

PERSONAL SAFETY OF PASSENGERS DURING THE FIRST PHASE COVID-19 PANDEMIC IN THE OPINION OF PUBLIC TRANSPORT DRIVERS IN KRAKOW

Marek BAUER¹, Wiesław DŹWIGOŃ², Matthias RICHTER³

^{1,2} Cracow University of Technology, Krakow, Poland

³ University of Applied Sciences Zwickau, Zwickau, Germany

Abstract:

The Covid-19 pandemic impact all public spheres of city inhabitants' lives, also changed the conditions of traveling by public transport, especially in the field of personal passenger safety. The introduced limits on people in public transport vehicles and the need to maintain social distancing or cover the mouth and nose in a public transport vehicle - for various reasons - have been met with different understanding by users. The question then arose: are passengers actually complying with the rules of the pandemic when traveling by tram or bus? The paper attempts to assess the behavior of passengers, based on the opinions of people who observe these behaviors in their daily work, driving public transport vehicles. For this purpose, a survey was carried out among bus and tram drivers of the main public transport operator in Krakow. On the basis of 334 fulfilled questionnaires, it was found that - according to the drivers - passengers often quite freely approach the limits of people in vehicles, and often do not respect the social distancing, especially when alighting and boarding. However, what is optimistic, the drivers highly assessed their own safety when performing their official duties - which is extremely important in the context of ensuring the continuity of public transport during a pandemic. Only 10% of drivers considered that the current solutions to protect passengers (and drivers themselves) are sufficient, therefore they called for an increase in the scope of protective measures: an increase in the number of public transport courses (to keep existing passengers), the obligatory use of protective masks (instead of ineffective loosely obligation to cover the face and nose), or the introduction of closed driver cabins in buses (as in trams). The obtained research results are of a cognitive nature, they can be a supplement to the travel studies at this specific time. They can also provide support in taking action in the case of a return of the Covid-19 pandemic or similar incidents in the future.

Keywords: Covid-19 pandemic, transportation behavior, public transport driver, public transport safety

To cite this article:

Bauer, M., Dźwigoń, W., Richter M., 2021. Personal safety of passengers during the first phase Covid-19 pandemic in the opinion of public transport drivers in Krakow. Archives of Transport, 59(3), 41-55. DOI: <https://doi.org/10.5604/01.3001.0015.0090>



Contact:

1) mbauer@pk.edu.pl [<https://orcid.org/0000-0002-8465-3716>] – corresponding author; 2) wdzwigon@pk.edu.pl [<https://orcid.org/0000-0003-1440-4818>]; 3) m.richter@fh-zwickau.de [<https://orcid.org/0000-0001-9861-8893>]

1. Introduction

The impact of a Covid-19 pandemic faced by countries, regions, and cities varies widely, as well as the interventions taken to protect the citizens, as is being shown by World Health Organization reports (WHO, 2020-2021). The greatest problems have been observed in urbanized areas because of the highest population density, and it is in these areas that there is the greatest risk of virus transmission. Already the first phase of the Covid-19 pandemic has transformed cities around the world in many aspects. First of all, it hit the social sphere of human life (Van Bavel et al., 2020). It quickly turned out, that one of the fastest and most effective methods of stopping spreading the new virus is limiting direct, interpersonal contacts (Morita, Kato & Hayashi, 2020). All solutions increasing the use of the scarce space in cities (e.g. multi-family housing, public transport), as well as solutions supporting the maintenance of social and cultural bonds (e.g. recreation places, shopping centers, restaurants, churches) were impugned. The Covid-19 pandemic has raised many questions about the further development of cities around the world (Budd & Ison, 2020), (Dong et al., 2021). Suddenly, it turned out that most offices, schools, universities and various offices changed their working mode to fully or at least partially remote. Everyday citizens' habits have changed: the daily activity of the inhabitants has decreased, and the delivery of goods directly to their homes has gained in popularity. Many aspects of life have moved to the virtual world, which must have resulted in a reduction in the number of daily journeys (Tirachini, 2020).

The reduction in the number of journeys resulted in an at least temporary change in the priorities of the users of the transport system. Travel time, generally regarded as one of the most important criteria for assessing travel (Kolawole Ojo, 2017), as well as the comfort, cost of travel or level of passenger information (Więcek et al., 2019) - have given way to travel safety, in the category of personal safety, that has often been somewhat neglected regarding to the comparison to road safety. Securing daily transport system users against infection turned out to be the most crucial transportation problem.

This applies in particular to public transport (Zhang, Hayashi, Lawrence & Frank, 2021), which in ordinary, undisturbed pandemic operating conditions is characterized by the highest efficiency among all

types of transport used in cities, among others due to high person capacity. This capacity results from the possibility of carrying a large number of people using a relatively small number of vehicles, which, however, is associated with the presence of passenger crowd at stops and especially in public transport vehicles. Under ordinary operating conditions, the acceptable level of comfort in a vehicle usually does not exceed 4 people on 1 m² of standing area (Ibarra-Rojas, 2015) – so each passenger has 0.25 m² at their disposal. This value can vary depending on passenger load factor and in-vehicle time (Shen, Feng, Li et al., 2016).

Meanwhile, one of the fastest and most common restrictions during a Covid-19 pandemic was the introduction of passenger limits in public transport vehicles. In Poland, in the initial phase of the pandemic, it was limited to only half of the number of seats in the vehicle (Regulation of the Minister of Health No. 522, 2020). At that time - depending on the type of vehicle - the passenger had at his disposal from 1.3 (midi-bus) to even 5.5 m² of vehicle surface (large-capacity tram). While maintaining such strict limits turned out to be a big challenge for the organizers of public transport in Polish cities. Further increasing the limit of people in vehicles to 30% of total capacity (seats + standing places) of the vehicle improved the situation only slightly.

2. Objectives of the paper

Since the beginning of the Covid-19 pandemic, the world of science became keenly interested in new problems. In the Google Scholar database, on August 2, 2020, more than 51,000 scientific publications, to a greater or lesser extent devoted to Covid-19, were already available. Much of them deals with medical aspects (Kangqi et al., 2020)(Fotios and Makridakis, 2020), but a lot of work has been done on economic and social aspects of Covid-19 (Baldwin & Weder di Mauro, 2020), (Nicola et al., 2020). Some publications are devoted to transport, but more in relation to the transport of patients (e.g.: Coccolini et al., 2020), than in terms of travel during pandemic.

Relatively small research has been devoted to the topic of daily travelling during Covid-19 pandemic - although significant decrease in mobility is one of the most visible pandemic effects (Kraemer et al., 2020)(De Vos, 2020)(Oum & Wang, 2020),

(Giancarlo, Taniguchi & Takami, 2020). The majority of the research results conducted during Covid-19 - which is fully understandable – concerns the behaviors of users of the transport system, declared by themselves. The results of these studies indicate lower number of travels in comparison to the before Covid-19 level and above-standard growth the share of car and bicycle travels, with a simultaneous decrease in the share of public transport.

The aim of this paper is to evaluate the behavior of public transport passengers from the point of view of the drivers of these vehicles. This assessment expresses the drivers' view on the behavior of passengers in vehicles and includes the degree of compliance with the introduced restrictions - during both stop-to-stop sections running, as well as during the passengers exchange at stops. It also takes into account the assessment of the effectiveness of the introduced restrictions and the drivers' own suggestions on other possible solutions. Research among public transport vehicle drivers on the behavior of people during the Covid-19 pandemic is the only research of this type carried out in Poland, so far.

According to the authors' intention, the results of the research - apart from their cognitive value - may be useful in introducing and modifying solutions enabling safe daily travelling both during the still present Covid-19 pandemic, as well as in the case of the possible emergence of similar circumstances in the future.

3. The scope of restrictions introduced on public transport in Poland regarding to the Covid-19 pandemic

The first Polish legal act regulating the rules of the functioning of the society during the Covid-19 pandemic was issued on March 2, 2020 in the form of an act on special solutions related to the prevention, counteraction and combating Covid-19, other infectious diseases and the crisis situations caused by them. The next breakthrough general documents were the regulations on the announcement of an epidemic threat in the territory of the Republic of Poland (Regulation of the Minister of Health of March 13, 2020) and regulations on the announcement of an epidemic in the territory of the Republic of Poland (Regulation of the Minister Of Health of March 20, 2020).

As the epidemiological situation have being developed, the Polish government introduced further regulations, that directly or indirectly influenced onto

public transport operations in Polish cities. The group of regulations indirectly affecting public transport includes, - inter alia - those, related to the temporary limitation of the functioning of educational system units and certain entities of the higher education and science system (reduction in the number of journeys related to education and science) and those, related to the temporary suspensions or restrictions on border traffic on certain border crossings and air traffic bans (reducing the number of tourist and business trips). Regulations directly affecting the operation of public transport in Polish cities were summarized in Table 1.

In addition, subsequent regulations specified the minimum spacing between pedestrians (initially 1.5m, in later regulations: 2.0m, with certain exceptions: when the journey takes place with a child up to the age of 13 or with a person with a certificate of disability or a person with a certificate of need for special education or a person who, due to his health condition, cannot move independently). These were not regulations strictly applicable to public transport vehicles, but the concept of social distancing became so deeply entrenched in society, that these recommendations somehow influenced the spatial arrangement of people in all public places, therefore also in public transport vehicles.

4. Method of assessing the passengers' behavior by public transport drivers

As it was not possible to organize a nationwide survey in such a short period of time, it was decided to conduct a survey among public transport drivers in Krakow.

4.1. Case study: main public transport operator in Krakow

The survey was possible thanks to the courtesy of Miejskie Przedsiębiorstwo Komunikacyjne S.A. of Krakow (in short: MPK). It is the larger of the two public transport operators in Krakow, which in 2019 realized 86% of the service-km in bus transport (from over 43 million service-km) and 100% of the service-km in tram transport (14.8 million train-km) - ordered by the Public Transport Authority in Kraków. In 2019, the company employed 705 bus drivers and 481 tram drivers, who are assigned to three bus depots (Bienczyce, Plaszow and Wola Duchacka) and two tram depots (Nowa Huta and Podgorze). However, this is not the full number of

Table 1. Polish legal acts directly related to the public transport operations during the Covid-19 pandemic (own study, based on: [22-27])

Date of announcement	Name of the legal act	Limiting the number of people in the PT vehicle		Obligation to cover the mouth and nose in the vehicle	
		period of validity	maximum number of passengers	period of validity	scope of protection (to whom it applies)
03/24/2020	Regulation of the Minister of Health [22]	from 03/25/2020 to 04/11/2020	no more than half the number of seats in vehicle	-	-
03/31/2020	Regulation of the Council of Ministers [23]	from 03/31/2020 until further notice	no more than half the number of seats in vehicle	-	-
04/10/2020	Regulation of the Council of Ministers [24]	until further notice	no more than half the number of seats in vehicle	from 04/16/2020 until further notice	by piece of clothing, a mask or a protective face mask (PT drivers and passengers*)
04/15/2020	Regulation of the Council of Ministers [25]	until further notice	no more than half the number of seats in vehicle	from 04/16/2020 until further notice	by piece of clothing, a mask or a protective face mask (only passengers*)
05/16/2020	Regulation of the Council of Ministers [26]	from 05/16/2020 until further notice	no more than half of the number of seats in vehicle or 30% of the total number of places in vehicle (and at least 50% of the seats unoccupied)	from 05/16/2020 until further notice	by piece of clothing, a mask or a protective face mask (only passengers**)
05/29/2020	Regulation of the Council of Ministers [27]	from 05/30/2020 until further notice	100% of the number of seats in vehicle or 50% of the total number of places in vehicle (and at least 50% of the seats unoccupied)	from 05/30/2020 until further notice	by piece of clothing or parts thereof, masks, protective face masks or a protective helmet

bus drivers, because the company also outsources the duties to drivers not employed in the company, as economic entities (on a self-employed basis). During the entire research period, some seats were disabled in all public transport vehicles in Krakow (by marking the places excluded from use), and all vehicle doors have information on the maximum number of persons permitted in the vehicle. There are also separate special excluded safety zones for drivers, consisting in the physical protection of the part of the vehicle adjacent to the driver's cabin, inaccessible to passengers. This meant a significant change, especially for bus drivers, used to working in a semi-open cabin, in close contact with passengers – the introduction of a safety zones was necessary to ensure safe work during the Covid-19 pandemic at all. The introduction of a safety zones in trams was not that revolutionary - in these vehicles, the cabins are closed while driving. It should be noted, however, that the introduction of the safety zone took place at the expense of a further reduction in the number of seats in the vehicle. The possibility of purchasing tickets from vehicle drivers has also

been completely eliminated - leaving the possibility of purchasing tickets in ticket machines in vehicles and via internet applications. Due to the very high share of transportation work realized by MPK (in total work), it was concluded that the results of the survey among the drivers of MPK vehicles will be reliable for those operating public transport vehicles in Krakow.

4.2. Questionnaire form

The questionnaire form was prepared in cooperation with the students of study spatial management, at the Cracow University of Technology, as a part of didactic classes. It consisted of 15 questions and covered the subject of the assessment of passenger behaviors from the point of view of public transport vehicle drivers and the subject of changes in the transportation behavior of the drivers themselves - during their journeys, not related to driving public transport vehicles. Table 2 presents a list of substantive questions concerning the assessment of passenger behavior.

Table 2. Questions about the passengers' behavior in public transport vehicles (own study)

No.	Question	Possible answers	Number of respondent's choices
1	Has the frequency of your official duties changed during the pandemic?	Value given by the respondent, from the range [-100%, +100%]	only one
2	Do passengers comply with the limit of passengers in the vehicle?	{yes, rather yes, diversely (50/50), rather not, no, I do not know}	only one
3	Do passengers keep the recommended distances from passengers in the vehicle?	{very often, often, diversely (50/50), rarely, very rarely, I don't know}	only one
4	How do passengers behave when alighting and boarding?	{they keep a safe distance, they board at appropriate distances, they move away from the door, they stand close next to each other, they board in large group together, they stand close to the door, other one - given by the respondent, I do not know}	a few (max 7)
5	Do passengers use ticket machines in the vehicle?	{very often, often, diversely (50/50), rarely, very rarely, I don't know}	only one
6	Do passengers try to buy a ticket from the driver?	{very often, often, diversely (50/50), rarely, very rarely, I don't know}	only one
7	Do passengers respect the driver's safety zone (introduced during a pandemic)?	{yes, rather yes, diversely (50/50), rather not, no, I do not know}	only one
8	Do you feel safe while driving public transport vehicle (due to the pandemic)?	{yes, rather yes, diversely (50/50), rather not, no, I do not know}	only one
9	What other options of passenger protection should be used?	{introducing larger limits on the number of passengers in a PT vehicle, introducing lower limits on the number of passengers in a PT vehicle, obligatory use of protective face masks in PT vehicle, introducing more PT courses, extending on demand services (Tele-Bus), the current possibilities are sufficient, another one - given by the respondent, I have no opinion}	a few (max 7)
10	What other options of PT driver protection should be used?	respondent's declaration	many

The next two questions concerned the share of private travel by bus and tram drivers themselves - before and during the Covid-19 pandemic, but this part of the study does not fall within the scope of this article. The last three questions were aimed at identifying the gender and age of public transport vehicle drivers and determining which type of vehicles (bus, tram) they drive while performing their official duties.

4.3. Realization of survey research

The surveys were carried out on May 15, 2020 until June 16, 2020, when the last completed questionnaire forms were submitted. The questionnaire forms were handed out to drivers at the depots, where they started their daily work on public transport lines in Krakow, with the principle, that each driver could fill in only one questionnaire form.

The relatively long period of availability of the questionnaires made it possible for the majority of public transport vehicle drivers in Krakow to participate in the study. Unfortunately, due to the restrictions related to the Covid-19 pandemic, it was not possible to conduct a direct interview with the interviewer, although this form of research - according to the authors - would be the best.

The completed questionnaires were successively forwarded to the authors of the paper by the employees of MPK (here again, MPK should be thanked for such kind and professional help in conducting the research). Partial results of the research were processed and pre-analyzed as part of didactic classes. Then, the scope of statistical analyzes was extended by the authors of the article, and another part of the completed questionnaire forms provided by MPK was included in the analysis.

5. Research results

A total of 334 completed questionnaire forms were obtained, of which 259 (77.5%) from bus drivers and 75 (22.5%) from tram drivers. Such a strong disproportion in the return of the questionnaires is closely related to the already mentioned dominance of bus drivers in the total number of drivers employed and contracted by MPK.

Unfortunately, the goal of making at least 100 surveys in the group of tram drivers was not achieved. Nevertheless, it was not possible to extend this part of the sample (with voluntary participation in the study) - all tram drivers in Krakow had a chance to fill the questionnaire. In this situation, the representation of this group (16% of all tram drivers) should be considered satisfactory.

5.1. Assessment of passenger behaviors in public transport vehicles

The general opinion of drivers about the behavior of passengers in public transport vehicles is rather negative. In case of passenger compliance on limits, as many as 57% of drivers assessed that passengers do not comply with the limits (27% "rather do not" and 30% "not") – as shown in Figure 1. Only 16% assessments were positive, including only 3% definitely positive (the answer "yes" was indicated by only 10 drivers).

As the bus and tram rolling stock differ in terms of, among others, the capacity, number and arrangement of seats, door arrangement and width, but also the degree of separation of the driver's cab from the passenger compartment, it was decided to check

whether there were differences in the ratings of bus and tram drivers (Table 3).

The differences in proportions in absolute values greater than 1 percent point occur only at the splice of the assessments "they rather do not respect" and "diversely" - and it is a maximum of 5 pp. Nevertheless, a series of significance tests were carried out for two proportions (the case, when the size of one of the compared research samples is less than 100), for single responses and for aggregated responses: positive ("they respect" and "rather they respect") and negative ("rather they do not respect" and "they do not respect"), treating the only neutral answer separately ("diversely"). In all analyzed cases, it can be concluded (at the significance level of 0.01), that there are no statistically significant differences between the compared proportions in the group of bus and tram drivers.

A much smaller number of assessments of tram drivers results in the size of errors in estimating the proportions of individual indications (also Table 3). They are much lower in the case of responses from bus drivers (max 6.0% for aggregated answers "they do not respect" and "rather they do not respect"), while in the case of tram drivers in three cases they exceed 10% (max 11.3% for the same aggregated answers). The estimation errors for the total indications of bus and tram drivers are obviously smaller - the maximum is 5.3%.

The situation is only slightly different in the case of assessing passenger compliance with the social distances between passengers, not strictly applicable to public transport vehicles, but deeply entrenched in

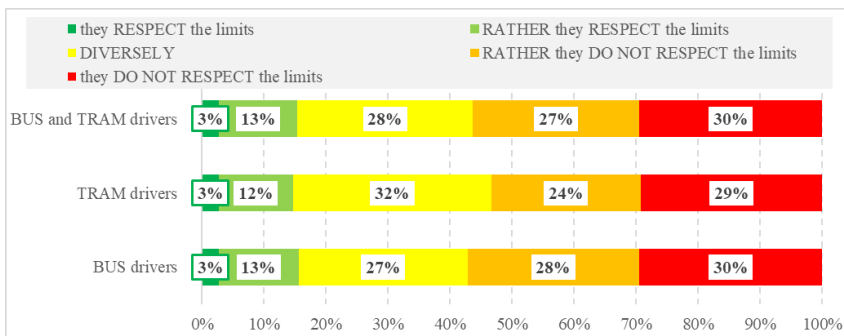


Fig. 1. Distribution of answers to the question about passengers' compliance with the limits of the number of people in buses and trams, in the opinion of public transport drivers in Krakow (own study)

Table 3. Errors of estimating the proportions of individual assessments of compliance with passenger limits in public transport vehicles and a statistical comparison of the proportions in groups of bus and tram drivers in Krakow (own study)

Answer	Shares of answers			Errors of estimation			Test for two means statistic
	BUS drivers	TRAM drivers	BUS & TRAM drivers	BUS drivers	TRAM drivers	BUS & TRAM drivers	
passengers RESPECT the limits	0.027	0.027	0.027	0.020	0.036	0.017	0.027
passengers RATHER RESPECT the limits	0.128	0.120	0.127	0.041	0.074	0.036	0.194
DIVERSELY	0.272	0.320	0.283	0.054	0.106	0.048	0.795
passengers RATHER DO NOT RESPECT the limits	0.276	0.240	0.268	0.055	0.097	0.048	0.632
passengers DO NOT RESPECT the limits	0.296	0.293	0.295	0.056	0.103	0.049	0.040
AGGREGATED SHARES							
they RESPECT and RATHER RESPECT	0.156	0.147	0.154	0.044	0.080	0.039	0.191
they DO NOT RESPECT and RATHER DO NOT RESPECT	0.572	0.533	0.563	0.060	0.113	0.053	0.592

According to nearly half of the drivers (49%), passengers very rarely (21%) or rarely (28%) respect the social distance in public transport vehicles, and another 34% of respondents admit, that this is diversely (Fig. 2).

These results are to some extent consistent with the results obtained for the assessment of compliance with the limits in vehicles, but also in this case it was checked whether the type of vehicle driven influences the perception of passenger behavior (Table 4). In this case, the differences between the indications of bus and tram drivers are greater - it is even

8.6 pp. (for answer: "rarely"), but from a statistical point of view, these differences are still not significant. For all responses, including the aggregate positive ("very often" and "often") and negative ("rarely", "very rarely") answers, there is no reason to conclude that the proportions of individual responses indicated by bus and tram drivers differ significantly - at the significance level of 0.01. Also, the size of errors in estimating the proportions of individual indications are very similar to those obtained in the case of assessing compliance with the limits of people in public transport vehicles.

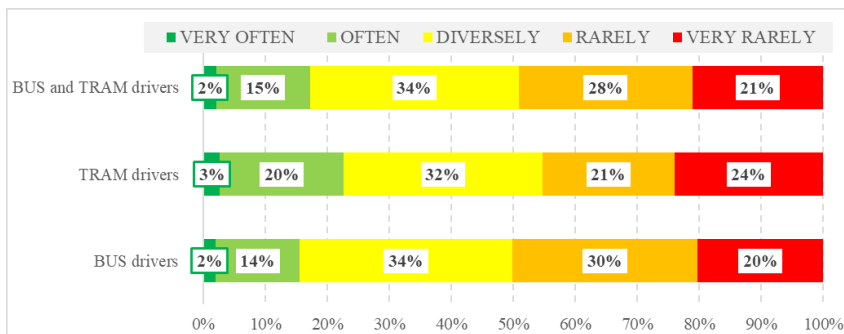


Fig. 2. Assessment of the abundance frequency of social distances between passengers in buses and trams, in the opinion of public transport vehicles drivers in Krakow

Table 4. Errors in estimating the proportions of individual assessments of compliance with social distances between passengers in public transport vehicles and a statistical comparison of proportions in groups of bus and tram drivers in Krakow (own study)

Answer	Shares of answers			Errors			Test for two means statistic
	BUS drivers	TRAM drivers	BUS & TRAM drivers	BUS drivers	TRAM drivers	BUS & TRAM drivers	
“VERY OFTEN”	0.019	0.027	0.021	0.017	0.036	0.015	0.367
“OFTEN”	0.136	0.200	0.151	0.042	0.091	0.038	1.306
“DIVERSELY”	0.342	0.320	0.337	0.058	0.106	0.051	0.363
“RARELY”	0.300	0.213	0.280	0.056	0.093	0.048	1.510
“VERY RARELY”	0.202	0.240	0.211	0.049	0.097	0.044	0.692
AGGREGATED SHARES							
“VERY OFTEN” and “OFTEN”	0.156	0.227	0.172	0.044	0.095	0.041	1.382
“RARELY” and “VERY RARELY”	0.502	0.453	0.491	0.061	0.113	0.054	0.742

It was also decided to check whether the respondents' assessments regarding compliance with vehicle limits and maintaining the social distance between passengers in public transport vehicles may be affected by a change in the frequency of performing official duties (as public transport drivers). In both cases, the analysis was made by comparing the aggregated proportions of positive and negative responses and neutral opinions ("diversely") - for the changing number of respondents, who declared a change in the frequency of performing their official duties.

The changes were taken into account in increments of 10%, as indicated by the drivers (of buses and

trams - in total). The individual proportions were being compared, starting with the number of drivers declaring a reduction in official duties during the Covid-19 pandemic, less than 80% (group of 94% drivers). Therefore, this group includes drivers declaring an increase in the frequency of performing duties, drivers declaring maintaining the current frequency of performing duties and drivers declaring reducing the frequency of their performance by a maximum of 80%). Then, drivers declaring a reduction by 70%, 60%, and so on – were successively subtracted, until only drivers declaring an increase in official duties by more than 10% remained (Fig. 3 and Fig. 4).

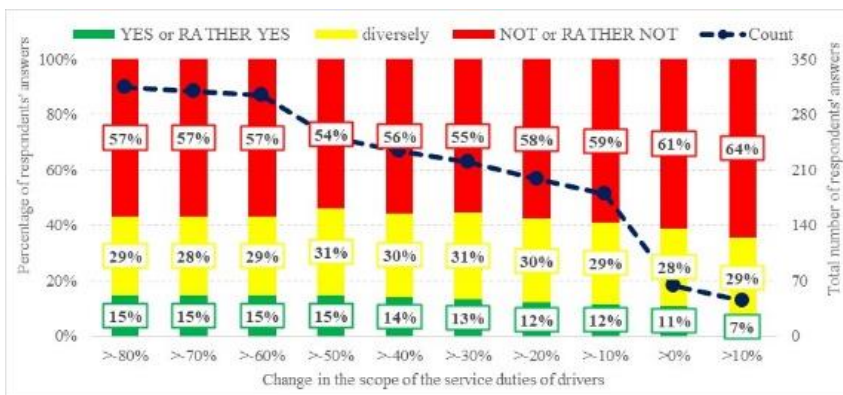


Fig. 3. Dependence of the proportion of respondents' responses on changes in the frequency of performing official duties (taking into account the changing number of respondents) - for the assessment of passengers' compliance with the limits of the number of people in buses and trams, in the opinion of drivers of public transport vehicles in Krakow (own study)

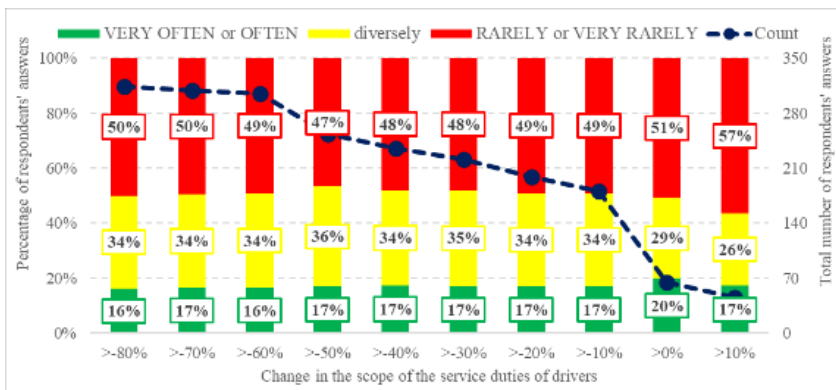


Fig. 4. Dependence of the proportion of respondents' responses on changes in the frequency of performing official duties (taking into account the changing number of respondents) - for the assessment of passengers' compliance with the social distance in buses and trams - in the opinion of drivers of public transport vehicles in Krakow (own study)

Individual proportions changed by a maximum of 3 pp., until the group of respondents who assessed that the frequency of their professional duties did not change during the Covid-19 pandemic. However, it is difficult to talk about the impact of the frequency of performing duties, because the values of proportions were much more influenced by low numbers of drivers - in both analyzed cases (limits of persons and social distance in vehicles) below 70 respondents. Therefore, it can be found that the change in the frequency of performance of official duties by bus and tram drivers (jointly) did not affect the assessment of passenger behavior in public transport vehicles, in terms of compliance with the limits of persons and social distance. Finally, it was decided that despite the lack of statistically significant differences in the indications of

bus and tram drivers - in the further analysis, the division into the indications of the representatives of these two groups will be maintained. On the other hand, in the further analysis, consideration of the changes in the duties of public transport drivers were abandoned.

5.2. Safety of passengers when alighting and boarding

Public transport vehicle drivers were also asked about the behavior of passengers while alighting and boarding the vehicle - by contrasting positive and negative behaviors. In the opinion of drivers, the dominance of the negative behaviors is clearly visible, regardless of the type of public transport vehicle (Fig. 5).

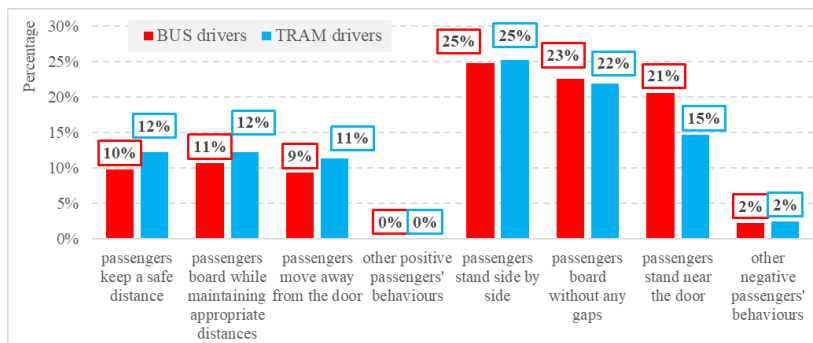


Fig. 5. Assessment of positive and negative passengers' behaviors when alighting and boarding, in the opinion of drivers of public transport vehicles in Krakow (own study)

Only 31% of drivers of public transport vehicles rated the behavior of passengers when alighting and boarding as positive (30% of bus drivers and 36% of tram drivers). It is difficult to assess this result unambiguously - during the passenger exchange, closer contact between passengers seems inevitable, despite the applicable limits and social distance.

Among passengers' negative behaviors, drivers most often indicated too close contact between alighting passengers and also persons waiting at the stop platform for possibility boarding (25% of all indications). Slightly less, because 23% of the answers concerned too small gaps between following alighting (as well as boarding) passengers. However, attention should also be paid to the behavior that was not indicated most often, but quite often (by 21% of bus drivers and 15% of tram drivers), which is standing in the door or very near the door of the vehicle. This is a problem generally observed not only during the Covid-19 pandemic, but especially during this time - particularly troublesome as it concerns the bottlenecks of every public transport vehicle, where the risk of close contact is the highest.

So it turns out, that even if passengers respect the limits of persons and try to keep social distance in vehicles, they are particularly exposed to close contact with other people and possible contamination when alighting and boarding. Therefore, at least educational activities in this area should be considered. A possible change in the organization of alighting and boarding through a separate door of the vehicle - due to the expected extension of the dwell time - is possible only on public transport lines of lesser importance.

5.3. Purchase of tickets in public transport vehicles

Drivers also assessed the frequency of passengers' attempts to make purchases in ticket machines in vehicles and directly from vehicle drivers, during Covid-19 pandemic. The first of the above-mentioned options was allowed throughout the entire period covered by the research - but the purchase required additional physical contact with the vehicle's components. The second way to buy tickets has been completely forbidden, among others by introducing driver safety zones.

According to 70% of drivers (Fig. 6), passengers often or even very often bought tickets in ticket machines in public transport vehicles, thus resigning from safer forms of purchase, like using internet applications. It should be noted that, according to the drivers, bus passengers used this form of ticket purchase much more often, although in trams the access to ticket machines is theoretically easier (many trams have two ticket machines).

However, the answers of the drivers to the question about the frequency of attempts to purchase tickets directly from the drivers, despite the introduced security zones, were completely surprising. Despite the clear marking of the zones, and even the physical barriers - according to as many as 9% of drivers, such attempts took place often or even very often, and another 8% declared that it happened diversely, and thus indirectly indicating that these were not rare cases (Fig. 7).

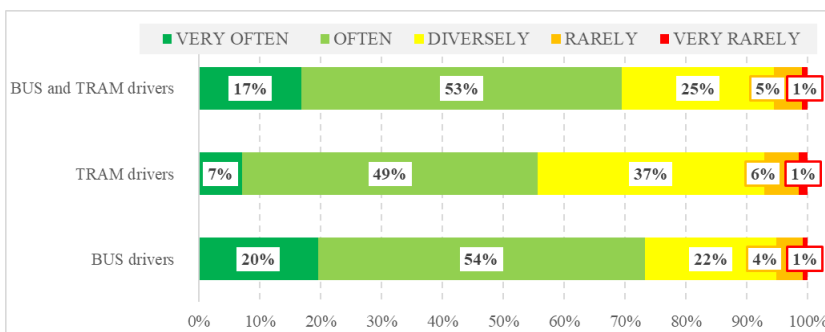


Fig. 6. The frequency of purchasing tickets from ticket machines, in the opinion of drivers of public transport vehicles in Krakow (own study)

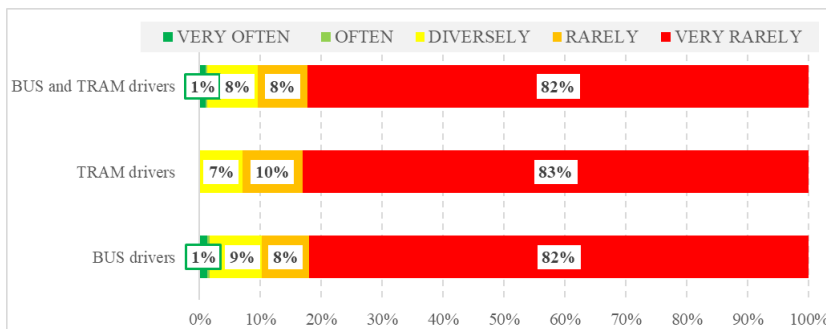


Fig. 7. The frequency of attempts to purchase tickets directly from, in the opinion of drivers of public transport vehicles in Krakow (own study)

The answers to the above questions indicate that it is worth intensifying efforts to popularize the purchase of tickets via internet applications, which will reduce the frequency of contacts with frequently touched vehicle elements. Of course, under normal circumstances, the best solution is to increase the popularity of season (monthly, yearly) tickets, but during a pandemic or similar incidents, when the number of daily trips is much smaller, it is difficult to expect greater interest in such kind of tickets.

5.4. Sense of personal safety for drivers of public transport vehicles

The personal safety of drivers of public transport vehicles was mentioned when discussed question about the frequency of attempts to purchase tickets directly from the drivers (despite the lack of such a

possibility). However, two other questions were devoted to this issue, aimed at determining the sense of safety of drivers during daily work on the public transport lines, during the Covid-19 pandemic.

The respondents were asked, whether the passengers respect the security zone (not only in connection with the attempt to buy a ticket from the driver). The answer is quite unambiguous, as many as 98% of respondents considered that the safety zone is respected (Figure 8), of which 72% of drivers had no doubts about it. At the same time, no significant differences were observed between the indications of bus and tram drivers (max. 2 pp. difference for individual answer options).

The obtained results mean that the introduction of a driver's safety zone has brought the expected effect. Passengers were permanently separated from drivers, which favors both groups.

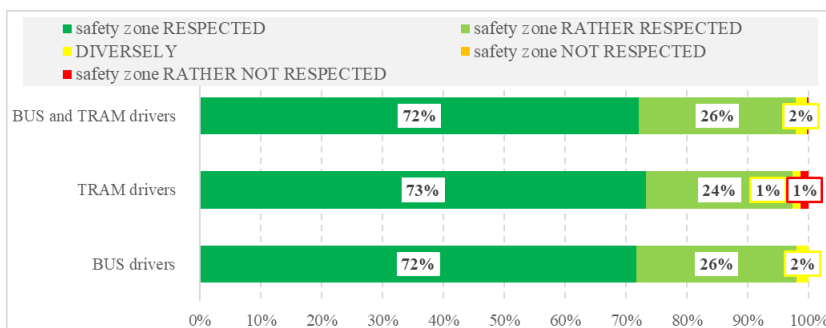


Fig. 8. Abidance of the driver's safety zone in the vehicle by passengers, in the opinion of drivers of public transport vehicles in Krakow (own study)

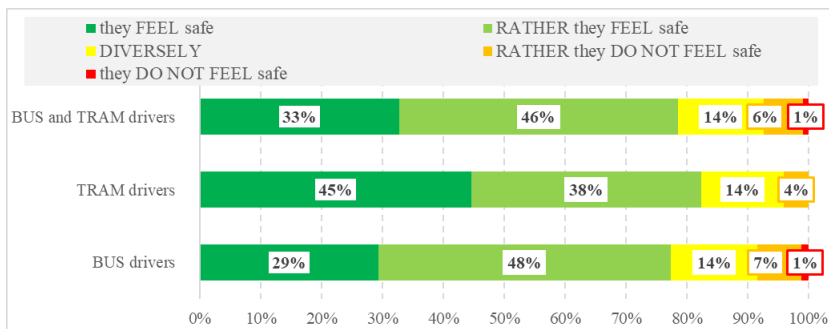


Fig. 9. A sense of personal safety while driving, in the opinion of drivers of public transport vehicles in Krakow (own study)

One of the most important questions in the survey was one related to the sense of personal safety of bus and tram drivers while driving public transport vehicles, during the Covid-19 pandemic. In general, after introducing safety zones and applying mentioned restrictions for passengers (limits of people in public transport vehicles, social distance) - drivers feel generally safe. 33% of drivers feel safe, or rather safe - another 46% of the respondents. Thus, 79% of drivers do not encounter major problems with personal safety while driving, during Covid-19 pandemic. It is also worth noting the relatively large differences between the indications of bus and tram drivers (Table 5) – bus drivers feel more exposed, a smaller

number clearly define their work as safe, during Covid-19 pandemic, which will be shown in the next section. The significance of the differences in this case was also confirmed by the result of the previously discussed significance test for two proportions (at the significance level of 0.01).

These differences are to a large extent due to the way the driver's cabin is separated from the passenger compartment in buses and trams - the tram driver's cabin is tight, and the additional introduction of a driver's safety zone makes it in practice completely inaccessible to passengers. Bus drivers dream of the same protection, not only in time of pandemic.

Table 5. Errors in estimating the proportions of individual assessments of personal safety of drivers and a statistical comparison of proportions in groups of bus and tram drivers in Krakow (own study).

Answer	Shares of answers			Errors			Test for two means statistic
	BUS drivers	TRAM drivers	BUS & TRAM drivers	BUS drivers	TRAM drivers	BUS & TRAM drivers	
drivers FEEL safe	0.294	0.446	0.328	0.056	0.113	0.051	2.398
drivers RATHER FEEL safe	0.480	0.378	0.457	0.062	0.111	0.054	1.558
DIVERSELY	0.143	0.135	0.141	0.043	0.078	0.038	0.169
drivers RATHER DO NOT FEEL safe	0.071	0.041	0.064	0.032	0.045	0.027	1.026
drivers DO NOT FEEL safe	0.012	0.000	0.009	0.013	0.000	0.010	1.654
AGGREGATED SHARES							
drivers FEEL safe and RATHER FEEL safe	0.774	0.824	0.785	0.052	0.087	0.045	0.955
drivers RATHER DO NOT FEEL and DO NOT FEEL safe	0.083	0.041	0.074	0.034	0.045	0.028	1.363

Research findings show that much has been done to prevent drivers from becoming infected with Covid-19. Sensual safety is very important to drivers. In the difficult time of the pandemic, they perform an important service function – among others – they enable travel of employees needed on the front lines of fighting the virus: medics and services responsible for the safety of citizens. That is why it is so important that the safety of drivers is ensured even before they start transporting people.

5.5. Drivers' proposals for further measures to increase the safety of passengers and drivers themselves in public transport vehicles

The respondents were also asked to indicate what other measures to improve the safety of passengers (and drivers themselves) could be implemented. These were actually two separate questions about passenger safety and the safety of the drivers themselves. However, drivers very often noticed, that there was no need for such a separation of answers. And although there was a slightly greater care for one's own safety, the responses were aimed at universal solutions.

Only 10% of bus drivers and only 11% of tram drivers (Fig. 10) considered that the measures taken so far to increase personal safety in public transport vehicles are sufficient. First of all, the drivers proposed to increase the number of journeys on public transport lines (35% of indications of bus drivers and 45% of indications of tram drivers). And although it can be considered that it is also a concern for own

employment, it is related to the concern to ensure the frequency of running, so that - despite the introduced limits of people in vehicles - it would be possible to transport all those, who want or need to use public transport. Of course, drivers did not consider the economic efficiency of such a solution here.

Drivers also indicated the need for the obligatory use of protective face masks (28% of indications by bus drivers and 45% of indications by tram drivers), instead of the rather loosely described obligation to cover the mouth and nose in any way - which is very often simply ineffective. It seems that the regulations should be clarified in this respect.

One can also notice the desire of bus drivers to ensure a more complete separation of the driver's cabin from the passenger compartment - which has already been discussed. On the other hand, one of the proposals to choose from, which is to launch more on demand services (in Krakow: Tele-Bus service), enjoyed relatively little interest - only 3% of all drivers chose this option.

6. Conclusions

Drivers are an extremely important element of the entire great public transport machinery. And although they will not replace the more and more advanced measurement infrastructure consisting of a system of internal and external monitoring cameras and passenger counting systems - thanks to their experience, they have the ability to diagnose a wide variety of problems, that they encounter in their daily work.

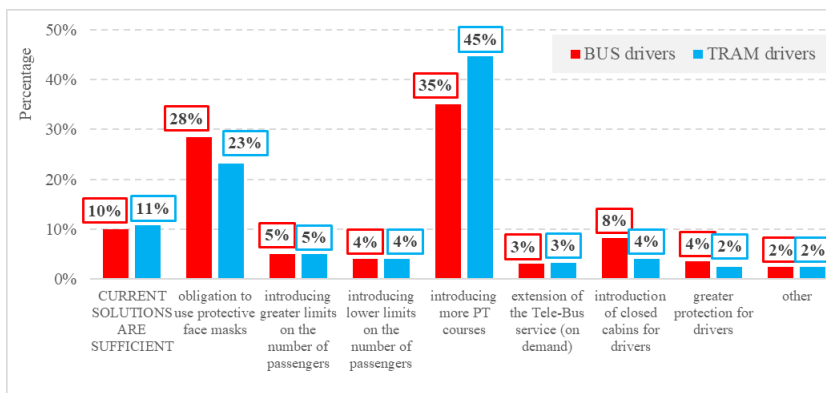


Fig. 10. Proposals for further solutions to improve personal safety in vehicles, in the opinion of drivers of public transport vehicles in Krakow (own study)

Therefore, it was decided to use the observation of MPK drivers in Krakow in order to conduct passengers' behavior in public transport vehicles during the first phase of Covid-19 pandemic. The drivers indicated a relatively low level of passenger compliance with the introduced restrictions on the use of public transport, in terms of the number of passengers in vehicles and keeping distance, especially when alighting and boarding.

There is an urgent need to develop mechanisms of responsible behavior of passengers in public transport vehicles in terms of maintaining social distance and effective (not sham) covering of the mouth and nose - from education to control of compliance with the applicable rules – in the next phases of pandemic. Fortunately, some such measures are now being implemented.

The sense of personal safety in the group of drivers themselves is high - and is necessary to ensure the continuity of public transport in all conditions, not only in pandemic conditions. Possible further actions in this regard should at least maintain this state. The issue of a fuller separation of the driver's cabin in buses is also worth considering.

The obtained research results can be used to supplement the range of solutions applied to increase the personal safety of passengers and drivers of public transport vehicles during a pandemic and in case of different incidents, during which it will be reasonable to regulate the rules of using the public transport vehicles.

Acknowledgement

The article has been presented on 13th International BRD GAMBIT 2020 Conference and is co-funded by the Science Excellence programme of the Ministry of Science and Higher Education

References

- [1] Baldwin, R. & Weder di Mauro, B. (2020). *Economics in the Time of COVID-19*. London: CEPR Press.
- [2] Budd, L. & Ison, S. (2020). Responsible Transport: A post-COVID agenda for transport policy and practice. *Transportation Research Interdisciplinary Perspectives*, 6, 100151.
- [3] Coccolini, F. et al. (2020). Surgery in COVID-19 patients: operational directives. *World Journal of Emergency Surgery*, 15, 1-7.
- [4] De Vos, J. (2020). The effect of COVID-19 and subsequent social distancing on travel behavior. *Transportation Research Interdisciplinary Perspectives*, 5, 100121.
- [5] Dong, H., Ma, S., Jia, N. & Tian, J. (2021). Understanding public transport satisfaction in post COVID-19 pandemic. *Transport Policy*, 101, 81-88.
- [6] Fotios, P. & Makridakis, S. (2020). Forecasting the novel coronavirus COVID-19. *PLoS ONE* 15(3), e0231236.
- [7] Giancarlo, P., Taniguchi, A. & Takami, K. (2020). Travel behavior changes during the COVID-19 pandemic in Japan: Analyzing the effects of risk perception and social influence on going-out self-restriction. *Transportation Research Interdisciplinary Perspectives*, 7, 100181.
- [8] Ibarra-Rojas, O.J., Delgado, F., Giesen, R. & Muñoz, J.C. (2015). Planning, operation, and control of bus transport systems: A literature review. *Transportation Research Part B: Methodological*, 77, 38-75.
- [9] Kangqi, Ng, et al. (2020). COVID-19 and the risk to health care workers: a case report. *Annals of internal medicine*, 172(11), 766-767.
- [10] Kolawole Ojo, T. (2019). Quality of public transport service: an integrative review and research agenda. *Transportation Letters The International Journal of Transportation Research*, 11(2), 104-116.
- [11] Kraemer, M. et al. (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science*, 1;368(6490), 493-497.
- [12] Madha, A., Salman, A.D., Hussain, H.D., Borhan, N., Riza Atiq, O.K.R. (2016). Analysis of travel behaviour in Petaling Jaya, Malaysia: an application of the theory of planned behaviour. *Archives of Transport*, 38(2), 29-38.
- [13] Morita, H., Kato, H. & Hayashi, Y. (2020). International comparison of behavior changes with social distancing policies in response to COVID-19. *SSRN*, 3594035.
- [14] Nicola, M. et al. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International journal of surgery*, 78, 185–193.
- [15] Oum, T.H. & Wang, K. (2020). Socially optimal lockdown and travel restrictions for fighting communicable virus including

- COVID-19. *Transport Policy*, 96, 94–100.
- [16] Shen, X., Feng, S., Li, Z. et al. (2016). Analysis of bus passenger comfort perception based on passenger load factor and in-vehicle time. *SpringerPlus*, 5, 62.
- [17] Tirachini, A. (2020). COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs. *Journal of Public Transportation*, 22 (1) 1-21.
- [18] Van Bavel, J.J. et al. (2020). Using social and behavioural science to support COVID-19 pandemic response. *Nature Human Behaviour*, 4, 460–471.
- [19] Więcek, P., Kubek, D., Aleksandrowicz, J.H. & Strózek, A. (2019). Framework for Onboard Bus Comfort Level Predictions Using the Markov Chain Concept. *Symmetry*, 11(6), 755.
- [20] Zhang, J., Hayashi, Y., Lawrence, D. & Frank, L.D. (2021). COVID-19 and transport: Findings from a world-wide expert survey. *Transport Policy*, 103, 68-85.
- [21] <http://kmkrakow.pl/informacje-o-systemie-kmk/zasady-funkcjonowania-systemu.html> (access: February 26, 2021).
- [22] <https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/covid-19-latest-updates> (access: February 25, 2021).
- [23] <https://www.mpk.krakow.pl/pl/zakres-dzialania-mpk> (access: February 26, 2021).
- [24] <https://www.who.int/emergencies/diseases/novel-coronavirus-2019> (access: February 25, 2021).
- [25] <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports> (access: February 25, 2021).
- [26] Act of March 2, 2020 on special solutions related to the prevention, prevention and combating of COVID-19, other infectious diseases and emergencies caused by them. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 374 (In Polish).
- [27] Regulation of the Minister of Health of March 24, 2020 amending the regulation on declaring an epidemic in the territory of the Republic of Poland, *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 522 (In Polish).
- [28] Regulation of the Minister of Health of March 13, 2020 on the declaration of an epidemic threat in the territory of the Republic of Poland. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 433 (In Polish).
- [29] Regulation of the Minister Of Health of March 20, 2020 on the declaration of an epidemic in the territory of the Republic of Poland. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 491 (In Polish).
- [30] Regulation of the Council of Ministers of March 31, 2020 on the establishment of certain restrictions, orders and prohibitions in connection with an epidemic. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 566 (In Polish).
- [31] Regulation of the Council of Ministers of April 10, 2020 on the establishment of certain restrictions, orders and prohibitions in connection with an epidemic. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 658 (In Polish).
- [32] Regulation of the Council of Ministers of April 15, 2020 amending the regulation on the establishment of certain restrictions, orders and prohibitions in relation to the outbreak of an epidemic. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 673 (In Polish).
- [33] Regulation of the Council of Ministers of May 16, 2020 on the establishment of certain restrictions, orders and prohibitions in connection with an epidemic. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 878 (In Polish).
- [34] Regulation of the Council of Ministers of May 29, 2020 on the establishment of certain restrictions, orders and prohibitions in connection with an epidemic. *Dziennik Ustaw Rzeczypospolitej Polskiej*, No. 964 (In Polish).