



# Implementation of COVID-19 measures in railway operation in the Slovak Republic

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## Abstract

Rail transport has a crucial role to play not only in the EU's strategy for a sustainable transport sector, but also in terms of economic and social cohesion. It contributes significantly to the mix of transport modes in the EU, while providing clean mobility and a high degree of efficiency. Following the outbreak of the COVID-19 pandemic, the volume of passenger and freight rail transport has fallen sharply due to constraints and lower demand for transport. Several players in the rail market had to close down. Rail operators had to face a sharp decline in transport services. In 2020, the demand for passenger transport was significantly lower than in the previous year. Thus, railway undertakings were not able to pay the charges for access to the railway infrastructure during the emergency caused by the COVID-19 pandemic. Infrastructure managers had the opportunity to temporarily reduce, waive or defer these charges. The negative economic consequences of the COVID-19 pandemic could reduce or significantly endanger their financial viability for market stakeholders. Reducing charges for access to railway infrastructure is just one of the few measures that will help railway undertakings to function better. The paper focuses on the analysis of the impact of the pandemic and the implemented measures on the passenger rail sector in the Slovak Republic and on the development of rail passenger and freight transport during the pandemic. It summarizes the proposed measures against the spread of the COVID-19 pandemic in rail transport in Slovakia.

## Keywords

Measures in railway transport, pandemic COVID-19, railway transport market, railway transport

## 1 Introduction

Since the beginning of 2020, the COVID-19 pandemic had a major impact on rail transport in the EU. The slowdown in the spread of the COVID-19 pandemic has been achieved by reducing the mobility of the population. Travel within the country and abroad and the transfer of a large proportion of the population to work were limited (Poltimäe et al., 2022). The reduction in mobility has an impact on passenger transport performance. The number of national rail passengers fell by as much as 90% during the first wave of the pandemic compared to the previous year. Several operators, especially new carriers, had to close down, while rail freight operators reported a dramatic drop in volumes as many sectors slowed or even stopped production as a result of the pandemic

On 7 October 2020, the European Parliament and the Council adopted Regulation (EU) 2020/1429 laying down measures for a sustainable rail market in view of the occurrence of COVID-19. The aim of the Regulation was to enable rail stakeholders to better manage the financial implications of the COVID-19 pandemic and to respond to their urgent liquidity needs by reducing, waiving or deferring charges for the minimum access package and for access to infrastructure connecting service facilities. These support measures covered fees payable throughout the reference period provided from 1 March 2020



to 31 December 2020. The scope of application has been limited to this timeframe to ensure that the measures are applied only for as long as necessary (European Union, 2020).

The second wave of the autumn 2020 pandemic has forced many countries to take further restrictive measures regarding population mobility. The outbreak of the third wave of the pandemic prevented a rapid recovery in rail transport, especially for passenger rail services (Gkiotsalitis and Cats, 2021). In October and November 2020, Member States introduced new mobility restrictions, which they only partially and gradually lifted in 2021. The number of passengers has not yet returned to pre-pandemic levels, and the time to return to pre-pandemic levels may be longer than expected, especially in the case of commercial passenger transport (Huang et al., 2020). The impact of the pandemic on the transport sector, therefore, remains significant. The arrival of a new extremely contagious variant of COVID-19, omicron in the autumn of 2021 with still unknown properties compared to previous variants raised concerns about the fourth wave of the pandemic and more stringent measures to prevent the spread of the disease (Mogaji et al., 2022). In an effort to help the railway sector cope with the ongoing pandemic, the EU extended the possibility for Member States to reduce, waive or defer railway infrastructure charges until 30 June 2022. The measure was first introduced in October 2020, and the aim is to reduce the financial burden on railway undertakings during the COVID-19 pandemic (Tirachini and Cats, 2020).

The aim of the proposed research is to analyze measures for limiting mobility during a pandemic and their impact on transport from the point of view of a sustainable transport system, based on the cooperation of researchers from the field of sectoral and cross-sectional economics and the field of transport. Subsequently, innovative approaches to ensure the usability of public transport in time of pandemic measures, which will contribute to the safety of passengers and maintain the attractiveness of transport connections with a focus on rail transport as a main transport system, are explored.

## **2 Impacts of the pandemic COVID-19 on the railway sector**

The effects of the measures introduced during the COVID-19 pandemic, which are related to transport, were addressed in his research by Zhang et al. (2021). These authors developed a case study focused on the development of COVID-19 transport policy in six developed countries. They describe the effectiveness of 418 policy measures based on the PASS approach (P: prepare — protect – provide; A: avoid – adapt; S: change – share; S: replace – stop) and examine it using 27 indicators. The authors reveal the dynamic relationships between policy-making, factors and consequences. The case study attempts to provide scientifically based evidence for proposing more effective COVID-19 policy measures in the transport sector. Meanwhile, Ding & Zhang (2021) developed a case study focusing on the dynamic relationships between temporary behavioral changes caused by the COVID-19 pandemic and subjective assessments of policy-making. They conducted a nationwide online survey in Japan to assess changes in population behavior during the COVID-19 pandemic. They reveal the effects of risk perception in the use of public transport during a pandemic.

Xin, et al (2021) evaluated the effects of COVID-19 on urban rail transport using the synthetic control method in their research. The authors try to estimate the impact of COVID-19 on the daily number of passengers in urban rail transport (URT) using the Synthetic Control Method (SCM). Six variables are selected as predictors, out of which four variables unaffected by the pandemic are employed. A total of 22 cities from Asia, Europe, and the US with varying timelines of the pandemic outbreak are examined in this study. The effect of COVID-19 on the URT ridership in 11 cities in Asia is investigated using the difference between their observed ridership reduction and the potential ridership generated by the other 11 cities. Two traditional methods (causal impact analysis and straightforward analysis) are employed to illustrate the usefulness of the SCM.

Many researchers and organizations have investigated and reported on the negative impacts of COVID-19 on various aspects of public transportation. Most notably, many cities around the globe have experienced major reductions in public transit demand as a result of the substantially reduced economic activities. Work at home and online business became the new norm after the outbreak of COVID-19, contributing to reductions in passenger demand in the range of 80% – 95% (Vickerman, 2021). Modal preferences by commuters were also impacted by the pandemic. For essential out-of-home activities, it was observed that commuters preferred the private car, cycling, and walking over public transit. On the supply-side, many transportation agencies have cut service levels to reduce costs and meet government restrictions on service hours (Wang and Noland, 2021). Such reductions have consequently contributed to further decline in public transit ridership.

It is thus obvious that the COVID-19 pandemic has adversely affected public transit ridership, both directly and indirectly. On the one hand, fewer people were commuting to work and school. Those who commuted were less likely to use public transit due to the perceived health risks while travelling (Tan and Ma, 2020). On the other hand, the restrictions enforced by governments and transit agencies have limited the public transport service levels, contributing to further decline



in transit ridership. The study by Marra et al. (2022) observes how the pandemic affected travel behaviour of public transport users, focusing on route choice and recurrent trips. They conducted a travel survey based on GPS tracking during the first pandemic wave. They analyse how the pandemic affected users, in terms of travel distance, mode share and location during the day. They specifically focus on recurrent trips, commuting and non-commuting, observing how mode and route changed between the two different periods.

The impact of the COVID-19 pandemic on rail transport in the EU was assessed by the Council of the Union in a report of 21 December 2021 (European Union, 2020). The performance occurred in the same way as in the Slovak Republic in April 2020, when performance in passenger transport decreased by 40.6%. The number of trains running on the network also declined, but by September, the segment of trains running in the public interest had recovered, reaching 2019 levels. The number of trains running on commercial lines did not recover until after the second wave broke out. The impact of the COVID-19 pandemic on rail passenger transport cannot be fully assessed as the pandemic situation still persists. What is certain, however, is that the negative economic impact on transport is significant. A decrease in the volume of performance of commercially motivated carriers and the associated financial problems may result in a reduction in the level of quality of services provided, due to lower competition between carriers.

The consequences of the first wave of the pandemic were exacerbated by the onset of the second wave in autumn 2020, when measures to reduce population mobility were reintroduced (European Union, 2020). Due to the exit ban in 2020 and reduced demand for train transport, the Railway Company of Slovakia (ZSSK) on 7 March, on the basis of instructions from the Ministry of Transport and Construction of the Slovak Republic, began to optimize the supply of train traffic from the first changes to the train schedule. Of the 34.4 million train kilometers planned for 2021; 917,000 train kilometers were lost. Traffic in the vicinity of Bratislava was temporarily limited, where even after the reduction, the hourly train cycle remained in the area of suburban transport, which was concentrated in the rush hour at a thirty-minute interval between trains. This meant a sufficient and high-quality transport offer due to reduced demand. Railway transport (8 trains) was permanently stopped on the Bánovce nad Ondavou – Veľké Kapušany line section due to long-term public disinterest. The reduction in the scope of transport services is the result of an agreement between the ZSSK and the Ministry of Transport and Construction of the Slovak Republic. The aim was to optimize train supply and public transport expenditure so that the impact of the reduction on the public was minimal due to reduced demand (Mašek et al., 2018; Dedík et al., 2019; Šipuš and Abramović, 2017).

In connection with the declaration of an emergency situation in the Slovak Republic, international train traffic with all neighboring states was temporarily stopped, and the operation of IC trains was also suspended. The operation of all customer centers, and of ticket office of selected points of sale was also interrupted, the sale of national reservations was temporarily suspended, and the ordering of restaurant, sleeping car and coachette and car carrier wagons was also limited. These measures negatively affected the management of the ZSSK, and the consequences of the COVID-19 pandemic were also felt in 2021 and later (Lupták and Pecman, 2021).

## **2.1 Development of transport performance in railway passenger transport in the Slovak Republic**

As a regulatory body, the Transport Authority monitors competition on the railway market in the territory of the Slovak Republic. Monitoring the development of the railway market is an important tool for obtaining up-to-date information on individual segments of the railway market and analyzing it (Daniš et al., 2019). This analysis is focused on the comparison of performances in passenger transport, passenger kilometers, and revenues (Torok, 2017; Gaal et al., 2015). The data and information presented in this article are taken from the analyses and documents of the infrastructure manager and from the information available from railway undertakings at the end of 2020, focusing on the monitored indicators of the impact of the pandemic during 2020 (Slovak Republic, 2020).

The COVID-19 pandemic crisis had a major impact on the supply, demand and economic performance of rail transport. The largest impact was recorded in the second quarter of 2020, from April to June. Passenger transport was more affected than freight transport, with international transport falling by an average of 85% in the second quarter of 2020, domestic transport falling by 18%, while freight transport fell by 14% in the second quarter of 2020. The reduction in rail transport in the first months of the crisis was a direct consequence of the public authorities' response to the COVID-19 crisis (restrictions on passenger mobility) as well as the impact of the global economic slowdown, which generally led to a reduction in transport demand (Slovak Republic, 2020). The number of passenger trains within the public service operated in the network in the period from January to September 2021 is comparable to the number for the same period in 2019, while in 2020 it was by



7.8% compared to 2019 lower. However, the number of commercial passenger trains between January and September 2021 was still 21.5% lower than in the same period in 2019, which means that compared to the same period in 2020, when it was 23.3% lower compared to 2019, there has been no recovery. The number of freight trains operating on the network was still 2.5% lower than in the corresponding period in 2019. Similar trends can also be observed when expressing the volume of traffic in train kilometers. From January to September 2021, the volume of passenger transport within public services expressed in number of trains was 5.2% lower compared to the same period in 2019. In 2021, commercial passenger transport services expressed in number of trains remained lower by 25.6% than in the same in 2019, which is in line with the (low) level already reached in 2020 (Slovak Republic, 2020). The development of transport performance during this period is shown in Figure 1.

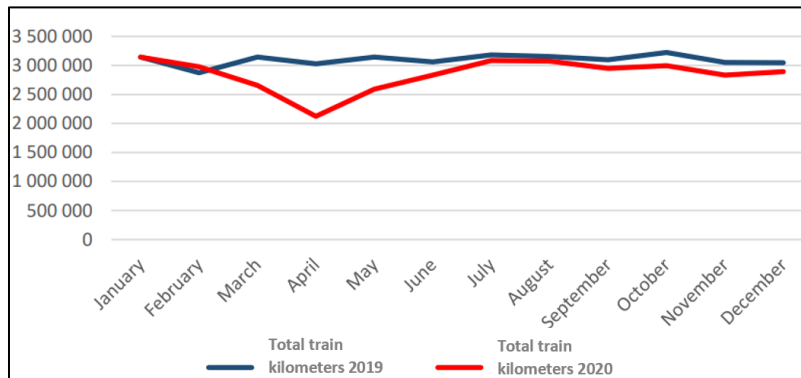


Figure 1. Comparison of total transport performance in passenger transport in the Slovak Republic in 2019 and 2020 (Slovak Republic, 2020).

In passenger transport, performances were significantly affected by the pandemic, which resulted from the restriction of passenger transport trains: it was introduced on 14 March 2020 by changing the schedule of public transport, the so-called Saturday timetable. The highest decrease in output was recorded in April 2020. Output (train kilometers) in the given month decreased by 37.60% compared to 2019. The most significant decrease in train was recorded in international transport due to restrictions, even disruption, of international rail transport. Figure 2 shows the change in total transport performance in rail passenger transport.

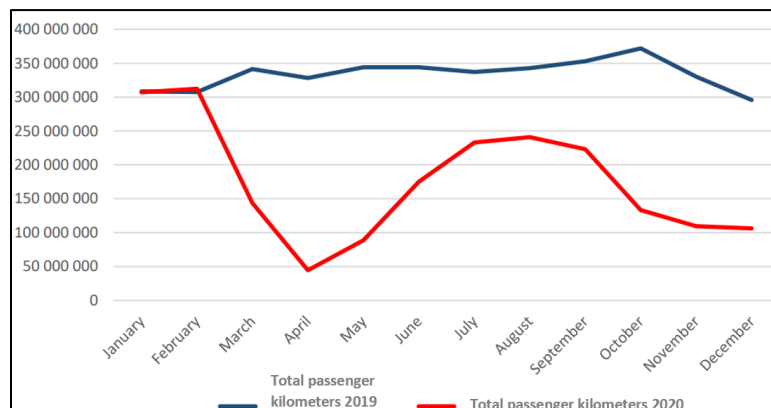


Figure 2. Comparison of transport performance in passenger transport in 2019 and 2020 (Slovak Republic, 2020).

Performance in passenger-kilometers in rail transport also shows that the most significant decrease was recorded in April 2020. The loss of performance measured in passenger kilometers is a direct consequence of a significant reduction in the number of passengers in passenger transport in the period considered. Overall, passenger transport performance in 2020 in the above indicator decreased by as much as 47.10% compared to the previous year 2019. The development of the number of passengers carried in domestic transport is shown in Figure 3.

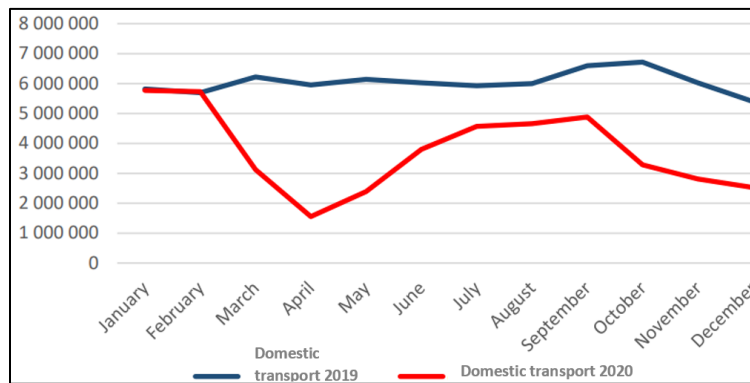


Figure 3. Development of number of passengers carried in domestic rail passenger transport in the Slovak Republic. (Slovak Republic, 2020)

During the first wave of the pandemic, passenger transport saw significant declines in the number of passengers transported in national and international transport. The number of transported persons in domestic transport decreased by 60.90% compared to 2019 and in international transport by 67.32%. The negative value in April represents the return of the fare. The development of the number of transported persons in international transport is shown in Figure 4.

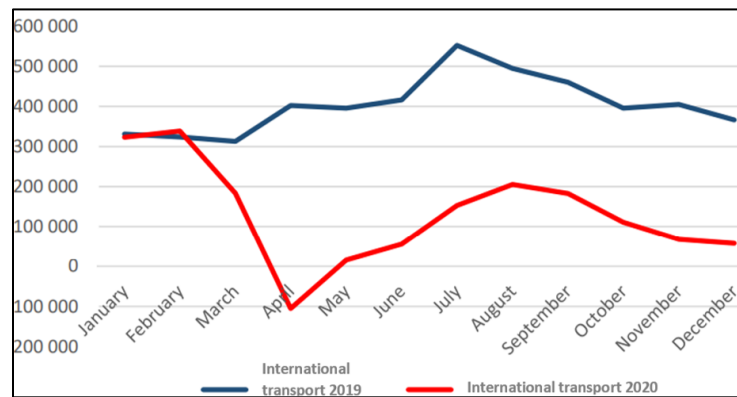


Figure 4. Development of number of passengers carried in international transport. (Slovak Republic, 2020)

The COVID-19 pandemic affected the management of the ZSSK in 2021. In January and February 2021, compared to 2020 (January and February 2020 were not yet marked by a pandemic), it transported 7.9 million passengers less (-65.24%), which corresponds to a shortfall in revenues from passenger transport in the amount of 9.2 million € (-71.24%). The shortfall in transport revenues in 2021 was at the level of 50% of the original plans, and expenditures rose for measures to eliminate the impact of coronavirus on the health of employees (ZSSK, 2020). Given the current situation in the economy and the continuing epidemiological situation, it can be assumed that its impact on the overall performance of rail transport will continue. The Transport Authority continuously monitors the individual indicators that will serve as the basis for further evaluation of the railway market and will prepare further reports on the impact of COVID-19 in the future (Slovak Republic, 2020).

### 2.2 Impacts of COVID-19 measures on a selected railway line in the Slovak Republic

The COVID-19 pandemic crisis had a major impact on the supply, demand and economic performance of rail transport. The largest impact was recorded in the second quarter of 2020, from April to June. Passenger transport was more affected than freight transport, with international transport falling by an average of 85% in the second quarter of 2020, domestic transport falling by 18%, while freight transport fell by 14% in the second quarter of 2020. The reduction in rail transport in the first months of the crisis was a direct consequence of the public authorities' response to the COVID-19 crisis (restrictions on passenger mobility) as well as the impact of the global economic slowdown, which generally led to a reduction in transport demand (Slovak Republic, 2020). The number of passenger trains within the public service operated in the network in the period from January to September 2021 is comparable to the number for the same period in 2019, while in 2020 it was by 7.8% compared to 2019 lower. However, the number of commercial passenger trains between January and September 2021



was still 21.5% lower than in the same period in 2019, which means that compared to the same period in 2020, when it was 23.3% lower in compared to 2019, there has been no recovery.

For the purposes of this article, the Bratislava–Košice railway line was chosen as an example. The largest year-on-year decline was recorded in April 2020 at -88.24% and in May (-76.63%). After these two critical months, transport performance began to rise again. Figure 5 shows the development of traffic performance on the Bratislava–Košice line in the years 2018–2020.

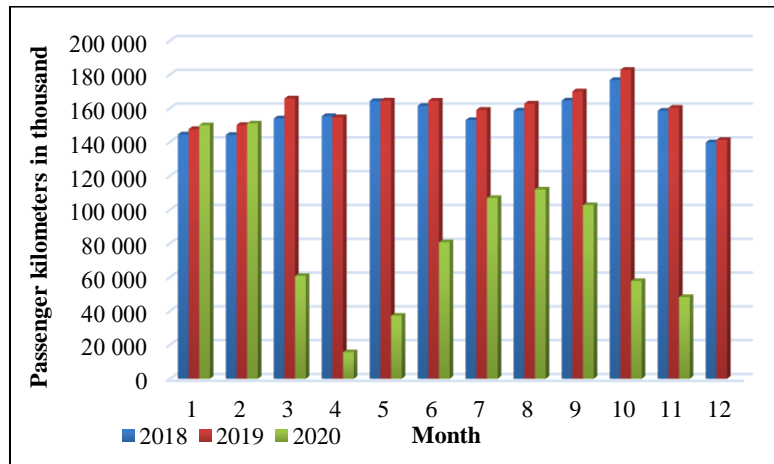


Figure 5. Development of transport performance on Bratislava–Košice line (Source: authors according to data from ZSSK)

In the Figure 5, we can observe transport performance on the Bratislava–Košice line in years 2018–2020. The data show the increasing popularity of long-distance rail transport during 2019 and the first months of 2020. Regular monthly services range between 140 million during less popular months up to 180 million during October 2019. Figure 6 shows year-on-year change in transport performance on the Bratislava–Košice line in 2020, compared to the corresponding data in 2019.

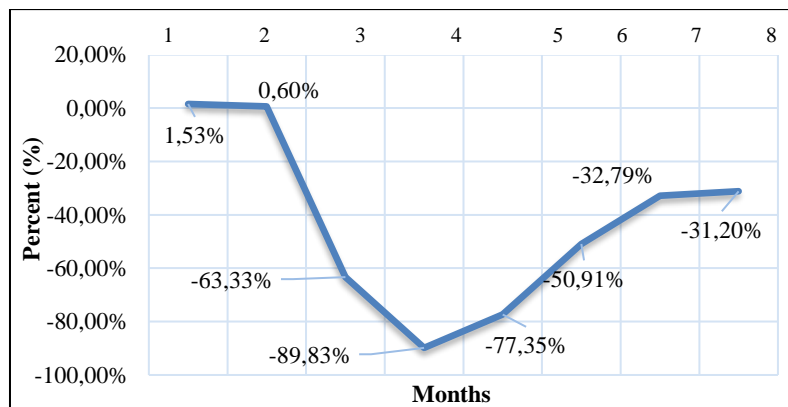


Figure 6. Year-on-year relative change in transport performance on the Bratislava–Košice line in 2020 (Source: authors according to data from Železničná spoločnosť Slovensko - ZSSK)

During the first months of 2020, the trend of steady growth in transport performance continued. With the arrival of the pandemic in March, we can again observe a two-thirds drop in performance, reaching an absolute bottom in April 2020. The renewed trend is the same as the return trend, but transport performance remained 33% to 31% lower during the summer months than in 2019, with passenger numbers only 25 to 22% lower. The reason for the lower performance may be the above-mentioned trend of longer trips during the summer, for example by students from Bratislava back to the east. As colleges remained closed during the first half of 2020, students traveling the entire length of the semester remained at home and transport performance was higher.

### 3 Identification of COVID-19 measures implemented in railway operation

The spread of the COVID-19 crisis seriously affected rail carriers due to a significant reduction in demand for rail transport services. Some carriers faced significant liquidity problems, large losses and, in extreme cases, the risk of



bankruptcy. As a result of these adverse changes, Regulation (EU) No 182/2011 of the European Parliament and of the Council 2020/1429 of 7 October 2020 was issued, laying down measures for a sustainable railway market with regard to the spread of COVID-19 (Haspra, 2021). All the measures below have been defined for national rail passenger services.

### 3.1 Measures of EU for a sustainable rail market

Regulation no. 2020/1429 addresses the issue that many railway businesses in the context of this emergency may not always be able to pay infrastructure access charges (or the cost of using the track). One of the tools to mitigate the negative economic impact on passenger or freight transport should be to allow these charges to be reduced, waived or deferred. According to Point 3 Article 31 of Directive 2012/34/EU of the European Parliament and of the Council, infrastructure access charges shall be set at the cost that is directly incurred as a result of operating the train service than the costs incurred in operating the rail service. However, in order to mitigate the impact of the COVID-19 crisis, Member States should be able to allow infrastructure managers to reduce, waive or defer such charges in a transparent, objective and non-discriminatory manner over a defined reference period (Kębłowski et al., 2022). In a similar way, the issue of surcharges should be addressed, and infrastructure managers should be able to assess the market segment's ability to bear this burden in times of crisis, or to reduce, waive or postpone these surcharges. Similarly, Article 36 of Directive 2012/34/EU provides for a capacity reservation fee scheme which is intended to provide an incentive for efficient capacity utilization. The spread of the pandemic in terms of restricting population movements caused serious disruption to rail transport, which in turn caused widespread disruption of train paths, leading to temporarily lower capacity utilization. Even in this case, infrastructure managers should have a relevant option not to collect these charges during the specified reference period (Haspra, 2021).

### 3.2 Measures of Slovak infrastructure manager ŽSR

The measures implemented by the infrastructure manager to slow down the spread of the COVID-19 virus, which have been analyzed since 2020, are arranged chronologically. For passengers, the measures are identical to those used in all ŽSR spheres of public life during the 2020 to 2021 pandemic, namely "cleaning and disinfection of railway station areas, in particular, the surfaces touched by people (door controls, handles, handrails, armrests, tables and the like). ŽSR regularly informs the public about the possibilities and ways of preventing the transmission of the disease during public transport. This education is carried out through information technology and leaflets in the station premises. For employees who come into close contact with passengers during their work, ŽSR will provide personal protective equipment and hand sanitizers (ŽSR, 2020).

ŽSR also plans to create premises for the shutdown of trains or their wagons for the needs of an unexpected shutdown. Employees coming into possible close contact with the traveling public on the platforms, for example dispatchers, shall be equipped to perform their activities with protective masks, protective gloves and hand disinfectants, the distribution of which to the affected workplaces is regularly carried out (ŽSR, 2020).

ŽSR tightened measures in the fight against the COVID-19 pandemic by suspending the sale of tickets by employees at 67 stations in the Slovak Republic. These are stations where the sale does not take place through the ZSSK, the sale has so far been mediated by ŽSR employees on the basis of contracts (ŽSR, 2020). Those interested in traveling by train from the above stations are still advised to purchase tickets electronically. The infrastructure manager has enabled the employees, who are allowed to do so by the nature of the activities performed, to work from home. Also in workplaces, where the conditions and nature of work allow it, the number of employees present was reduced as part of the change (ŽSR, 2020). Another change is characterized by a return to the timetable before the beginning of the pandemic situation, respectively by adjusting it to the current pandemic situation.

### 3.3 Measures of the railway carrier ZSSK

Based on the decision of the Government of the Slovak Republic, travel by long-distance trains (IC and express trains) was allowed until further notice, only in the "OTP" mode (vaccination – testing – overcoming). These are passengers with a complete vaccination, passengers with a valid test or those who have already had Covid. In all ZSSK train connections, passengers had to be protected by a mask, so it was mandatory to have a covered nose and mouth during the entire transport period according to measures (ZSSK, 2020).

ZSSK has also introduced a series of measures required of passengers, concerning masks, distance, hands (see Figure 7):

- Mask – covered mouth and nose;
- Distance – keep a distance of at least 2 meters from unknown people;
- Hands – frequent and thorough disinfection or hand washing.



Figure 7. Pictogram of valid measures for passengers in ZSSK trains at the time of the pandemic COVID-19. (ZSSK, 2020)

Since the beginning of the pandemic, the ZSSK has ensured, to the maximum extent possible, that trains meet the highest hygienic and safety standards. The individual measures taken in coordination with the public authorities and in accordance with the guidelines of the Chief Hygienist were a guarantee that train travel remained safe even in difficult times. With the introduction of new disinfection and increased hygiene measures in the vehicle areas, including air conditioning, as well as other key measures, passengers could travel by train comfortably, safely and responsibly (ZSSK, 2020).

Based on the statement of the Minister of the ZSSK and in accordance with the guidelines of the Chief Hygienist, measures were introduced in all passing trains (ZSSK, 2020):

- daily check of air conditioning functionality,
- 9-12 times per hour fresh air from outside,
- monthly filter change,
- disinfection at least once a day beyond routine cleaning,
- twice a week polymer disinfection with an effectiveness of 6-7 days,
- increased protection of personnel in operation.

At least once a day, surfaces were disinfected beyond the usual cleaning (in addition to toilets, these surfaces included handles, buttons, waste bins, etc.), twice a week the vehicles were disinfected with polymer with an efficiency of 6-7 days. The personnel also provided 9-12 times per hour air exchange for fresh thanks to air conditioning. At the same time, according to the technical possibilities of individual trains, some regular trains of the IC, Ex, R, RR and Os categories, which were expected to be of greater interest to the traveling public, were also strengthened. It was recommended to book tickets and seats well in advance. Their purchase was possible not only at the ZSSK cash registers, but also conveniently via the ZSSK e-shop or the *Ideme vlakom* mobile application, or as an SMS ticket. To achieve maximum safety, protective equipment for train staff was also provided (ZSSK, 2020).

The company has also introduced a series of temporary measures related to off-train services (ZSSK, 2020):

- closure of all customer centers,
- closure of the reservation center,
- closure of selected points of sale,
- stopping the transport of consignments marked COURIER,
- suspension of the admission of luggage to the depository,
- ban on sending and handing over found items on the train.

Passengers were allowed to reimburse the full amount of tickets and seats purchased after the introduction of these measures from March 2020. From December 2021 until the revocation of the ZSSK, traffic was limited by more than 350 trains. Restaurant wagons were not used on national trains during the pandemic period. Passengers had the opportunity to take To Go food or order it from their place via the *Najedzsavovlaku.sk* application (ZSSK, 2020).





#### 4 Proposal of systematic measures against the spread of COVID-19 in railway operations

The proposed measures against the spread of COVID-19 can also be regarded as operational-organizational measures. We methodically divided them into direct measures and indirect measures. These measures are characterized by not requiring high investments and they are not significantly demanding to implement. The proposed direct measures are shown in Figure 8.

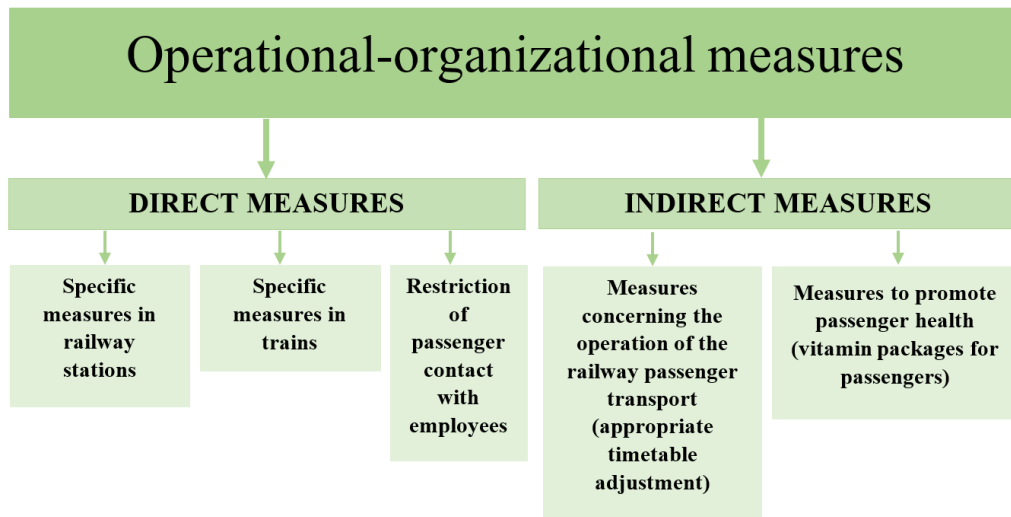


Figure 8 Proposal of Operation – organizational direct and indirect measures (Source: authors)

Direct measures can be divided into specific ones in railway stations, trains and the restriction of passenger contact with employees. Indirect measures included measures concerning the operation of the railway passenger transport and measures to promote passenger health.

##### 4.1 Special free vitamin packages for passengers

As several studies in the field of virology have shown, the regular use of the right vitamin composition has a significant effect on the body protection increasing against infections, including SARS 2-Covid-19. Taking vitamins significantly alleviates disease, relieves certain difficulties and accelerates recovery. Thus the company planned to offer passengers free packages, including:

- Vitamin C 250 mg,
- Vitamin D3 2000iu – 30 tablets,
- Selenium, Zinc Forte – 30 tablets,
- 200 ml hand sanitizer,
- disposable mask (10 pcs/FFP2 type respirators 5 pcs).

These packages will be provided to passengers upon fulfillment of at least one of the following conditions, but not more than once a month:

- after traveling 300 km,
- for daily commuting by train to any distance (in the range of at least 15 calendar days per month).

##### 4.2 Modification and disinfection of common areas in wagons and stations

The interior of the vehicle must ensure the health safety of the vehicle. This means influencing the bacterial, viral and fungal microflora to make the environment as safe to humans as possible. Bacteria and viruses enter the air through the breathing, talking, but especially coughing and sneezing of passengers. Bacteria and viruses may also attach to the wall surface:

- if they can find a source of nutrients there,
- they may multiply there if the material does not affect them adversely,
- may be directly destroyed by the material from which the vehicle is constructed.



In order to ensure health safety, the third mentioned option is optimal, the surfaces of the means of transport must be adapted to be able to directly destroy bacteria and viruses. Other effective measures must also be provided that can eradicate these microorganisms quickly and effectively.

#### **4.3 Restriction passengers' contact with employees**

It is strongly recommended to apply measures to passenger transport processes that limit passenger contact with carriers' employees. It is primarily a matter of limiting this contact both at railway stations and on trains.

##### **Measures at railway stations**

These measures consist of limiting passengers' contact with cashiers at personal cash registers, which should be kept to a minimum in this case. This will motivate passengers to buy tickets online (via the internet or via a mobile application), which will also be more advantageous for users, as they will not have to wait in lines at the cash desks at train stations, but they can comfortably arrive at the station just before the train leaves.

Another measure could be the introduction of turnstiles in the interior of railway stations, underpasses or platforms. These turnstiles would be located in reserved places and each passenger would have to go through them and would only be released after reading a valid travel document. In the case of the introduction of turnstiles, regular checks of travel documents by train drivers would not have to be carried out on trains, a random check by inspectors would be sufficient. It would also be appropriate to consider the installation of special devices that would be able to measure the body temperature of passengers before boarding the train, or identify other symptoms of COVID-19 or the possible degree of infectivity of the passenger to their surroundings. These operations could also be carried out at railway stations in the area before entering the underpasses or platforms, or before entering the station building by means of a special device (something similar to walk-through metal detectors at airports). Each passenger would pass through such a device, and this device would immediately measure his body temperature, or other indicators of his health and, based on the results, he would then be admitted to the platform and onto the train. An alternative solution could be to install a sanitizer dispenser with body temperature measuring facilities.

##### **Measures in trains**

Contact with the train staff should be limited for passengers, which will also be due to the lack of train drivers in the ZSSK. The control of travel documents may take place on the train in such a way that an automatic QR code reader of travel documents will be placed in each wagon above each seat, while the passenger will scan his travel document before taking a specific seat. After the travel document has been scanned, a green light will illuminate above the place. If a valid travel document is scanned but in the wrong place, the light will turn yellow, and if no travel document is scanned, the light will turn red. However, this progressive system can only be introduced in the case of trains with mandatory seat reservation. Subsequent checks will be carried out by an auditor or other authorized employee, and only in the case of such passengers, whose control indicator over their seat will not turn green. This measure could serve as an alternative to the introduction of turnstiles at stations.

#### **4.4 Introduction of mandatory seats and limitation of the capacity of individual train connections**

If certain measures are put in place to help reduce the mobility of citizens, and thus a reduction in passenger frequencies can be considered, it will also be possible to reduce the capacity of individual trains. This measure could also only be implemented if mandatory train seats are introduced. This measure can be applied especially in long-distance transport, as in regional transport it is significantly more complicated. However, capacity constraints could also take into account the groups in which the passengers travel (whether the passenger is alone, a couple, or a family or a larger group). Based on this, compartments could be reserved for families or groups of people. The implementation of most of the above proposed measures will have a major impact on employment in the rail passenger transport sector. As a significant reduction is considered, or absolute abolition of regular ticket inspectors and personal cashiers, it will be necessary for these people to find an alternative job. They could find application, for example, as special inspectors on trains, checking only those passengers who did not read their travel document correctly (their indicator light would not turn green), and they could also help to disinfect trains and stations and to check passengers when crossing the turnstile, or the body temperature measuring device. They could also work as operators who could assist in the electronic sale of travel documents and also in organizing the distribution of vitamin packages for passengers.



Another group of measures could concern construction and renovation processes (see Figure 9). These measures are technologically, temporally and financially more demanding.

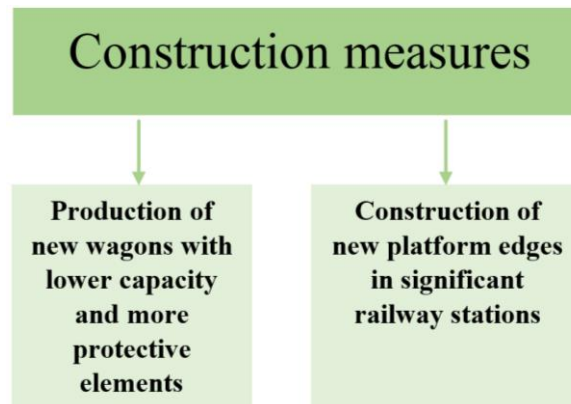


Figure 9 Proposal of construction and reconstruction measures (Source: authors)

The proposal of construction and reconstruction measurements contains production of new wagons with lower capacity and more protective elements and reconstruction of new platform edges in significant railway stations.

## 5 Conclusion

During the first wave of the pandemic, rail transport in Slovakia suffered a significant drop in transport performance. With the declaration of the global pandemic and a state of emergency in the Slovak Republic in March 2020, an average drop in performance on all routes by 61% was observed. The sharp decline in output continued until April, when it stopped at an average of 87%, compared to the previous year. Before the pandemic, the positive trends in rail transport in the Slovak Republic had been evident for several years. The number of passengers grew every year before 2020, and it can be assumed that after the end of the pandemic, the growth trend will resume. Functioning railway connections within the Slovak Republic offer a suitable alternative to the individual automobile transport for transfer between regional cities. There is a presumption that with the resurgence of cars on the roads, potential passengers will find their way back to rail transport. The EU's efforts to reduce emissions through the financing of greener modes of transport provided by rail can also contribute to long-term positive developments. With the gradual reconstruction of lines from sources partially provided by the European Union, the competitiveness of train transport in Slovakia may increase.

The negative effects of the pandemic are more of a short-term threat to rail transport. Weakened passenger confidence in the sterility of trains and stations is unlikely to persist for more than half a year after the end of the pandemic. The transfer of passengers to the individual automobile transport, combined with the effort to avoid human contact, will no longer be an attractive option with a large number of cars returning to the roads and opening up the economy. Regular contact with people at work and leisure is overshadowed by the fear of contact with unknown passengers during the train journey. The biggest threat to the smooth development of railway transport in the Slovak Republic is the shortage of financial resources caused by more than an annual decrease in passengers. The national carrier ZSSK has an almost monopoly position on the railway transport market within the Slovak Republic. For this reason, the losses caused by the pandemic could be covered by a state subsidy. However, it is not clear whether the Slovak government will be prepared to spend sufficient funds to cover the losses incurred.

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