowledge and gender, as the χ^2 is 59.47, where the theoretical χ^2 is 9.49. Those in the age range of 26-35 and 46-55 have the greatest knowledge on the subject. As many as 30.21% of rural residents do not know what the EURO standard defines. In contrast, residents of cities up to 50,000 have the most knowledge and those who have successfully passed the state driving test have some knowledge on the subject. The group of people with knowledge of the meaning of the abbreviation "EURO norm" includes: 36.41% of working people, 12.61% of students, 9.3% of pensioners and 12.5% of student unemployed respondents. A large number of people cannot identify the assumptions of European emission standards. The Chi-square test shows that there is no relationship between the purchase of a car regarding the EURO standard and knowledge of the subject and possession of a driver's license. In this case, the χ^2 is equal to 183.02 and the theoretical χ^2 is equal to 9.49 (Table 7).

Air quality is affected by the amount of exhaust

fumes emitted by personal vehicles. Respondents were asked whether they pay attention to the level of pollutants emitted by a vehicle when buying an individual means of transportation. The survey found that 35.5% paid no attention to this issue and for 15.6% of people it is not important when choosing a vehicle. For only 12.1% of respondents, the EURO standard is an important criterion when acquiring a new means of transportation. Due to the fact that many people do not have knowledge of European exhaust gas standards, 14.3% of those questioned did not know that this is a factor worth considering when choosing a passenger car (Figure 13).

It is men who do not weigh the emission standard when choosing an individual means of transportation. For 13.74% of women, it is an important criterion when choosing a personal vehicle. The chi-square test shows that there is no relationship between the purchase of a car with a certain standard and gender, as the χ^2 is 27.93, where the theoretical χ^2 is 9.49. When purchasing a vehicle, as many as 20.34% of

Table 8 EURO standard as a criterion for buying a new vehicle (%)

	This is an important criterion when purchasing a vehicle	It matters little to me	I didn't know it was something to pay attention to	I wasn't paying attention	Not applicable
Sex					
Women	13.74	11.85	10.43	31.75	32.23
Men	10.34	19.21	18.23	39.41	12.81
Age					
Under 18 years	0.00	0.00	0.00	0.00	100.00
18-25	11.59	12.56	8.70	33.82	33.33
26-35	20.34	16.95	10.17	37.29	15.25
36-45	6.52	15.22	17.39	54.35	6.52
46-55	18.38	8.16	24.49	42.85	6.12
Over 55	4.17	35.42	31.25	18.75	10.41
Status in the labor market					
Pupil	0.00	6.25	0.00	25.00	68.75
Student	12.61	12.61	10.81	26.13	37.84
Working	14.03	15.79	16.23	44.30	9.65
Unemployed	18.75	18.75	0.00	43.75	18.75
Pensioner	2.32	23.26	23.26	13.95	37.21
Place of residence					
Village	9.38	21.88	11.46	43.74	13.54
City of up to 50.000 residents	12.82	13.68	19.66	35.89	17.95
City of 50.000 to 100.000 residents	16.30	17.39	15.22	30.44	20.65
City >100.000 residents	10.09	10.09	10.09	32.12	37.61
Driver's license					
Yes	12.89	17.76	16.91	40.69	11.75
No	7.69	3.08	0.00	7.69	81.54

those in the 26-35 age group and 18.38% of those in the 46-55 age group consider the EURO standard as an important criterion. In contrast, more than half of respondents in the 36-45 age group have never paid attention to the emission standard. In addition, when buying a vehicle, as many as 18.75% of the unemployed and 12.61% of students consider the EURO standard as an important criterion. In contrast, almost half (44.3%) of the working respondents and (43.75%) of the unemployed did not pay attention to this aspect. Among those with knowledge of the meaning of the abbreviation "EURO standard" are: 36.41% of working, 12.61% of students, 9.3% of pensioners and 12.5% of unemployed respondents. A large number of people cannot identify the assumptions of European emission standards. In addition, the respondents' place of residence does not affect the answers in the context of purchasing a vehicle, the main criterion of which is the Euro standard. Most people indicated that they do not pay attention to the level of pollution emitted by the car they are looking for. The situation was similar in the questions about the Euro standard, as they were aimed at those with a cat. B driver's license. 40.69% of people never paid attention to the level of pollution emitted by the vehicle. The chi-square test shows that there is no correlation between

the purchase of a car regarding the Euro standard and knowledge of the subject and having a driver's license. For the first question, the χ^2 is 153.73 and the theoretical χ^2 is 9.49 (Table 8).

The amount of exhaust fumes emitted by a vehicle depends on fuel consumption. Of great importance is the driving style of drivers. Smooth acceleration, braking or the way gears are changed, are characterized by the fact that driving is more efficient and as a result, the driver reduces the vehicle's production of harmful exhaust components. The European Union has begun to promote and support the new economical driving style. Half of those surveyed drive according to the principles of Eco-driving. 20% know what the method is about, but do not use it and only 12.6% have never heard of the economic driving technique (Figure 14). Thus, drivers who apply eco-driving principles individually affect the environmental protection caused by road transportation.

An important issue, related to the environmental impact of transportation, is the driving style of drivers. Definitions of eco-driving have been created and for this reason respondents were asked whether they use it in their daily driving of passenger cars. As many as 59.61% of men and 40.28% of women use this driving technique. According to the Chi-square test, there is no

Table 7 Use of Eco-driving technique (%)

	Yes	No. but I know the rules	No. I don't know what eco-driving is	Not applicable
Sex				
Women	40.28	19.43	13.74	26.55
Men	59.61	20.69	11.33	8.37
Age				
Under 18 years	0.00	0.00	0.00	100.00
18-25	42.52	20.77	12.56	24.15
26-35	52.54	25.42	10.18	11.86
36-45	60.87	28.26	0.00	10.87
46-55	65.31	12.24	20.41	2.04
Over 55	56.25	12.50	20.83	10.42
Status in the labor market				
Pupil	18.75	12.50	6.25	62.50
Student	44.14	15.32	16.22	24.32
Working	57.02	23.25	10.96	8.77
Unemployed	50.00	31.25	0.00	18.75
Pensioner	37.22	13.95	18.60	30.23
Place of residence				
Village	42.71	30.21	17.71	9.37
City of up to 50.000 residents	56.41	18.80	12.82	11.97
City of 50.000 to 100.000 residents	54.35	16.30	9.78	19.57
City >100.000 residents	44.95	15.60	10.09	29.36
Driver's license				
Yes	57.88	22.06	14.04	6.02
No	6.15	9.23	4.62	80.00

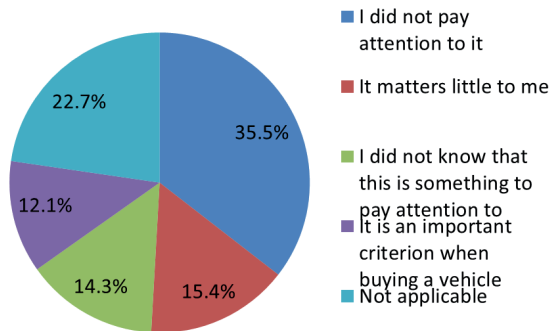


Figure 13 EURO standard as a criterion for buying a new vehicle

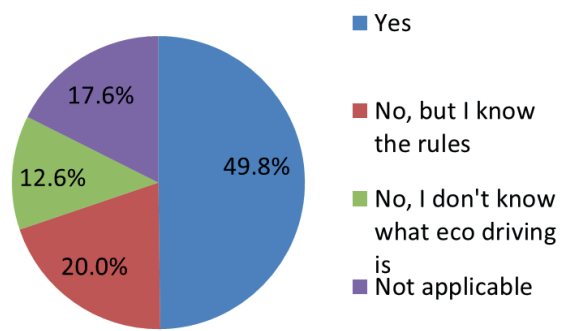


Figure 14 Use of Eco-driving technique by respondents

relationship between the use of eco-driving and gender, as the χ^2 is 27.69, where the theoretical χ^2 is 7.81. The economical driving technique is used by more than half of the respondents in each age bracket who have reached the appropriate age to take the driving test. The eco-driving style is used by students (44.14 %), working people (57.02%) and the unemployed (50 %). The eco-driving technique is used by almost half of the respondents in each group of localities. An interesting phenomenon is that as many as 30.21 % of respondents

from rural areas know the eco-driving method, but do not use it. More than half of the people (57.88 %) use the eco-driving. The Chi-square test shows that there is no correlation between the use of eco-driving and having a driver's license, as the χ^2 is 39.16, where the theoretical χ^2 is 7.8 (Table 9).

Many car brands are producing and releasing more and more cars with alternative powertrains, such as hybrids and electrics. Their registration and popularity in Poland are growing. Respondents with

Table 9 Use of Eco-driving technique (%)

	Yes	No. but I know the rules	No. I don't know what eco-driving is	Not applicable
Sex				
Women	40.28	19.43	13.74	26.55
Men	59.61	20.69	11.33	8.37
Age				
Under 18 years	0.00	0.00	0.00	100.00
18-25	42.52	20.77	12.56	24.15
26-35	52.54	25.42	10.18	11.86
36-45	60.87	28.26	0.00	10.87
46-55	65.31	12.24	20.41	2.04
Over 55	56.25	12.50	20.83	10.42
Status in the labor market				
Pupil	18.75	12.50	6.25	62.50
Student	44.14	15.32	16.22	24.32
Working	57.02	23.25	10.96	8.77
Unemployed	50.00	31.25	0.00	18.75
Pensioner	37.22	13.95	18.60	30.23
Place of residence				
Village	42.71	30.21	17.71	9.37
City of up to 50.000 residents	56.41	18.80	12.82	11.97
City of 50.000 to 100.000 residents	54.35	16.30	9.78	19.57
City >100.000 residents	44.95	15.60	10.09	29.36
Driver's license				
Yes	57.88	22.06	14.04	6.02
No	6.15	9.23	4.62	80.00

Table 10 Respondents' willingness to purchase an alternatively powered vehicle (%)

	Yes	No	Not applicable
Sex			
Women	38.39	38.86	22.75
Men	54.68	38.42	6.90
Age			
Under 18 years	0.00	0.00	100.00
18-25	38.65	39.13	22.22
26-35	49.16	38.98	11.86
36-45	54.35	45.65	0.00
46-55	65.31	34.69	0.00
Over 55	54.17	37.50	8.33
Status in the labor market			
Pupil	18.75	18.75	62.50
Student	39.64	36.04	24.32
Working	53.07	41.23	5.70
Unemployed	25.00	50.00	25.00
Pensioner	46.52	34.88	18.60
Place of residence			
Village	37.50	53.13	9.37
City of up to 50.000 residents	47.86	41.03	11.11
City of 50.000 to 100.000 residents	54.35	25.00	20.65
City >100.000 residents	45.87	34.86	19.27
Driver's license			
Yes	51.86	42.98	5.16
No	16.92	15.39	67.69

internal combustion cars were asked if they had ever considered buying an alternatively powered car. 46.4% of respondents said they had been able to switch from gasoline or diesel modes of transportation to environmentally friendly cars. Only 38.6% had never thought about buying a hybrid or electric vehicle (Figure 15).

More often it is men who are willing to purchase an electric or hybrid vehicle. According to the Chi square test, there is no relationship between vehicle purchase and gender, as the χ^2 is 23.29, where the theoretical χ^2 is 5.99. Nearly half of respondents aged 26 to over 55 are willing to switch from an internal combustion vehicle to an electric or hybrid vehicle. Readiness to purchase such a car indicated: 39.64% of students, 53.07% of working people and 46.52% of retirees. Nearly half of respondents living in cities are willing to switch from a combustion vehicle to an electric or hybrid car. 53.13% of respondents from small towns and cities have not considered buying an environmentally friendly vehicle. Those without a driver's license also considered buying an alternatively powered car. 42.98% of respondents with driving skills had never considered buying an electric or hybrid car. The chi-square test shows that there is no relationship between the willingness to purchase an alternatively-powered vehicle and having

a driver's license, as the χ^2 is 168.30, where the theoretical χ^2 is 5.99 (Table 10).

The European Union is seeking and constantly studying possible solutions to reduce the negative impact of road transport on the environment. The European Commission is urging member countries to implement a policy of sustainable development by supporting and funding research into environmentally friendly transportation activities. For this reason, respondents were asked what solutions they think would minimize the negative environmental impact of road transportation. Most would like to see those in power allocate more resources to properly functioning public transportation. In the second place was the idea of more electric vehicles on Polish roads. As many as 179 people marked the solution of introducing green zones in cities. Respondents do not want to eliminate all internal combustion vehicles from the roads, but would prefer more restrictive diagnostic testing of older cars (Figure 16.). Respondents typed in their own ideas such as:

- limiting the production of new vehicles,
- greater subsidies for electric means of transportation,
- building a nuclear power plant in Poland to generate electricity to power electric vehicles,
- the invention of alternative fuel,

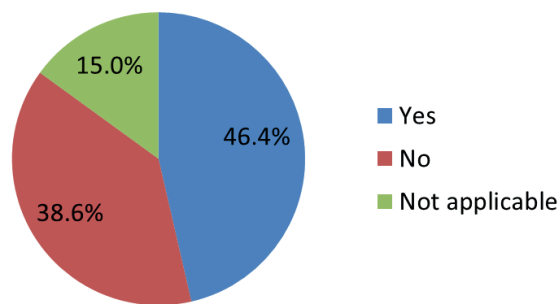


Figure 15 Willingness of respondents to purchase an alternatively-powered vehicle

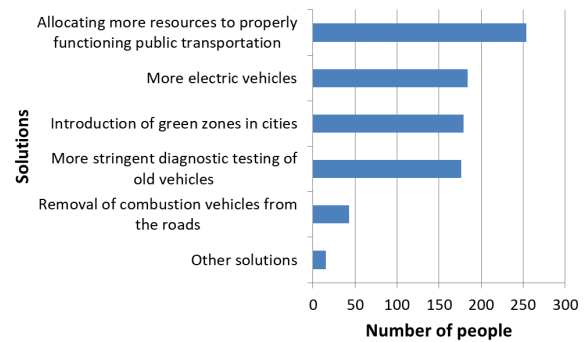


Figure 16 Summary of solutions to reduce the negative impact of road transport on the environment

- popularizing the use of alternative means of transportation,
- modernization of roads,
- increasing parking fees in cities and introducing a 30-mph speed limit in built-up areas.

The next step presents a summary of correlations

between Poles' awareness of the impact of transportation on the environment, the way respondents drive in and out of built-up areas, drivers' knowledge of EURO standards, purchase of a car with the applicable exhaust gas standard, Eco-driving and purchase of an alternatively powered vehicle. As can be seen, there is no correlation

Table 9 Correlation of answers given

Criterion	df	α	χ^2	χ^2_d	Conclusion
Awareness of Poles related to the impact of transportation on the environment	4	0.05	10.47	9.49	No correlation between the responses of men and women
Manner of movement of respondents in a built-up area	4	0.05	20.9	7.81	No correlation between the way of movement in the city and gender
The way respondents travel outside built-up areas	2	0.05	18.43	5.99	No correlation between mode of movement in the city and gender
Drivers' knowledge of knowledge of EURO standards	4	0.05	59.47	9.49	No correlation between knowledge and gender
Drivers' knowledge of knowledge of EURO standards	4	0.05	183.02	9.49	No correlation between buying a car regarding the EURO standard and knowledge about it and having a driver's license
Purchase of a car	4	0.05	27.93	9.49	No correlation between buying a car with a particular standard and gender
Purchase of a car	4	0.05	153.73	9.49	No correlation between buying a car regarding the EURO standard and knowledge about it and having a driver's license
Eco-driving	3	0.05	27.69	7.81	No correlation between the use of Eco-driving and gender
Eco-driving	3	0.05	39.16	7.81	No correlation between using eco-driving and having a driver's license
Purchase of an alternatively powered vehicle	2	0.05	23.29	5.99	No correlation between buying a vehicle and gender
Purchase of an alternatively powered vehicle	2	0.05	168.30	5.99	No correlation between buying a vehicle and having a driver's license.

where:

df - the degrees of freedom,

α - the significance level,

χ^2 - the Chi-square statistic,

χ^2_d - the critical Chi-square value.

between the answers given among respondents to the question by gender and driver's license held (Table 11)

Summarizing the survey results, rural residents cannot imagine daily life without a personal car. It turns out that rural households usually own three or more vehicles. It can be concluded that every person with a driver's license owns a personal car. The reason for this phenomenon is that public transportation to small towns is poorly developed. Therefore, rural residents are forced to have their own car for each family member. Official errands, professional work and education are the main activities for which the rural residents must travel to larger settlements. In smaller settlements, on the other hand, there are usually one to two means of transportation per household, while residents of metropolitan areas mainly own one personal car or no vehicle at all. This is due to the fact that public transportation in larger cities is well-developed, so the urban population prefers to use public transportation such as buses, streetcars, light rail, among others.

The Covid-19 pandemic has changed transportation behavior in Polish cities. It was enforced by government-imposed restrictions, such as limits on the number of passengers in public transportation vehicles. In addition, fear of contracting the coronavirus was widespread among the public. During the pandemic, the population abandoned public transportation in cities shifting mainly to the personal car. Many respondents declared that they walk in urban areas. Respondents who declared that they were switching from public transportation to a personal car were those with a driver's license. In contrast, respondents who did not have driving privileges were forced to use the bus or streetcar. Summarizing urban mobility, the pandemic is the result and the main factor that changed the public's choice of mode of transportation in the urban area. In addition, outside the built-up area, respondents are most likely to choose a passenger car. On the other hand, for longer routes, passengers prefer to choose rail transportation (train) rather than bus.

Public transportation is not so popular among respondents that they choose it for longer routes. Respondents were asked what discourages them from using the public transportation. The main factor is the offerings of transportation companies and their shortcomings in performing transportation services. For this reason, carriers should work together to create consistency in schedules and the frequency of courses that occur. Reaching a destination even with a change, but without unnecessary waiting, is the biggest advantage of choosing the public transportation. This will minimize the travel time, which a very large number of people pay attention to when planning a trip and choosing a mode of transportation. In addition to schedules, public transportation passengers point to the comfort found in public transportation as a deterrent. In addition, carriers should provide more funding for modern vehicles, which will change the vision regarding

the quality and safety of travel. Respondents' answers, about the problems they face in public transportation, are the best way for carriers to see the bad sides of company management. As a result of changes in creation of transportation offers suggested by the public, more people will choose to travel by public transportation than by individual means.

The public most often uses the passenger car for travel, which is an emitter of a large amounts of harmful components into the air, from fuel combustion. The largest number of combustion vehicles travel on Polish roads. However, the number of passenger cars with an alternative source of propulsion is steadily increasing. Nearly a half of the survey's respondents are considering purchasing an electric or hybrid vehicle. There are people in every age group who are willing to swap their gasoline or internal combustion vehicle for an environmentally friendly means of personal transportation. In addition to the choice of means of transportation, driving technique is important for environmental protection in the context of the road transport. Eco-driving style is now popular and since 2015 it has been one of the tasks tested on the driving test. Half of the respondents use Eco-driving as a result of their individual commitment to minimizing the amount of harmful exhaust components in the air. Those who marked the answer "no, I don't know what Eco-driving is" are mostly young people who are licensed to drive a vehicle with a maximum permissible weight of up to 3.5 tons, having acquired it after 2015. It can be inferred that they drive according to certain principles of economical driving, but do not realize it. On the other hand, there are many people who have knowledge of Eco-Driving, but do not apply this method in their daily driving of passenger cars.

The survey also tested knowledge of the European emissions standard. More than a half of the respondents do not know or only somewhat associate the meaning of EURO standards. One in five has full knowledge of permissible emission limits. Another question concerned those who own an individual means of transportation. A very large number of people, that took part in the survey, do not pay attention to which EURO standard their vehicle has. For only 50 people, this is an important criterion when buying a personal vehicle. The responses of those surveyed show that knowledge of the introduced exhaust gas standards is low among the Polish public. Thus, on this topic, more education should be introduced for the future applicants to drive motor vehicles. In this way, the nation's awareness of the negative impact of vehicles' engines combustion on the environment can be increased.

The public's awareness of the environmental impact of the road transportation is improving. A very large number of respondents are interested in environmental protection to some extent. This is a positive result of the survey, as the future population will deeply analyze their behavior and choices to act in accordance with the principles of sustainable development. Pro-

environmental actions can be encouraged through various social campaigns, subsidies and increased fees for those who will negatively impact the ecosystem. Respondents also identified environmentally friendly transportation solutions that should be introduced in Poland. More than a half believe that the state should allocate more money for properly functioning public transportation. Create it according to the public's expectations, which will result in more people being able to replace individual means of transportation with public transportation. In the second place was the idea of electric vehicles, to increase their number and increase subsidies for purchase of an alternatively powered car. However, to power such a vehicle, electricity is needed, which in Poland is generated from a coal-fired power plant. Therefore, there is a need to change the way electricity is produced, which will be less invasive to the environment. Only one person indicated that a nuclear power plant should be built as a source of energy to power electric vehicles. Respondents pointed to solutions that should be introduced in cities, such as green zones, a 30km/h speed limit in built-up areas and higher parking fees. This would result in less congestion on the roads and, in part, encourage the public to use public transportation.

3 Conclusion

The survey of the Polish public revealed their transportation preferences and knowledge of the negative impact of the road transport on the environment. The respondents' responses were influenced by the current situation of the infectious disease Covid-19. The population is trying to protect itself from contagion, so it chooses individual means of transportation. Before the outbreak of the pandemic, they were able to swap the personal car in favor of public transportation. However, there are many factors that influence the decision to choose the public transportation. The public is willing to travel more often by public transport when carriers create transportation offers that are in line with citizens' needs. As a result, there will be fewer passenger cars on the roads, thus reducing the negative components from the fuel combustion.

Public interest in environmental protection in the context of road transportation, is growing all the time. Many people are basing their activities on environmental solutions. Drivers, in addition to the proper operation of the vehicle, are interested in the technologies used in their vehicles to reduce exhaust fumes and are prudent in deciding the fate of used car parts. Respondents want the Polish state to function in accordance with the principles of sustainable development. For this

reason, green innovations should be introduced, such as development of public transportation, elimination of old combustion vehicles and more electric cars. Those measures will affect the environment to some extent, but will not minimize the negative impact of the road transport on the ecosystem.

The road transport plays a very important role for the proper functioning of the country's economy. It is also growing very rapidly and is the most popular mode of transport chosen for transporting people and cargo. In an uncontrolled way, road passenger transport has begun to dominate in the form of individual transport. The public seeks to move as quickly as possible between designated points than to travel according to public transportation schedules. Road transportation has a significant impact on the environment. Currently, transportation means are powered by gasoline or diesel fuel, which emit large amounts of harmful products of their combustion into the environment. The highest concentration of pollutants is shown by use of the passenger car. Their registrations are increasing every year, resulting in increased traffic caused by personal travel vehicles. Road transportation also affects the health and life of the public. This is influenced by noise and air, soil and groundwater pollution.

There is a growing awareness in Polish society of the negative impact of individual road transport on the environment. For environmental action is to use buses or streetcars to get around cities. A better way is to choose a bicycle or cover routes on foot. This is ideal for the environment and for human health and fitness. Even such small measures can, to some extent, reduce the negative impact of transportation on the ecosystem.

The aim is to make residents think about the planet and the environment when choosing a means of transportation and actions in the context of operating their own vehicle. All the time, it is necessary to educate the public and increase their knowledge about the drastic development and impact of the road transport on the ecosystem.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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