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Draft of Public Rail Passenger Transport During the COVID-19 Pandemic

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Abstract: During the COVID-19 pandemic, the railway sector experienced a significant worldwide decrease in the number of passengers due to the reduced transportation capacity of trains introduced for limiting social contacts and passengers fears from the disease. The reduction in population mobility resulting from national anti-pandemic measures led to the fact that carriers in the Slovak Republic began to optimize and limit the rail transport performance. Several measures were also implemented to reduce the risk of the spread of the COVID-19 disease so that passengers feel safe while traveling by train. Globally, we are entering the third year of coronavirus, and the pandemic is expected to continue even this year. For this reason, forecasting passenger demand for rail transport is becoming increasingly important and it is necessary to take measures in public passenger transport that will consider the reduced mobility due to the COVID-19 pandemic. The paper deals with the proposal of a methodology for planning transport services on selected regional railway lines during the COVID-19 pandemic.

Keywords: Regional trains, COVID-19 pandemic, demand, measures, passengers

1. Introduction

The Covid-19 pandemic and its rapid spread has had a major impact on rail transport due to the anti-pandemic measures adopted. As a result of these measures, several train connections were cancelled, which temporarily reduced capacity utilized. The decrease in population mobility was reflected in the passenger transport performance [1,2]. During the first wave of the pandemic, the number of passengers in rail passenger transport dropped significantly by almost 90 % [3,4]. Many new carriers were forced to stop operating their trains. In the second wave of the pandemic, more stringent measures were introduced to limit population mobility even more [5]. Even the third wave of the

pandemic did not increase railway passenger transport performance [6]. Planning transport services in the context of COVID-19 requires the implementation of targeted measures that should take into account the reduced demand, regional needs, the capacity of the railway infrastructure, requirements for the line intensity, optimization of the need to rotate trains, vehicles, and staff for their effective use, efficiency in supplying trains at peak times of the day, planned integrated transport system, construction of new transport hubs, etc. [7,8].

2. State of the Art

The impact of the Covid-19 pandemic on the activity of the railway sector has been addressed in research conducted by several authors. Interesting information can be found in [9], who describe the effects of the Covid-19 pandemic on the activity of the railway sector and assess the significant drop in demand for rail transport. The paper by [10] describe an interesting approach to assessing the impact of the pandemic on the railway market. The authors analysed and evaluated anti-pandemic measures divided into six groups and developed an evaluation architecture within the framework of efficiency, acceptability, and privacy. The output is a tool for further prevention and control of the effects of epidemics in railway transport. [11]. Based on the research, conclusions are drawn for potential future health emergencies. In this regard, a new resilient paradigm of population mobility must be implemented that would meet the specified environmental requirements.

3. Current State of Regional Rail Passenger Transport in the Slovak Republic

The potential of rail passenger transport in Slovakia is not being fully utilized [12]. Its travel offer is often insufficient, even in the directions of important transport flows and on routes with favourable parameters for ensuring passenger rail transport. This results in a low level of rail passenger transport use in Slovakia [13]. This situation is exacerbated by the retreat of regional pressure to ensure rail passenger transport even on routes where it is not justified according to the current number of passengers carried [14].

On most of the occupied regional lines, the railway does not have the prerequisites to be a supporting system of regional transport without the necessary investments and coordinated cooperation of carriers [15]. Here, trains usually carry a minimum number of passengers and do not offer services on natural transport sections [16,17]. The accessibility of railway stations here is usually disadvantageous and significantly worse compared to bus transport. In several cases, the travel speed of regional trains is also lower than the speed of parallel bus transport. This means that trains are not sufficiently competitive for the needs of regular commuting [18].

Irregular intervals are typical for some regional lines, especially on single-track lines, which causes inefficient use of vehicles and personnel and increasing costs. On regional lines, it can also be

considered uneconomical to operate trains before 4 a.m. (in the direction from the catchment area before 5 a.m.) with arrivals at the catchment area before 5 a.m., unless they provide a connection to long-distance trains, and overloading long-distance trains after 23 p.m. and before 5 a.m. (except for night trains and other specific cases). A high percentage of trains run only at working days´ peak times due to concentrated mobility to some centres, which means a significantly higher need for vehicles and staff at peak time. Therefore, some trainsets are usually in service only in the morning and afternoon rush hours, which means they are not used efficiently most of the time [4,15].

The Ministry of Transport of the Slovak Republic performed an analysis of the perspective of regional and suburban train lines based on several criteria. This research was carried out for a standard working day. For further calculations, it is assumed that the transport performance on non-working days is be at the level of approximately 75 % of the standard working day performance for standard lines (i.e., lines not used mostly for tourist transport) [15]. The research confirmed the perspective of the line Košice – Lipany.

3.1 Development of Transport Performance in Railway Passenger Transport

A comparison of passenger rail transport performance before and during the pandemic shows that 46,657 thousand passengers were transported in 2020, while in 2019, the number of passengers transported was 30,700 thousand lower. This implies that the year-on-year decrease was 39.69 % [19]. In domestic transport, the year-on-year decrease was 27,432 thousand, which accounts for -37.84 %. In commercial trains, the year-on-year decrease was 587 thousand passengers, which accounts for -71.76%. The year-on-year decrease in international transport was 3,338 thousand passengers (-25.27 %).

When comparing the year 2021, when the pandemic was still spreading, with 2020, it can be seen that 45,672 thousand passengers were carried in 2021, while in2020, it was 984 thousand more. This shows that the year-on-year decrease was 2.11 % [20]. In domestic transport, the year-on-year decrease amounted to 1,548 thousand, i.e., a 3.44% decrease. In commercial trains, the year-on-year decrease was 151 thousand passengers (-66.45 %). On the other hand, international transport reached an increase of 562 thousand passengers, which accounts for 35.50 %. -Customer buying behaviour have also changed due to the adopted anti-pandemic measures, as travelling by train was used in the most urgent cases and for short distances, as inter-district movement was prohibited. The transport performance expressed in passenger-kilometres (pkm) was 2,117,957 thousand pkm in 2020. In 2019, it was 1,885,774 thousand passenger-kilometres more. The year-on-year decrease thus accounted for -47.10% [19].

The transport performance in train kilometres in 2020 was 32,455 thousand, including replacement bus service. The comparison of this value with the year 2019 shows a decrease in

transport performance by 2,048 thousand train kilometres, which accounts for -5.94 %. In 2021, the total volume of transport performance in the railway passenger transport in the Slovak Republic was 1,966,146 thousand passenger-kilometres. In 2020, the total volume of transport performance was 151,811 thousand passenger-kilometres more, which means that the year-on-year decrease was -7.17 % [19,20]. Table 1 shows the development of transport performance before and during the pandemic [18].

Table 1 Overview of transport performance of ZSSK. Source: authors, according to [19,20]

Total rail passenger transport	Transport performance (billion passenger kilometres)	Passengers (billion passengers)	Transport performance (billion train kilometres)
2011	2,431.72	45.959	31.331
2012	2,413.49	43.445	30.559
2013	2,421.95	44.287	30.438
2014	2,503.13	47.286	30.791
2015	3,081.25	57.275	31.856
2016	3,193.72	65.606	31.477
2017	3,759.92	72.473	32.641
2018	3,815.15	73.808	33.649
2019	4,003.73	77.357	34.503
2020	2,117.96	46.657	32.455
2021	1,966.15	45.670	34.070

In 2021, transport performance in train kilometres reached a total of 34,070 thousand train kilometres. When comparing this value with the year 2020, it can be seen that transport performance has increased by 1,614 thousand train kilometres, which accounts for a 4.97% increase.

The pandemic has had a major impact on supply, demand, and economic performance in the rail sector, particularly from April to the end of June 2020. During this period, rail passenger transport was affected more than freight transport. International railway transport experienced a decrease by approximately 85 % from April to the end of June (with international transport stopped completely); the decline in domestic railway transport was approximately 18 % (limited services) [19,20].

3.2 Characteristics of the Track Košice – Lipany

The goal of the paper is to propose a transport service plan on the Košice - Lipany track section with regard to objective criteria. The route Košice – Prešov – Lipany is characterized as prospective in REG or REX mode. The analysed route section Košice - Lipany is a part of track no. 188 Košice – Plaveč – Muszyna. Track no. 188 is electrified with a DC voltage of 3,000 volts on the entire section. The tracks are of normal gauge. The track section Košice - Lipany is 65 kilometres long. The minimum interval that can be achieved on the track is 30 minutes [20].

For a correct proposal, it is important to know the territory of interest. This includes characterizing the territory in terms of the number of inhabitants, demography, and determining

significant settlements. According to the analysis performed within the diploma thesis entitled Impacts of the implementation of IDS in the East Slovak region on railway passenger transport on the route Košice – Prešov – Plaveč [19], the number of inhabitants in the subject areas is growing slightly, but in 2019, a slight decrease was recorded due to the COVID-19 pandemic. In terms of age structure, the largest group of residents (more than 56 %) are aged 25-64, followed by the group 65+ (17.5 %) and 0-14 (14 %). Age groups 15-19 and 20-24 (usually high school and university students) represent approximately 6 % each. From the point of view of the analysis of important catchment areas, according to the results of the diploma thesis, it can be concluded that most schools are located in the city of Košice. This city is thus marked as the most important catchment area and the place of the greatest demand for the transport services. The conclusion of the analysis of the territory is that the cities of Košice and Prešov - regional centres - can be considered the most important settlements from this point of view, followed by Sabinov, Lipany, and Velky Šariš [19,20].

4. Impact of Pandemic Measures on Railway Transport in the Slovak Republic

Transport performance in railway passenger transport was significantly reduced due to the COVID-19 pandemic. The operation of trains was restricted to the Saturday mode and several other measures were introduced [21]. Figure 1 shows the development of transport performance in domestic rail passenger transport in Slovakia in the period before and during the pandemic [22,23].

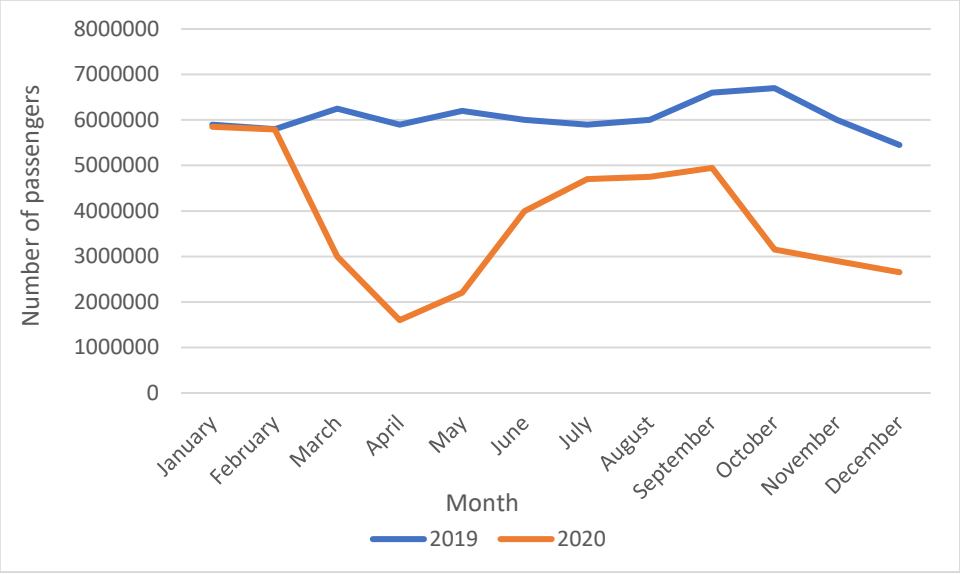


Fig. 1 Development of carried passengers in domestic rail passenger transport. Source: [22,23]

To monitor the development of the Covid-19 epidemic, Covid automat was developed and introduced in Slovakia. Anti-pandemic measures are taken based on the pandemic situation in a certain observed period, which are introduced depending on the intensity of the spread of this disease. Covid automat is a monitoring and alert system, whose task is to provide early warning in the case of

the rapid spread of the disease. This system is set up in such a way that, based on the early warning, the public health authority can take the necessary preventive measures and thus prevent the spread of Covid-19 in advance [24]. Table 2 shows the 7-degree and 5-degree system of Covid automat.

Table 2 COVID automat. Source: authors, according to [24]

COVID automat 7 degree				COVID automat 5 degree			
Colour	**Risk**	**Description**	**Level of risk**	**Colour**	**Risk**	**Description**	**Level of risk**
Green	Monitoring	Unlimited	0				
Yellow	1st level of vigilance	Home-Office Recommended	1	**Green**	Monitoring	Unlimited	0
Orange	2nd level of vigilance	Home-Office Recommended	1				
Pink	1st level of waring	Home-Office Recommended	1	**Orange**	Vigilance	OTP mode	1
Red	2nd level of waring	Home-Office Highly Recommended	2	**Red**	1st level of waring	OTP mode	1
Burgundy	3rd level of waring	Home-Office Ordered if possible	3	**Burgundy**	2nd level of waring	Unlimited	0
Black	4th level of waring	Home-Office Ordered if possible	3	**Black**	3rd level of waring	Unlimited	0

Covid automat consists of different levels or degrees defined by colour and level of risk. The more the level of risk increases, the stricter anti-pandemic measures are implemented. The colour shows the risk of infection, while the numbers refer to the level of the risk. The higher the risk of infection (for example in each region), the greater the probability of infection. The numbers are assigned to individual risks and provide a clear picture of the impact of a given risk on the given measure [24].

5. Results and Discussion

The presented proposal of transport service is based on the objective criteria analysed in the previous chapters of this article. At the same time, this proposal is intended to determine how many PSOtrains should run on the line under consideration, starting point, destination, schedule, and what the transit will be at each point. The proposal may also serve as a basis for ordering services of public interest in railway transport under the competence of the Ministry of Transport of the Slovak Republic [25].

The railway line Košice - Prešov – Lipany is one of the most used railway lines in the Slovak Republic from the point of view the number of passengers carried. Until the outbreak of the COVID-19 pandemic, the number of passengers transported daily increased every year, especially since 2014, when free transport for selected groups of passengers (pupils, students, pensioners, etc.) was introduced. The available data shows that 2019 is the strongest year in terms of the number of transported passengers on the Košice – Prešov – Lipany line, with an average number of passengers being more than 10,000 a day. The COVID-19 pandemic, which broke out in Europe at the beginning of 2020, caused ca. 40% decrease in the number of transported passengers compared to 2019. This

decrease is probably due to both government pandemic measures and the reduction of railway services (Table 3) [15].

Table 3 Comparison of transport performance on the line under study before and during the pandemic. Source: authors, according to [15-20]

Normal condition					Pandemic condition				
Type of train	Average operational performance in train-kilometres		Average vehicle capacity in seating places	Average transport performance in seat-kilometres per day	Type of train	Average operational performance in train-kilometres		Average vehicle capacity in seating places	Average transport performance in seat-kilometres per day
	per day	per year				per day	per year		
REX	2,032	741,580	294	597,408	**REX**	1,828	667,220	307	561,196
REG	859	313,500	247	212,149	**REG**	660	240,900	247	163,020
REX + REG	2,891	1,055,080	273	809,557	**REX + REG**	2,488	908,120	286	724,216

According to the transport service plan published by the Ministry of Transport of the Slovak Republic (Table 4), the operation of passenger railway transport on the line Košice - Prešov - Lipany will undergo transformation, while the planned changes should help to increase the offer of railway transport services due to the high demand for transport in thegiven region [26-28].

Table 4 Ministry plan. Source: [14]

		Normal conditions									
REX	**Košice**	4:17	5:17	6:17	7:17	8:17	9:17	10:17	11:17	12:17	13:17
	↓	4:47	5:47	6:47	7:47	8:47	9:47	10:47	11:47	12:47	13:47
	↓	14:17	15:17	16:17	17:17	18:17	19:17	20:17	21:17	22:17	
	Prešov	14:47	15:47	16:47	17:47	18:47	19:47	20:47	21:47	22:47	
	Prešov	4:49	5:49	6:49	7:49	8:49		10:49		12:49	13:49
	↓	5:27	6:27	7:27	8:27	9:27		11:27		13:27	14:27
	↓	14:49	15:49	16:49	17:49	18:49		20:49		22:49	
	Lipany	15:27	16:27	17:27	18:27	19:27		21:27		23:27	
	Lipany	4:33	5:33	6:33	7:33	8:33		10:33		12:33	13:33
	↓	5:11	6:11	7:11	8:11	9:11		11:11		13:11	14:11
	↓	14:33	15:33	16:33	17:33	18:33		20:33		22:33	
	Prešov	15:11	16:11	17:11	18:11	19:11		21:11		23:11	
	Prešov	5:13	6:13	7:13	8:13	9:13	10:13	11:13	12:13	13:13	14:13
	↓	5:43	6:43	7:43	8:43	9:43	10:43	11:43	12:43	13:43	14:43
	↓	15:13	16:13	17:13	18:13	19:13	20:13	21:13	22:13	23:13	
	Košice	15:43	16:43	17:43	18:43	19:43	20:43	21:43	22:43	23:43	
REG	**Košice**	5:01	6:01	7:01	8:01	9:01		11:01		13:01	14:01
	↓	5:40	6:40	7:40	8:40	9:40		11:40		13:40	14:40
	↓	15:01	16:01	17:01	18:01	19:01		21:01	23:01		
	Prešov	15:40	16:40	17:40	18:40	19:40		21:40	23:40		
	Prešov	4:20	5:20	6:20	7:20	8:20		10:20		12:20	13:20
	↓	4:58	5:58	6:58	7:58	8:58		10:58		12:58	13:58
	↓	14:20	15:20	16:20	17:20	18:20		20:20	22:20		
	Košice	14:58	15:58	16:58	17:58	18:58		20:58	22:58		

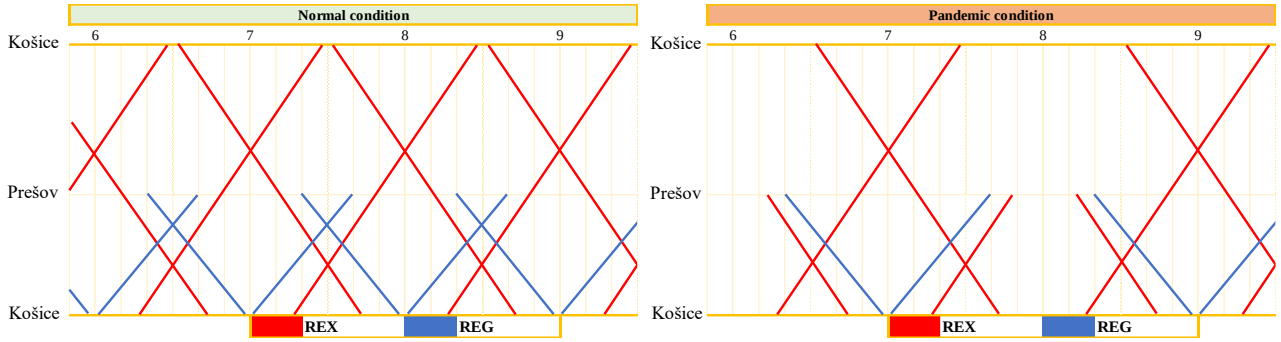
The most significant change, apart from the increase in the number of connections offered, will be the introduction of two different train lines. One line will be the REX regional express train (REX), which will be operated as a fast regional train in the route (Humenné) - Košice - Lipany and the other line will be the classic regional train operated as a classic commuter train in the route (Michaľany) - Košice - Prešov. Table 5 shows the draft schedule of passenger railway trains provided by the REX and REG lines in pandemic conditions.

Table 5 Draft timetable. Source: authors

		Pandemic conditions								
REX	**Košice**	4:17	6:17	7:17	8:17	9:17	10:17	11:17	12:17	13:17
	↓	4:47	6:47	7:47	8:47	9:47	10:47	11:47	12:47	13:47
	↓	14:17	15:17	16:17	17:17	18:17	19:17	20:17	21:17	22:17
	Prešov	14:47	15:47	16:47	17:47	18:47	19:47	20:47	21:47	22:47
	Prešov	4:49	6:49		8:49		10:49		12:49	
	↓	5:27	7:27		9:27		11:27		13:27	
	↓	14:49		16:49		18:49		20:49		22:49
	Lipany	15:27		17:27		19:27		21:27		23:27
	Lipany	4:33		6:33		8:33		10:33		12:33
	↓	5:11		7:11		9:11		11:11		13:11
	↓		14:33		16:33		18:33		20:33	22:33
	Prešov		15:11		17:11		19:11		21:11	23:11
	Prešov	5:13	6:13	7:13	8:13	9:13	10:13	11:13	12:13	13:13
	↓	5:43	6:43	7:43	8:43	9:43	10:43	11:43	12:43	13:43
	↓	14:13	15:13	16:13	17:13	18:13	19:13	20:13	21:13	23:13
	Košice	14:43	15:43	16:43	17:43	18:43	19:43	20:43	21:43	23:43
REG	**Košice**	5:01	7:01		9:01		11:01		13:01	
	↓	5:40	7:40		9:40		11:40		13:40	
	↓	15:01		17:01		19:01				23:01
	Prešov	15:40		17:40		19:40				23:40
	Prešov	4:20	6:20		8:20		10:20		12:20	
	↓	4:58	6:58		8:58		10:58		12:58	
	↓	14:20		16:20		18:20				22:20
	Košice	14:58		16:58		18:58				22:58

According to the service plan published by the Ministry of Transport, train service on the REX line will be operated by combining Electric Multiple Units (EMU) 661 and the trainsets 1XX+4B, which will reach an average capacity of 294 seats per one train. The REG line will be operated by EMU 661 with a capacity of 247 seats per one train [14]. According to available research a greater living area between passengers could reduce the risk of the spread of contagious diseases. Therefore, during a pandemic, it is advisable to increase the capacity of vehicles, thus ensuring a lower load of railway vehicles. This was taken into account in designing the transport service on the line Košice – Prešov – Lipany during the pandemic. As the capacity of EMU cannot be simply increased, a passenger carriage B will be added in the trainset on the REG line, which will increase the average capacity of trains and reduce its load. In the text below, fragments of the integrated train traffic diagrams are processed based on the proposed timetables in the route section Košice – Prešov – Lipany. The first fragment represents the planned train traffic diagram valid during the normal state (proposed by the Ministry); the second fragment represents the proposed train traffic diagram with

reduced transport services, which could ensure transportation during a pandemic (which is the goal of the paper). The REX line is marked in red and the REG line in blue.. These colour divisions are applied for both alternatives (Fig. 2a – normal conditions and Fig. 2b – pandemic conditions).



a) b)

Fig. 2 Train traffic diagram of the a) normal conditions and b) pandemic conditions. Source: authors

Based on the analysis of the timetables proposed by the Ministry of Transport of the Slovak Republic on the line Košice – Prešov – Lipany, the planned average operational performance per day (in train kilometres) and the total operational performance per year of operation were determined. The analysed performance is summarized in the table for individual lines and for both together. In addition, the table shows the average train capacity in seats and the total transport performance in seat-kilometres. The values are in the upper table entitled Normal condition (Fig. 2a). The performance values for the proposed (reduced) pandemic timetable are in the lower table titled Pandemic condition (Fig. 2b) [15-20].

The total planned year performance on the line in question during normal state of operation is 1,055,080 train-kilometres per year, the majority of which is on the REX line. The transport performance is 295,759,020 seat-kilometres per year, with an average vehicle capacity of 273 seats (Table 6).

Table 6 Comparison of average operatioal performance. Source: authors, according to [19,20]

Normal conditions				
Type of train	Average operational performance in train kilometres		Average vehicle capacity by seats	Average transport performance in seat kilometres per day
	per day	per year		
REX	2,032	741,580	294	218,024,520
REG	859	313,500	247	77,434,500
REX+REG	2,891	1,055,080	273	295,459,020
Pandemic conditions				
Type of train	Average operational performance in train kilometres		Average vehicle capacity in seating places	Average transport performance in seat kilometres per day
	per day	per year		
REX	1,828	667,220	307	204,836,540
REG	660	340,900	247	59,502,300
REX+REG	2,488 ↓	908,120 ↓	286 ↑	264,338,840 ↓

The second part of the table shows the values of the reduced train traffic diagram, with the annual and daily operatinal performance reduced to ca. 21 %, i.e., 908,102 train-kilometres per year. However, due to the addition of 1 carriage to the trainsets on the REX line, the average train capacity will increase. The total transport capacity will be only 11 % lower compared to the transport capacity during the normal condition, and the risk of disease transmission will be also reduced (Table 6).

6. Conclusion

The article deals with the analysis of the impact of the COVID-19 pandemic and the introduced measures in the form of Covid automat on passenger transport in the conditions of the Slovak Republic. The analyses carried out show a significant decrease in passenger transport, which also caused a decrease in the revenues of carriers resulting from insufficient utilization of train connections. Therefore, it is necessary to propose an adequate rail service for the area applicable in the times of pandemic and the measures to be taken for this purpose. As an example, in this article the line Košice - Lipany is chosen.

The proposed pandemic timetable on the given line will ensure sufficient transport service during the validity of the measures and at the same time enables reducing railway transport performance and the associated costs and the required staffing.

The presented proposal of the transport service is also intended to reduce the risk of the spread of COVID-19 during travel thanks to higher capacity of trains, and to increase the competitiveness of rail transport during the pandemic.

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