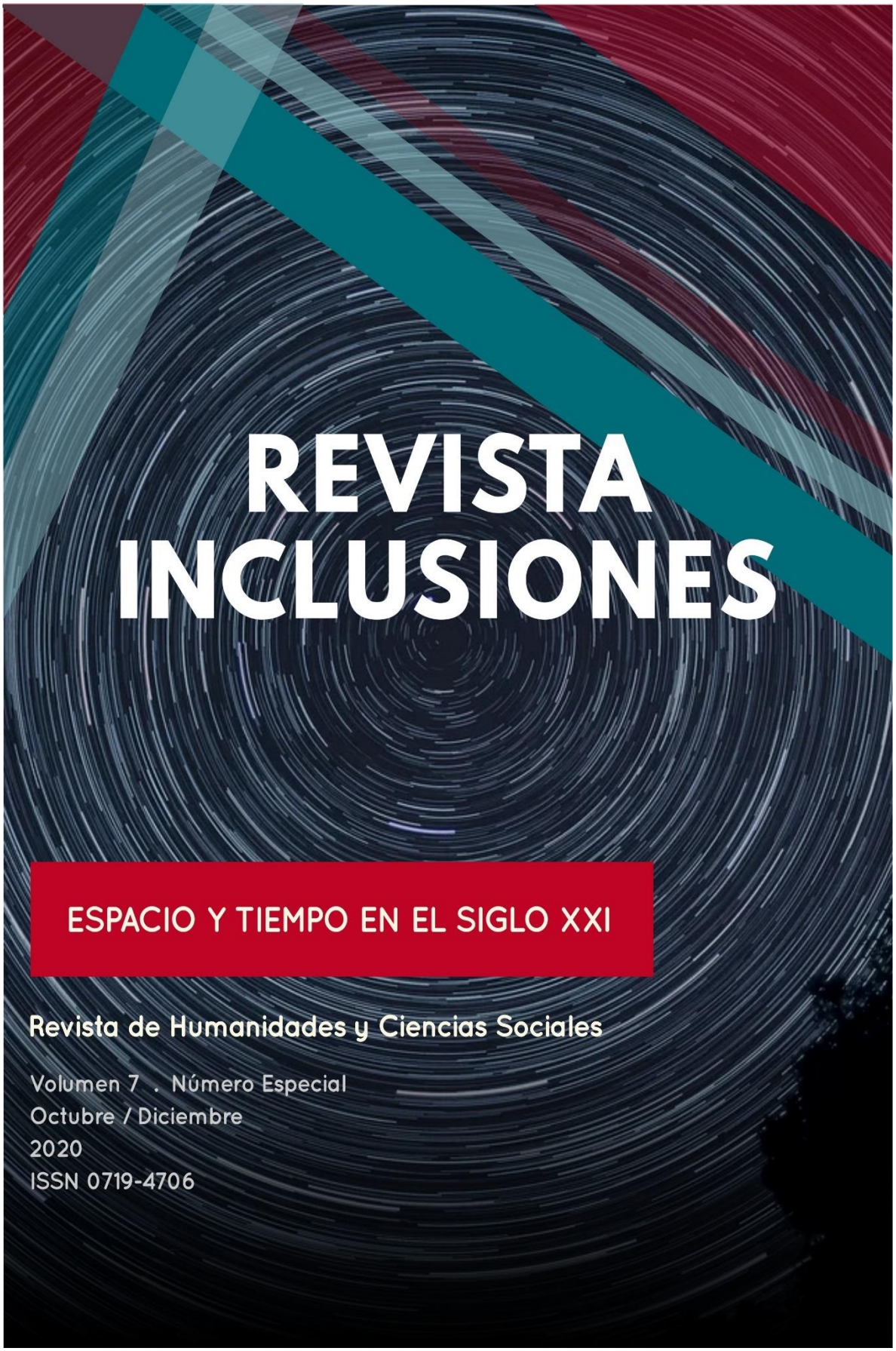

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CHANGES OF TRAFFIC MOBILITY AND ROAD TRAFFIC INJURIES IN MOSCOW DURING LOCKDOWN

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Abstract

COVID-19 pandemic has quickly propagated all around the world and exerted significant effect on cities and traffic mobility. In this article, traffic data from various sources (State Center of Traffic Organization, Yandex, Citymapper) are analyzed to determine the changes of traffic mobility during lockdown in Moscow. The data of State Road Safety Inspectorate (GIBDD) were analyzed reflecting road traffic injuries on Moscow roads during lockdown. Despite the fact that in April there were significantly fewer vehicles and people on the roads than in 2019, road traffic injuries equaled to 10%, which was by 7.8 p.p. higher than in the previous year.

Keywords

Road traffic accidents – Road traffic injuries – Road traffic safety – Traffic mobility – COVID-19

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Introduction

Outbreak of COVID-19, caused by SARS-CoV-2 coronavirus, was for the first time detected in Wuhan, China, in December 2019[1]. The virus was rapidly spread to all the world, mainly due to global air flights to major cities of Europe, USA, and other countries[2]. Then the centers of pandemic rapidly migrated from Asia to USA (for instance, New York) and Europe (Italy, Spain, Great Britain, etc.). On January 30, 2020 the World Health Organization (WHO) declared this outbreak as emergency situation in the field of public health of international importance[3]. On March 11, 2020 WHO declared that the propagation of the new coronavirus reached pandemic level, since it affected most countries and all continents[4]. At that time 118,000 cases were recorded in 114 countries, 4,291 persons died.

On August 22 the number of recorded cases of coronavirus infection exceeded 23 million. More than 808 thousand people died, 15.9 million people recovered. In Russia, the total number of cases of coronavirus infection was 951.9 thousand, the number of died patients with coronavirus was more than 16 thousand, the number of recovered persons was more than 767.4 thousand[5].

Various countermeasures against the epidemic were applied in countries and cities, inclining restriction of social contacts, closing colleges, higher schools, shops, restaurants and bars, prohibition to perform social gatherings, promotion of work from home. All these actions can be considered as social distancing, they are especially efficient in the case of illnesses (such as COVID-19), which are airborne and require for certain closeness of people [Wilder-Smith and Freedman, 2020]. There have been initial evidences that the COVID-19 pandemic could be suppressed by isolation and social distancing[6]. In Moscow the lockdown was announced, which lasted from March 30 to June 9. The lockdown implied prohibitions for population concerning movement around the city. Let us analyze the events preceding the lockdown in Moscow, what restrictive measures were activated in the city with regard to the COVID-19 coronavirus infection. The first case of COVID-19 coronavirus infection was confirmed for a Muscovite on March 2[7]. On March 5, Mayor of Moscow Sergey Sobyanin signed the decree about high alert mode in Moscow due to hazard of coronavirus infection[8]. According to the decree the high alert mode

[1] Novel Coronavirus – China. WHO. January 12, 2020. Retrieved from: https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/ru/

[2] C. Huang; Y. Wang; X. Li; L. Ren; J. Zhao; Y. Hu, et al. “Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China”, Lancet Vol: 395 (10223) (2020): 497-506.

[3] Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). WHO. January 30, 2020. Retrieved from: https://www.who.int/ru/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).

[4] WHO Director-General's opening remarks at the media briefing on COVID-19. March 11, 2020. Retrieved from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.

[5] Worldometer. Retrieved from: https://www.worldometers.info/coronavirus/

[6] Atalan, A. Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. Annals of Medicine and Surgery Vol: 56 (2020): 38-42.

[7] Coronavirus was detected in a Russian citizen who came from Italy. Interfax. March 2, 2020. Retrieved from: https://www.interfax.ru/russia/697390

[8] High alert mode is activated in Moscow due to coronavirus. Interfax. March 5, 2020. Retrieved from: https://www.interfax.ru/moscow/697971

obliged people, who returned from the countries with unfavorable situation, as well as the countries in the list of the Russian Agency for Health and Consumer Rights (Rospotrebnadzor), to inform about their return by phone. In addition, the mode stipulated necessity of home lockdown for two weeks from the day of return.

Starting from March 10 in Moscow, mass events with more than 5,000 people were restricted[9]. Starting from March 13, Russia restricted passenger air traffic with Italy, Germany, Spain, and France[10]. Starting from March 14, free school attendance was introduced. Parents decided whether the child continued to go to school or stayed at home[11]. Employers were obliged not to admit to working place and territory of company those employees who should be under home lockdown.

Starting from March 16, higher schools transferred to distance learning due to risks of coronavirus propagation [12]. Starting from March 17, leisure events with participation of 50 persons at a time were prohibited. In land vehicles, ticketing by drivers in passenger compartments was cancelled[13].

On March 18, Sergey Sobyanin asked Moscow companies to transfer employees to remote work[14]. Starting from March 21, all schools and institutions of supplemental education were closed.

Starting from March 26, Muscovites older than 65 years and persons suffering from chronic diseases (diabetes mellitus, bronchial asthma, cancer, as well as those who have had a heart attack or stroke) were obliged to stay at home[15]. Free travel by public transport was suspended for students of colleges and higher schools as well as for persons older than 65 years and those suffering from chronic diseases[16]. Cinemas, children's entertainment centers and game rooms were closed. On March 25, the President of the Russian Federation Vladimir Putin declared the week starting from March 30 as nonworking[17]. In Moscow, starting from March 28, operation of restaurants, cafeterias, bars, canteens and other catering places was suspended. The only exclusion was ready meal delivery without visiting the places of production[18].

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[9] Decree of Mayor of Moscow No.17-DM. March 10, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/17-YMot10032020(2).pdf.

[10] Temporal restrictions of air flights to Italy, Germany, Spain, and France. Site of Mayor of Moscow. March 11, 2020. Retrieved from: https://www.mos.ru/news/item/70857073

[11] Decree of Mayor of Moscow No.20-DM. March 14, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/20-YM.pdf

[12] Cafeterias, clothes shops, and parks in Moscow will be closed from March 28 to April 5. Vedomosti. March 26, 2020. Retrieved from: https://www.vedomosti.ru/politics/articles/2020/03/26/826269-sobyanin-zakril

[13] Decree of Mayor of Moscow No.21-DM. March 16, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/21-YM.pdf.

[14] Coronavirus. Working from home. Site of Sergey Sobyanin. March 18, 2020. Retrieved from: https://www.sobyanin.ru/koronavirus-rabota-iz-doma.

[15] Decree of Mayor of Moscow No.26-DM. March 23, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/26-YM.pdf.

[16] Decree of Mayor of Moscow No.28-DM. March 25, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/28-YM.pdf.

[17] Putin declared the following week nonworking. RBC. March 25, 2020. Retrieved from: https://www.rbc.ru/society/25/03/2020/5e7b5c939a7947f15a9150f0.

[18] Decree of Mayor of Moscow No.31-DM. March 26, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/31-YM.pdf.

Already on the first nonworking day, March 28, in Moscow passenger traffic decreased by 67% in subways, by 55% in land vehicles, by 37% in suburban railway transport, by 42% in taxis, by 36% for car sharing in comparison with usual Saturdays. Traffic of personal vehicles decreased by 27% of total amount, road traffic accidents – by 27%, arriving by buses from the oblast – by 70%[19].

On March 30, lockdown was introduced in Moscow, movements around the city were restricted. Citizens should not have left homes[20]. At the same time, similar measures were introduced in Moscow oblast. Traffic restriction of personal and service vehicles, special and public transport was not stipulated in the decree of Sergey Sobyanin.

On the first day of lockdown, March 30, in comparison with similar period of the previous year, the passenger traffic decreased by 85% in subways, by 74% in land public transport, by 56% in suburban railway transport, by 47% in taxi, by 39% for car sharing[21].

On March 30, Russia completely closed its state border[22]. On April 2, the President Vladimir Putin signed the decree about prolongation of nonworking days to May 1, therefore, all previous restrictions introduced in Moscow were also prolonged to May 1. On April 4, amendments to Administrative Violations Code were validated stipulating responsibility for violation of high alert mode[23].

Starting from April 10, free bicycle sharing was introduced for messengers and volunteers[24]. On April 11, Sergey Sobyanin signed the decree, according to which travelling around Moscow and Moscow oblast by personal and public transport from April 15 was allowed by special digital identity cards[25].

Starting from April 13, additional prohibitions and restrictions were introduced in Moscow, namely, operation of nearly all enterprises and companies was suspended, construction (repairing) activities were suspended, car sharing was suspended[26]. As of April 15, 3.2 million digital identity cards were issued in Moscow for travelling around the city by personal or public transport[27].

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[19] Keep distance. Results of the first nonworking day. Site of Sergey Sobyanin. March 29, 2020. Retrieved from: https://www.sobyanin.ru/soblyudaite-distantsiyu-itogi-pervogo-nerabochego-dnya.

[20] Decree of Mayor of Moscow No.34-DM. March 29, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/34-YM.pdf.

[21] Department of transportation of Moscow. Traffic analytics. March 30, 2020. Retrieved from: https://t.me/DtRoad/2469

[22] Decree No.763 of the Government of the Russian Federation. March 27, 2020. Retrieved from: http://static.government.ru/media/files/uPySAqzA9AV39jD1h71za3OR9esIxlDj.pdf.

[23] Decree of Mayor of Moscow No.39-DM. April 4, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/39-YM(4).pdf.

[24] Coronavirus. Free bicycle sharing for messengers and volunteers. Site of Sergey Sobyanin. April 3, 2020. Retrieved from: https://www.sobyanin.ru/koronavirus-besplatnyi-veloprokat-dlya-kurerov-i-volonterov.

[25] Decree of Mayor of Moscow No.43-DM. April 11, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/43-YM(2).pdf.

[26] Decree of Mayor of Moscow No.42-DM. April 10, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/42-YM(4).pdf.

[27] 3.2 million digital identity cards were issued in Moscow. Emergency center of Moscow. April 14, 2020. Retrieved from: https://t.me/COVID2019_official/287

Starting from April 15, 2020, digital identity cards became obligatory for travelling. Due to identity check, in front of numerous subway stations in Moscow there were a lot of people in queues, and at entries to Moscow from MRHW and on major highways to the city center there occurred traffic jams[28].

Starting from April 22, the amendments to the access mode were validated. Travelling by public transport was allowed only using Troika, Strelka e-cards, monthly travel card as well as social cards of the Muscovite and the resident of Moscow oblast. The access mode during travelling by vehicle was controlled by road safety cameras and road patrol service. Temporal restrictions of April 14 were prolonged to May 1[29].

In addition, on April 22, the decree of Mayor of Moscow introduced supplemental control measures against coronavirus. Starting from April 22, citizens suspected of coronavirus as well as citizens with signs of ARVI and other respiratory diseases should fulfill the requirements of home lockdown. The lockdown was applied to all persons, who lived together with those suffering from ARVI and suspected of coronavirus. Aiming at control of compliance with lockdown requirements, electronic monitoring of location was applied[30].

On April 28, the President Vladimir Putin prolonged nonworking days up to nearly two weeks. Mayor of Moscow Sergey Sobyanin signed the decree of prolongation of all restrictions in Moscow up to May 11, inclusively[31].

On May 11, the President Vladimir Putin declared that starting from May 12, the common period of nonworking days was terminated[32]. Starting from May 12, the introduced restrictions were relaxed in Moscow. Industrial and constructing enterprises resumed their operation. The use of masks and gloves became obligatory in trading centers, in Moscow public transport and taxi. Temporal restrictions of trading companies, catering, servicing and other non-industrial enterprises as well as lockdown were prolonged up to May 31. Previously issued identity cards were automatically prolonged to May 31[33]. On May 21, Sergey Sobyanin declared the first stage of restrictions relaxation in Moscow. Starting from May 25, 2020, multifunctional centers of state services, My Documents, were opened. Starting from May 25, 2020, car sharing resumed its operation, though, only partially: car sharing was allowed for at least five days. Starting from May 27, traveling around Moscow was allowed only with Moscow digital identity cards[34].

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[28] Propusknoy rezhim v Moskve. Meduza. April 15, 2020. Retrieved from: https://meduza.io/feature/2020/04/15/v-moskve-vveli-propusknoy-rezhim-na-neskolko-chasov-vernulis-probki-i-ocheredi-v-metro

[29] Pervye itogi prinyatykh mer. Dopolnitelnye izmeneniya v propusknom rezhime. Retrieved from: https://www.sobyanin.ru/dopolnitelnye-izmeneniya-v-propusknom-rezhime

[30] Decree of Mayor of Moscow No.47-DM. April 21, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/47-YM(4).pdf.

[31] Decree of Mayor of Moscow No.51-DM. April 28, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/51-YM.pdf.

[32] Soveschanie o sanitarno-epidemiologicheskoi obstanovke. Retrieved from: http://kremlin.ru/events/president/news/63340

[33] Decree of Mayor of Moscow No.55-DM. May 7, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/55-YM(7).pdf.

[34] Decree of Mayor of Moscow No.59-DM. May 21, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/59-YM.pdf.

On May 27, the second stage of restrictions relaxation was declared in Moscow. Starting from June 1, all citizens, including people over 65 years and persons with chronic diseases, were allowed to leave homes for walking and sporting. All parks and green sites were opened. Starting from June 1, car dealerships and stores of nonfood products resumed their operation. Dry cleaners, laundries, shoe repair shops and other consumer services also resumed their activities. Operation of municipal bicycle sharing was completely resumed. Herewith, the Mayor announced prolongation of lockdown and other restrictions up to June 14. The term of validity of digital identity cards was prolonged automatically[35].

Special rules for walking were stipulated, available for Muscovites as experiment for two weeks from Jun 1 to 14. Walking schedule was predetermined. Sporting outdoors was allowed daily until 9:00 a.m. Walking was allowed from 9:00 to 21:00 not more than three times per week: two times on workdays and one time on the days off. The schedule of walking days for each house was published at mos.ru, Yandex, and in mobile applications[36].

On June 8, Sergey Sobyanin announced termination of lockdown in Moscow from June 9. On June 9, operation of hairdressers, beauty salons, photo studios, veterinary clinics, and employment agencies was resumed. All restrictions for car sharing were canceled[37].

Methods

In order to analyze the influence of the introduced restrictions on the performances of transport complex of Moscow, let us consider the following indicators: dynamics of the number of vehicles moving around Moscow every day from January to June 2019 and 2020; dynamics of average daily speed of vehicles moving around Moscow during daytime hours from January to June 2019 and 2020; dynamics of average daily Yandex rating of traffic jams during daytime hours from January to June 2019 and 2020; dynamics of Yandex rating of lockdown from February to June 2020; dynamics of trips by public transport and by walking in Moscow according to data by Citymapper.

Moscow is the largest transport hub in Russia. Five modes of transport intersect here: 11 railway lines, 15 highways, five gas pipelines and three oil pipelines converge in Moscow; three river ports, five airports, and nine railway terminals are located in Moscow. According to the data by Center of Traffic Organization, in 2020 the decrease in the number of vehicles on the roads of Moscow started from March 16, i.e. before initiation of lockdown in Moscow[38]. At the same time, free college attendance was introduced, and higher schools transferred to distant learning. If in the last week of March 2019, 3.13 million vehicles moved around Moscow daily, then in 2020, their amount was only 2.96 million, that is, the decrease was 5% (–164,000 vehicles) (Fig.1).

[35] Decree of Mayor of Moscow No.61-DM. May 27, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/61-YM(2).pdf.

[36] Progulki I sport na svezhem vozdukhe. Osnovnye pravila. May 27, 2020. Retrieved from: https://www.sobyanin.ru/progulki-i-sport-na-svezhem-vozduhe-osnovnye-pravila

[37] Decree of Mayor of Moscow No.68-DM. June 8, 2020. Retrieved from: https://www.mos.ru/upload/documents/docs/68-YM(4).pdf.

[38] Moscow State Public Institution - Center of Traffic Organization at the Moscow Government. Retrieved from: http://www.gucodd.ru/

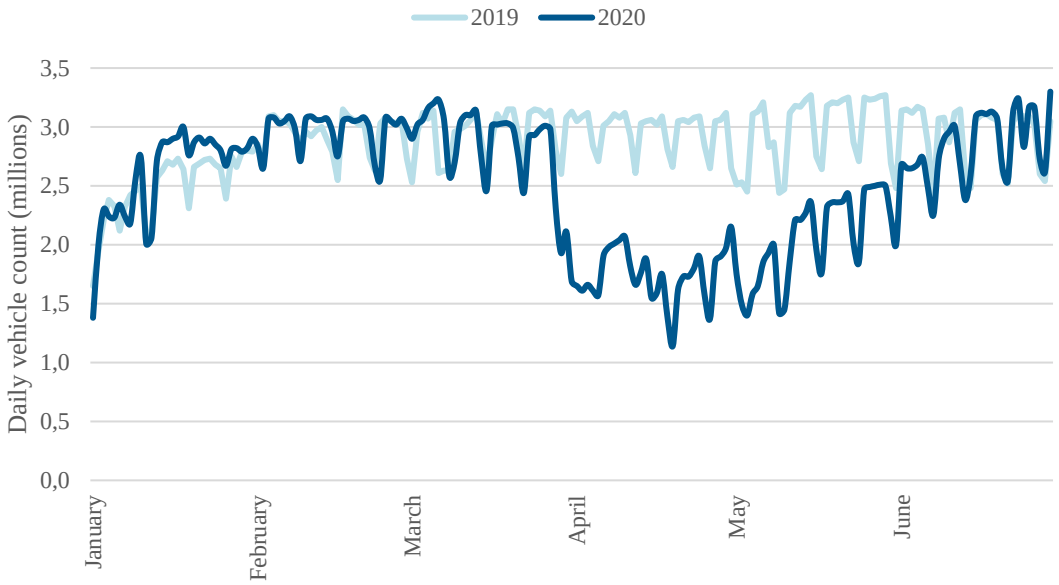

Figure 1
Dynamics of daily number of vehicles on the roads of Moscow in 2019 and 2020

On March 30, the first day of lockdown in Moscow, the number of vehicles on the roads decreased by 31%; in Tuesday, March 31, the decrease was already 46% in comparison with the same day in 2019. Average decrease in the number of vehicles in weekdays of April was 40%. Starting from May 12, the number of vehicles on the roads of Moscow started to increase in comparison with April–early May 2020. On May 12, the introduced restrictions were relaxed in Moscow. In the second half of May, the average decrease was 26% in comparison with the similar period of the previous year.

In June, the number of vehicles on the roads of Moscow gradually returned to the level of 2019. On June 9, the lockdown in Moscow was canceled. And already on June 10, the number of vehicles exceeded the level of the previous year by 3%.

Let us consider average daily speed on the roads of Moscow in 2019 and 2020, that is, the average speed from 6:00 to 23:59. Due to decrease in the number of vehicles on the roads and absence of traffic jams, peculiar for Moscow, starting from March 20, the speeds were increasing. On March 20, it was 10% higher in comparison with the similar day in 2019. Starting from March 21, 2020, all colleges and institutions of supplemental education were closed.

Sharp increase of average daily speed took place on Saturday, March 28, the first nonworking day, it was 32%. On March 30, the first lockdown day in Moscow, the speeds on the roads increased by 48% in comparison with the similar day of the previous year (Fig.2).

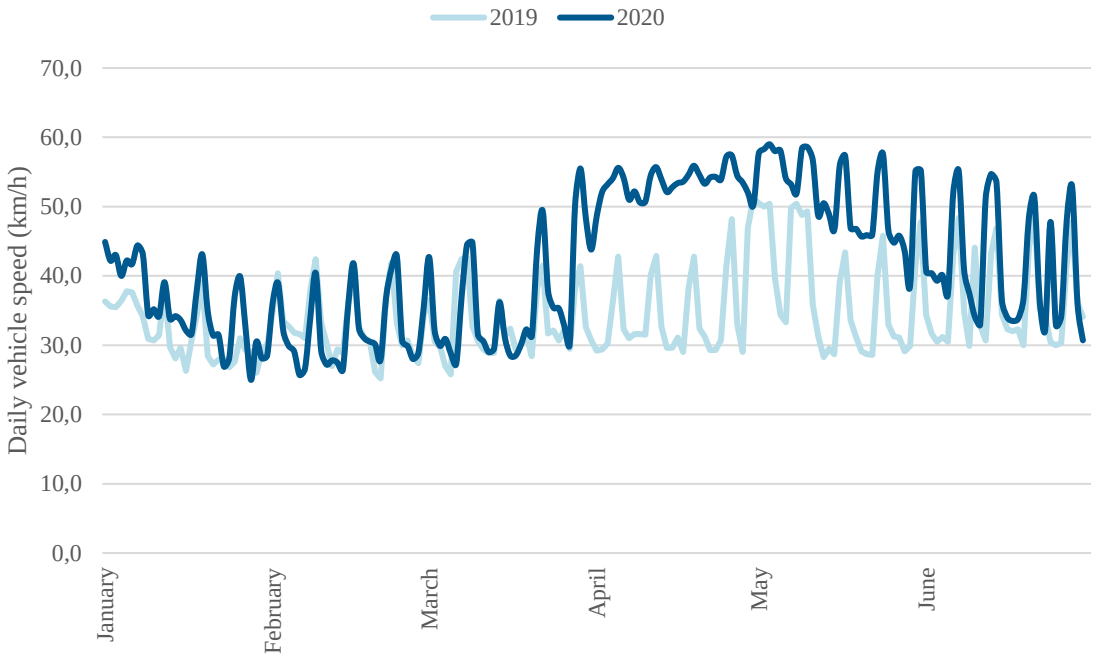

Figure 2
Dynamics of average daily vehicle speed on the roads of Moscow in 2019 and 2020

On April 22 and 23 (Wednesday and Thursday), the speed growth reached 85%. The average speed increase in weekdays of April was 64%. Starting from May 12, the introduced restrictions were relaxed in Moscow and, as a consequence, the average daily speed on the roads of Moscow started to decrease in comparison with April–early May 2020. In the second half of May, the average speed increase in the working day was 53%.

In June, the average daily speed on the roads of Moscow gradually returned to the level of 2019. On June 9, the lockdown in Moscow was cancelled, but the speeds were higher than in the previous year. From June 15 to 18, the increase in the speeds in comparison with the previous year was about 5-6%.

One of the key indicators of traffic congestion in Moscow is traffic jams rating by Yandex[39]. In Moscow, the Yandex.Traffic service evaluates the situation according to 10-point scale (0 points: the traffic is free, 10 points: the city is jammed).

[39] Operation principle of Yandex.Traffic. Yandex. Retrieved from: https://yandex.ru/company/technologies/yaprobki/

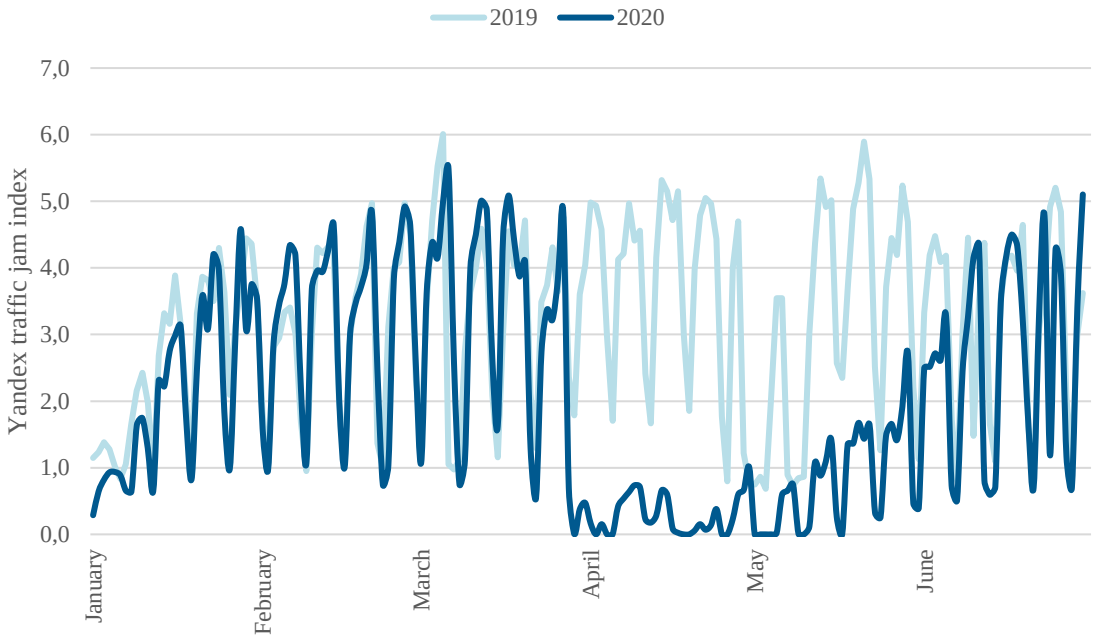

Figure 3
Dynamics of average daily Yandex traffic jam index in Moscow in 2019 and 2020

Let us consider the average daily rating of traffic jams in Moscow in 2019 and 2020, that is, the average rating from 6:00 to 23:59. The average daily rating started to decrease from March 23, sharp decrease in the rating on March 27 was stipulated by the fact that people left Moscow prior to nonworking week.

On March 30, the first lockdown day, the average daily rating of traffic jam dropped to 0.4 points, on the similar day of the previous year, it was 3.6 points. Starting from March 30 to May 15, the roads in the city were free, the average rating did not exceed 1.1 points. In average, the April rating of traffic congestion was by three points lower than in the previous year. Starting from the middle of May, the rating started to gradually increase, on June 15, it was 3.5, on the similar day of 2019, the rating was also 3.5 points (Fig.3).

During the pandemic Yandex developed the lockdown index. This rating demonstrated the lockdown level in various cities including Moscow[40]. In order to determine the rating, the level of city activity was compared with usual day before the pandemic. The usual weekday was determined by the level of activity obtained by averaging of data from March 2 (Monday) to March 5 (Thursday). If the level of activity was the same as in peak hours of usual weekday, then the lockdown level was low, there were a lot of people in the streets. If almost no one was in the streets as at night, this was five points. The higher was the rating, the fewer people were in the streets.

[40] Lockdown index. Yandex. Retrieved from: https://yandex.ru/company/researches/2020/podomam

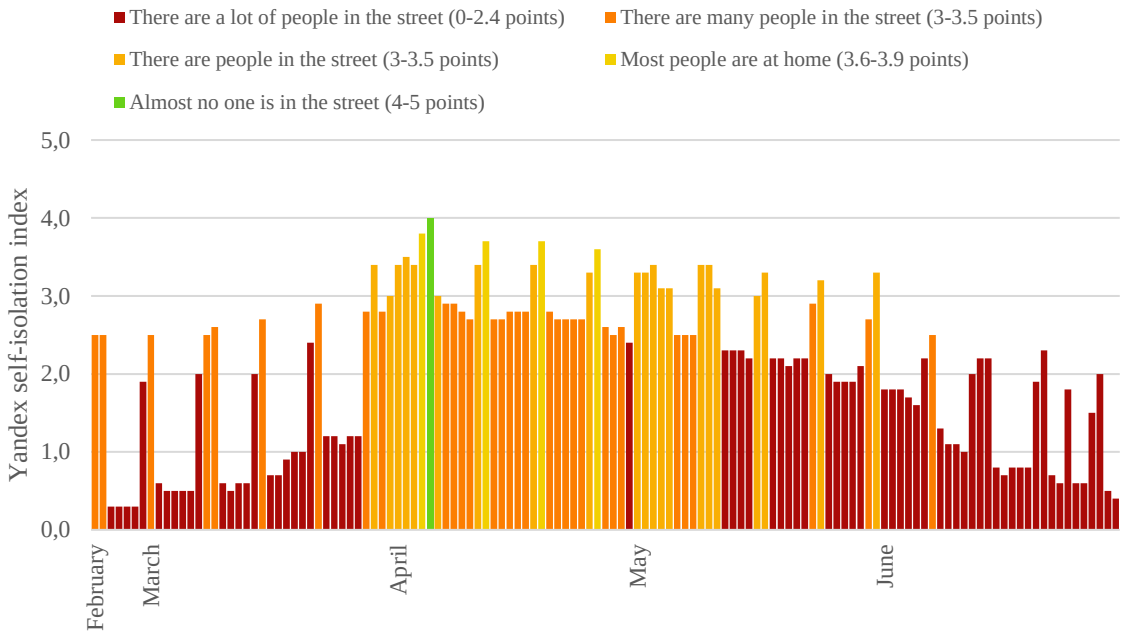

Figure 4
Dynamics of Yandex lockdown index in Moscow from February to June 2020

From February 23 to March 29, the lockdown index in Moscow did not exceed 3.5 points, i.e. there were a lot of people in the streets. Until May 15, the index did not decrease to 2.4 points, i.e. the level of city activity decreased significantly. From March 29 to May 11, there were significantly less people in the streets than in February and March. From May 12, the lockdown index started to decrease, i.e. the level of city activity was increasing. At the end of lockdown, June 9, the lockdown level returned to the situation of the last week of March (1.1 points, a lot of people were in the streets) (Fig.4).

Citymapper is the application for public transport and cartographic service, which reflects variants of transport. The mobility index of Citymapper was calculated by comparison of trip number obtained in Citymapper with usual period of the application usage. The usual period of usage was four weeks between January 6 and February 2, 2020[41].

[41] Citymapper Mobility Index. Retrieved from: https://citymapper.com/cmi

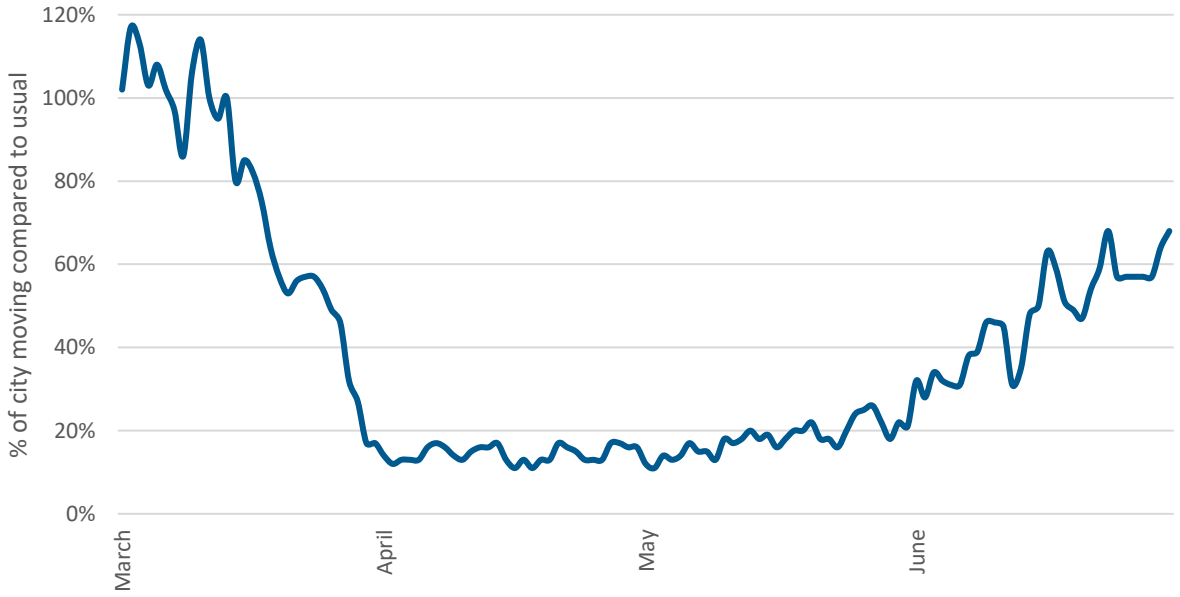

Figure 5
Dynamics of trips by public transport and by walking in Moscow according to Citymapper

If in early March the number of trips by public transport and by walking was 80-117% of usual level, then in late April–early May, the fraction of trips by transport was about 17%. In average, in April, the number of trips by public transport and by walking amounted to 15% of the usual level. Starting from May 12, when nonworking days in Russia were cancelled, the fraction of trips by transport in Moscow started to gradually increase. On June 9, the lockdown in Moscow was cancelled, the fraction of the trips reached 46%. Even at the end of June the fraction of the trips did not return to the level of February and March, the maximum fraction of the trips was 68% (Fig.5).

Therefore, during lockdown the number of vehicles was significantly lower on the roads of Moscow, and the speeds were higher than in the previous year. In April 2020, the number of vehicles on the roads of Moscow was nearly two times less than in 2019, in May, it was by 26% less. To June 10, the number of vehicles reached the level of the previous year. The average increase in speed on the roads during weekdays of April was 64%. Even after cancellation of lockdown in Moscow, the average daily speeds were higher than in 2019. According to the data of lockdown index by Yandex, from March 29 to May 12, 2020, there were significantly less people in the streets than in February and March of the same year. Decrease in the number of vehicles and pedestrians in the streets of Moscow during the lockdown should have led to decrease in road traffic injuries, however, the increase in average daily speed of vehicles resulted in increase of mortality rate due to road traffic accidents.

Results

Decrease in the number of vehicles on the roads, the number of traffic jams, and simultaneous increase in the speeds during lockdown resulted in the fact that the number of road traffic accidents and people injured in the road traffic accidents in Moscow decreased, and, at the same time, the number of people killed on the roads and the mortality rate increased.

Let us consider the indicators of road traffic injuries in Moscow before and during the lockdown. According to the data of the Russian Road Inspectorate,[42] the number of road traffic accidents decreased in 2016 and 2017. In 2016, the number of road traffic accidents was by 13% lower than in 2015, in 2017– by 2% lower than in 2016. Starting from 2018, the number of road traffic accidents started to increase. In 2018, the number of road traffic accidents was by 3% higher than in 2017, and in 2019, the increase in the number of road traffic accidents with regard to the year 2018 was 2% (Fig.6).

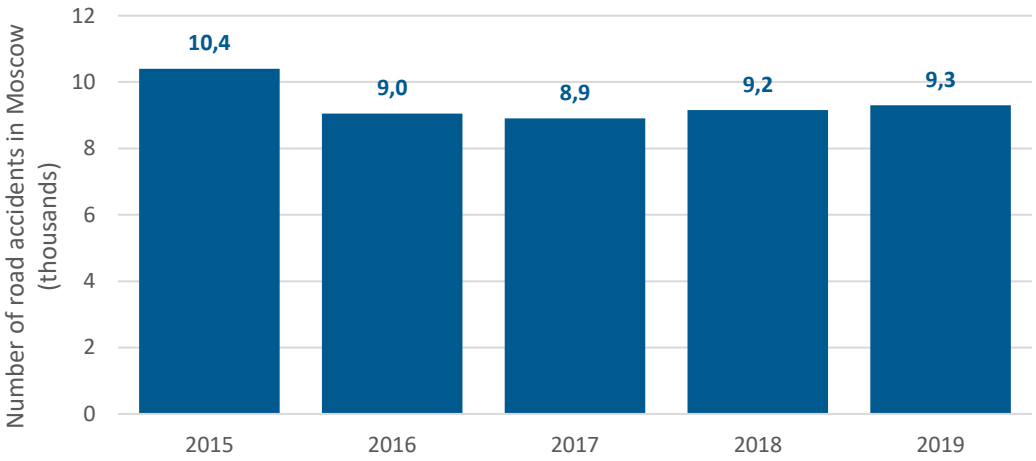

Figure 6
Dynamics of road accidents in Moscow from 2015 to 2019, thousands

From 2015 to 2019, the number of people killed on the roads gradually decreased. In 2016, the number of people killed on the roads of Moscow was by 17% lower than in the previous year, this was the most significant decrease for overall considered period. In 2017, the number of people killed on the roads decreased by 12% in comparison with 2016. In 2018, the decrease was 6%, in 2019 – 5% (Fig.7).

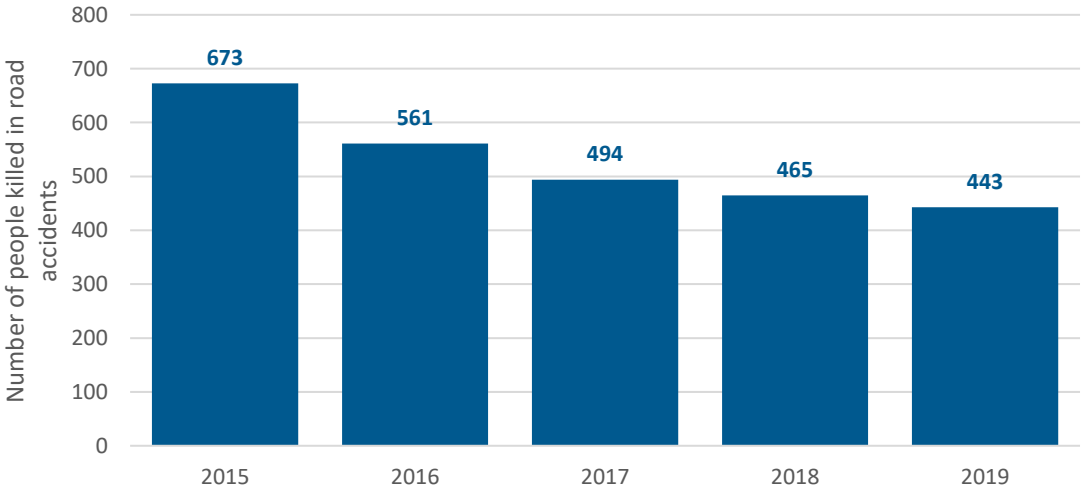

Figure 7
Dynamics of people killed in road traffic accidents in Moscow from 2015 to 2019

[42] Road traffic safety. Official site of Road Inspectorate. Retrieved from: http://stat.gibdd.ru

In 2016 and 2017, the number of people injured was lower than in the previous year, starting from 2018, the number of people injured increased. In 2016, the number of people injured on the roads was by 13% lower than in 2015, in 2017 – by 2% lower than in 2016. From 2018, the number of people injured increased. In 2018, the number of people injured was higher by 3% than in 2017, and in 2019, the increase in the number of people injured with regard to 2018 was 2% (Fig. 8).

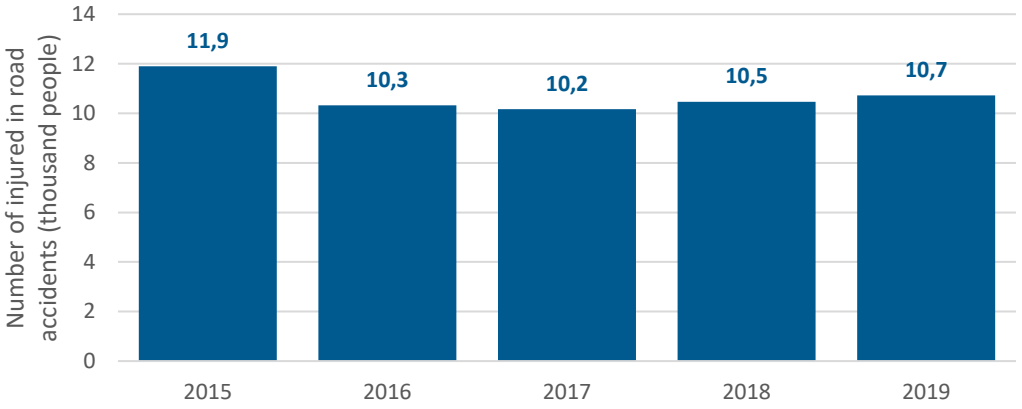

Figure 8
Dynamics of injured in road traffic accidents in Moscow from 2015 to 2019, thousand people

From 2015 to 2019, the mortality rate, i.e. the number of people killed in road traffic accidents with regard to all victims, was decreasing. In 2016, the mortality rate decreased by 0.2 p.p. in comparison with 2015. In 2017, the decrease was by 0.6 p.p.; in 2018 and 2019, the mortality rate decreased by 0.3 p.p. (Fig.9)

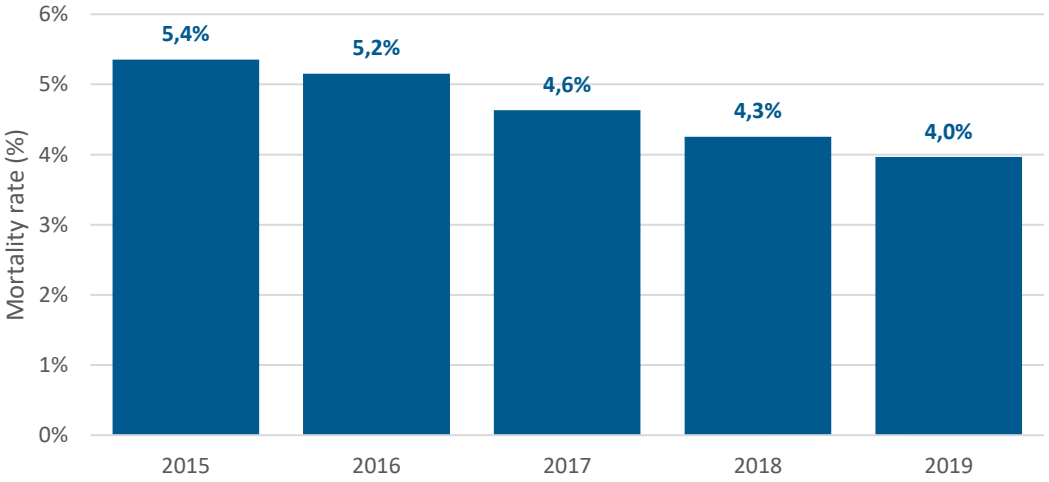

Figure 9
Dynamics of mortality rate in road traffic accidents in Moscow from 2015 to 2019, %

Social risk is the number of people killed in road traffic accidents per 100,000 inhabitants. From 2015 to 2019, the social risk in Moscow was decreasing. The most significant decrease was recorded in 2016, the social risk decreased by 18% in comparison with 2015. In 2017, the decrease was 12%, in 2018 and 2019 – 7 and 6%, respectively (Fig.10).

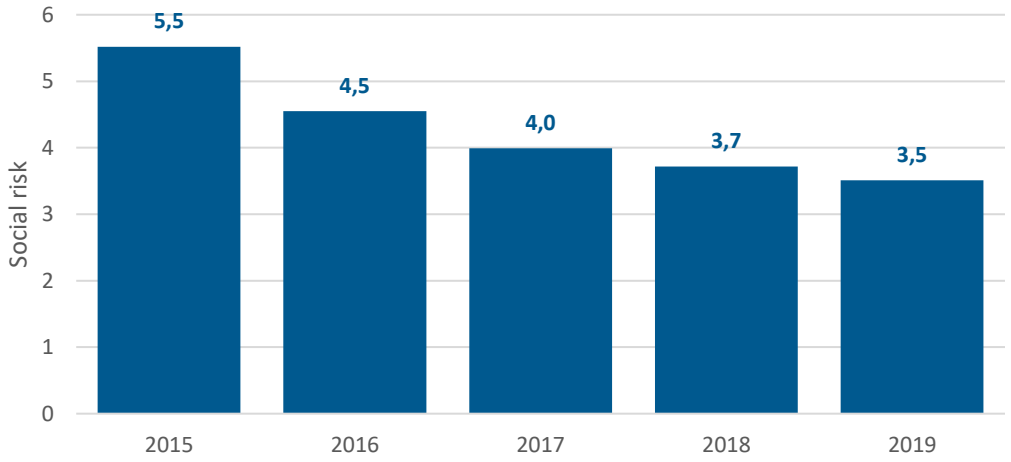

Figure 10
Dynamics of social risk in Moscow from 2015 to 2019

As already mentioned, on March 30, 2020 (Monday), the lockdown was introduced in Moscow, which was active to June 9 (Tuesday), i.e. it lasted for ten complete weeks. For 2019, the comparable dates were from April 1 (Monday) to June 11 (Tuesday).

In 2019, there occurred 9,296 road traffic accidents in Moscow, in which 443 people were killed, 10,723 people were injured, the mortality rate was 4.0%. For the first half-year of 2019, there occurred 4,137 road traffic accidents, 189 people were killed, 4,810 people were injured, the mortality rate was 3.8%; and from April 1 (Monday) to June 11 (Tuesday), 2019, there occurred 1,690 road traffic accidents, 67 people were killed, 1,920 people were injured, the mortality rate was 3.4% (Fig.11).

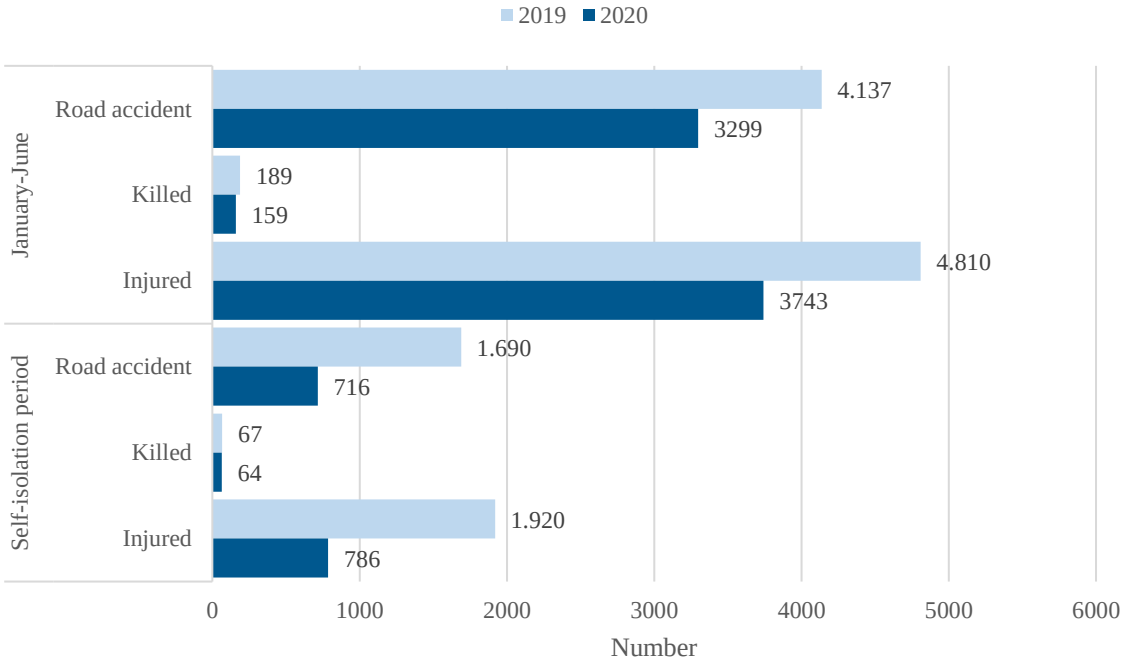

Figure 11
Statistics of road traffic accidents in Moscow in 2019 and 2020

In Moscow from January to June 2020, there occurred 3,299 road traffic accidents, 159 people were killed, 3,743 people were injured, the mortality rate was 4.1%. In the first half-year period of 2020, there occurred by 838 road traffic accidents less than for the similar period of 2019, the number of people killed was lower by 30 people, the number of people injured was lower by 1,067 people, the mortality rate increased from 3.8% to 4.1%. During the lockdown from March 30 (Monday) to June 9 (Tuesday), there occurred 716 road traffic accidents, 64 people were killed, 786 people were injured, the mortality rate was 7.5%. During the lockdown, there occurred by 974 road traffic accidents less than for the similar period of 2019, the number of people killed was by three people lower, the number of injured - by 1,134 people, the mortality rate increased more than twice from 3.4% to 7.5% (Fig.12).

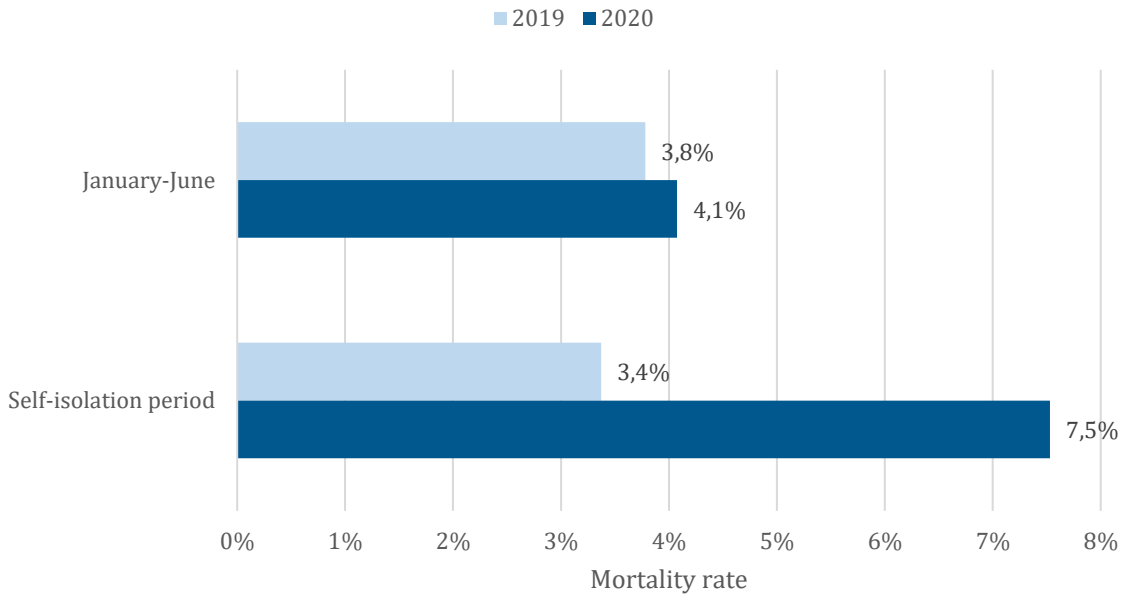

Figure 12
Statistics of mortality rate in Moscow in 2019 and 2020

Therefore, during the lockdown there was significant decrease in the number of road traffic accidents (by 58%) and the number of people injured (by 59%), the number of people killed decreased insignificantly (by 4%), and the mortality rate increased more than two times, from 3.4% to 7.5%. Hence, during the pandemic the severity of consequences of road traffic accidents in Moscow increased more than twice. The number of people killed and the mortality rate can be even higher, since a person is included in the statistics of killed for June 2020, if he dies in 30 days after the accident.

Let us consider the monthly statistics of road traffic accidents for the first half-year periods of 2019 and 2020.

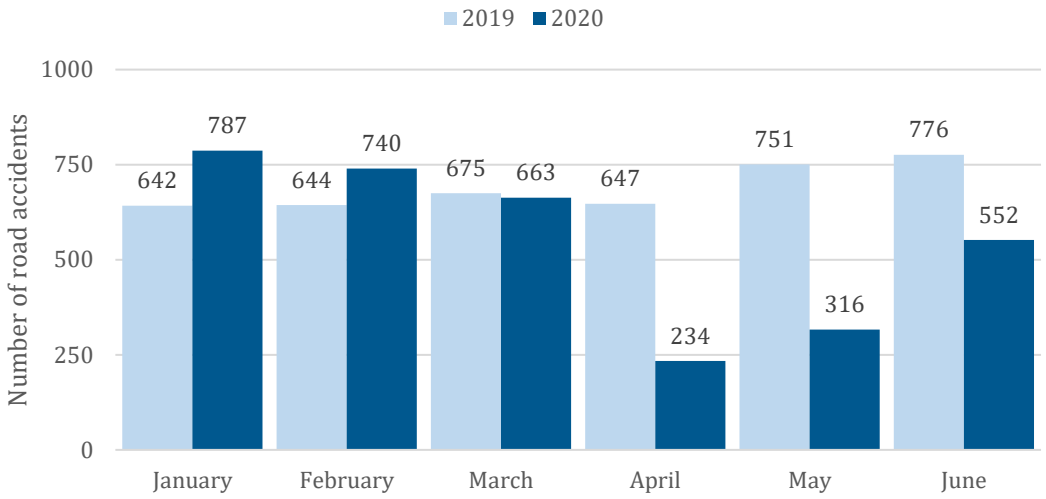

Figure 13
Monthly dynamics of road traffic accidents

In January 2020, the number of road traffic accidents was by 23% higher than in 2019 (642 road traffic accidents in 2019 against 787 in 2020). In February 2020, the number of road traffic accidents was higher by 15% (644 road traffic accidents in 2019 against 740 in 2020). From March 2020, the number of road traffic accidents was lower than in the previous year. The most significant drop was detected from April to June. In April, the decrease in the number of road traffic accidents was 64% (647 road traffic accidents in 2019 against 234 in 2020). In May, the number of road traffic accidents in comparison with the previous year decreased by 58% (751 road traffic accidents in 2019 against 316 in 2020). In June 2020, the number of road traffic accidents decreased by 29% (776 road traffic accidents in 2019 against 552 in 2020). The decrease in the number of road traffic accidents was stipulated by the lockdown, the decrease in the number of vehicles on the roads (Fig.12).

In 2019, gradual increase in the number of road traffic accidents was observed from April to June. In 2020, this trend remained.

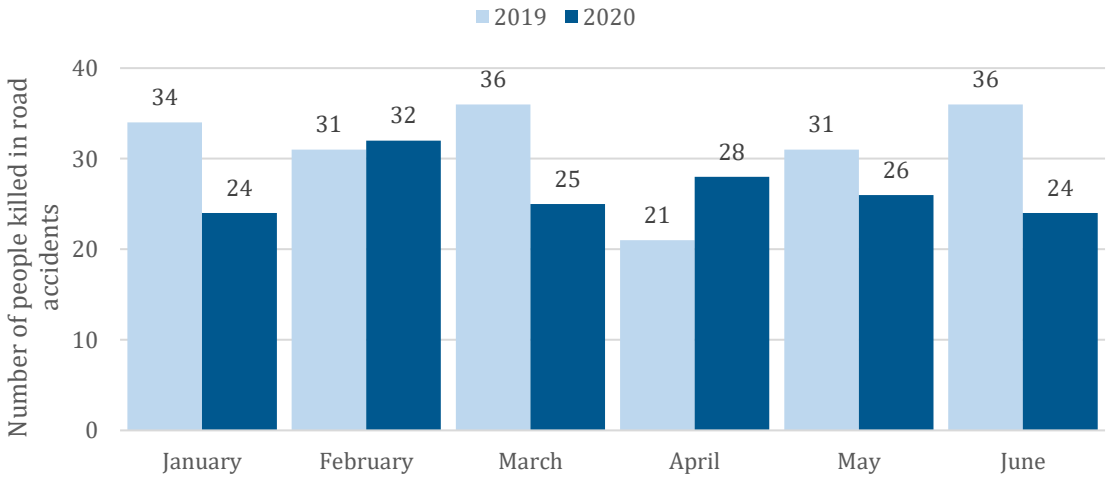

Figure 14
Monthly dynamics of people killed in road traffic accidents

In January 2020, on the roads of Moscow the number of people killed was by ten people lower than in the previous year (34 people killed in 2019 against 24 people killed in 2020). In February 2020, the number of people killed remained nearly the same (31 people killed in 2019 against 32 people killed in 2020). In March, the decrease was 31% (36 people killed in 2019 against 25 people killed in 2020) (Fig.14).

The trends of changes of the number of people injured differ significantly from those of the number of road traffic accidents. If during the lockdown the number of road traffic accidents radically decreased, then the number of people killed decreased not so significantly, and in April 2020, it even increased.

In April 2020, the number of vehicles on the roads of Moscow was nearly two times less than in 2019, in May — by 26% less. The average speed increase on the roads on weekdays of April was 64%. According to the data of lockdown index by Yandex, from March 29 to May 12, 2020 the number of people in the streets was significantly lower than in February and March of the same year. Despite this fact, on the roads of Moscow in April 2020, the number of people killed was by seven people more (33%) than in the previous year (21 people killed in 2019 against 28 people killed in 2020). In May, the decrease in comparison with the previous year was 16%, the number of people killed was by five people less than in 2019 (31 people killed in 2019 against 26 people killed in 2020). In June, there was a record decrease in the number of people killed on the roads, the decrease was 33%, the number of people killed was by twelve people less than in June 2019 (36 people killed in 2019 against 24 people killed in 2020).

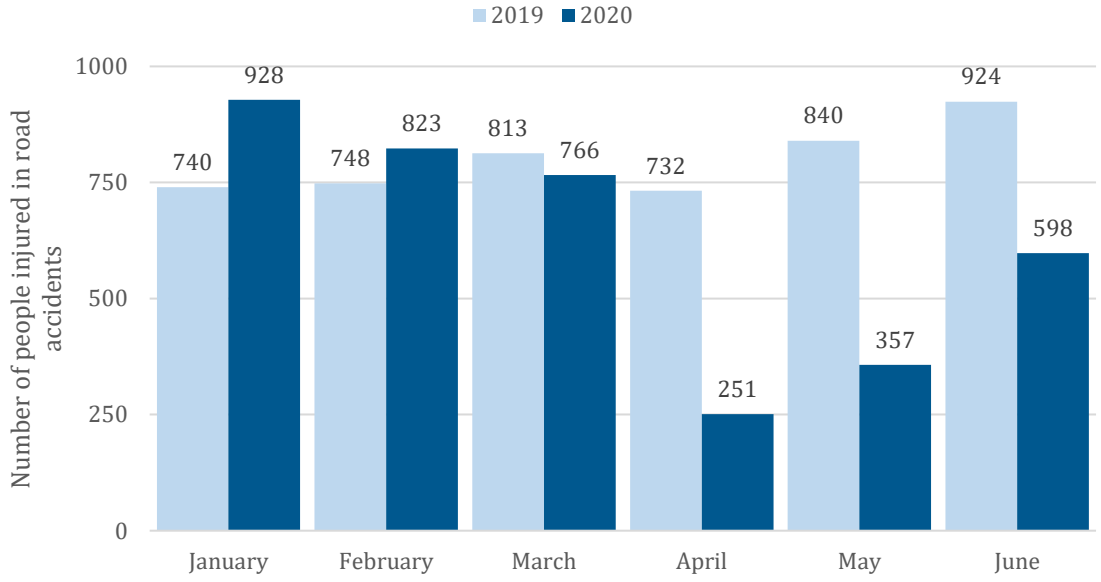

Figure 15
Monthly dynamics of people injured in road traffic accidents

The trends of the number of people injured coincide with those of the number of road traffic accidents. In January and February, the number of people killed was higher than in the previous year (by 25% and 10%, respectively). Starting from March, the number of people injured began to decrease: by 6% in March. In April 2020, the number of people injured was by 66% lower than in the previous year (732 people killed in 2019 against 251 people killed in 2020).

In May, the decrease was 58% (840 people killed in 2019 against 357 people killed in 2020). In June 2020, on the roads of Moscow the number of people injured was by 35% lower than in the previous year (924 people killed in 2019 against 598 people killed in 2020) (Fig. 15).

As in the case with the number of road traffic accidents in 2019, the gradual increase in the number of people injured was observed from April to June. In 2020, this trend remained.

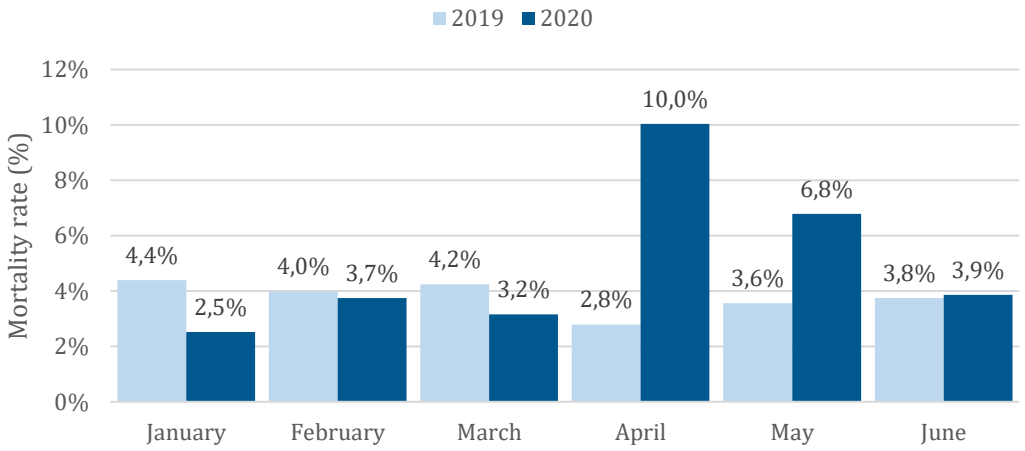

Figure 16
Monthly dynamics of mortality rate

If from January to March the mortality rate was lower than in 2019 (by 1.9 p.p. in January, by 0.3 p.p. in February, and by 1.0 p.p. in March), then from April the mortality rate was sharply increasing. In April 2020, the mortality rate was 10%, which was by 7.2 p.p. higher than in 2019. In May, the mortality rate increased from 3.6% in 2019 to 6.8% in 2020. In June 2020, the mortality rate was 3.9%, in 2019, it was 3.8%. (Fig.16).

Let us consider the statistics of road traffic accidents in ten lockdown weeks, without data for two days (June 8-9, 2020) (Table 1).

Lockdown week	**2019**		**2020**	
	Monday	**Sunday**	**Monday**	**Sunday**
Week 1	01.04.2019	07.04.2019	30.03.2020	05.04.2020
Week 2	08.04.2019	14.04.2019	06.04.2020	12.04.2020
Week 3	15.04.2019	21.04.2019	13.04.2020	19.04.2020
Week 4	22.04.2019	28.04.2019	20.04.2020	26.04.2020
Week 5	29.04.2019	05.05.2019	27.04.2020	03.05.2020
Week 6	06.05.2019	12.05.2019	04.05.2020	10.05.2020
Week 7	13.05.2019	19.05.2019	11.05.2020	17.05.2020
Week 8	20.05.2019	26.05.2019	18.05.2020	24.05.2020
Week 9	27.05.2019	02.06.2019	25.05.2020	31.05.2020
Week 10	03.06.2019	09.06.2019	01.06.2020	07.06.2020

Table 1
Lockdown weeks in 2020 in comparison with respective weeks in 2019

During the lockdown in 2020, the number of road traffic accidents was lower than in 2019.

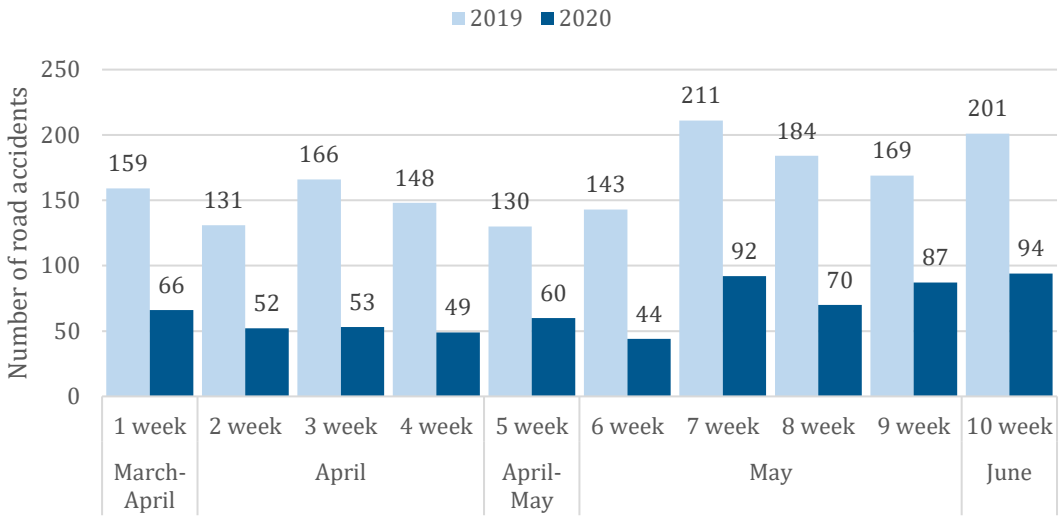

Figure 17
Dynamics of road traffic accidents by weeks of lockdown

In 2020, during the lockdown the highest number of road traffic accidents took place in the last lockdown week (June 3-9, 2020). The most significant decrease in the number of road traffic accidents (-69%) in comparison with 2019 was detected in the 6th lockdown week (May 6-12, 2020). In average, in 2019 from April 1 to June 9, there occurred 164 road traffic accidents per week, in 2020 - 67 road traffic accidents (Fig.17).

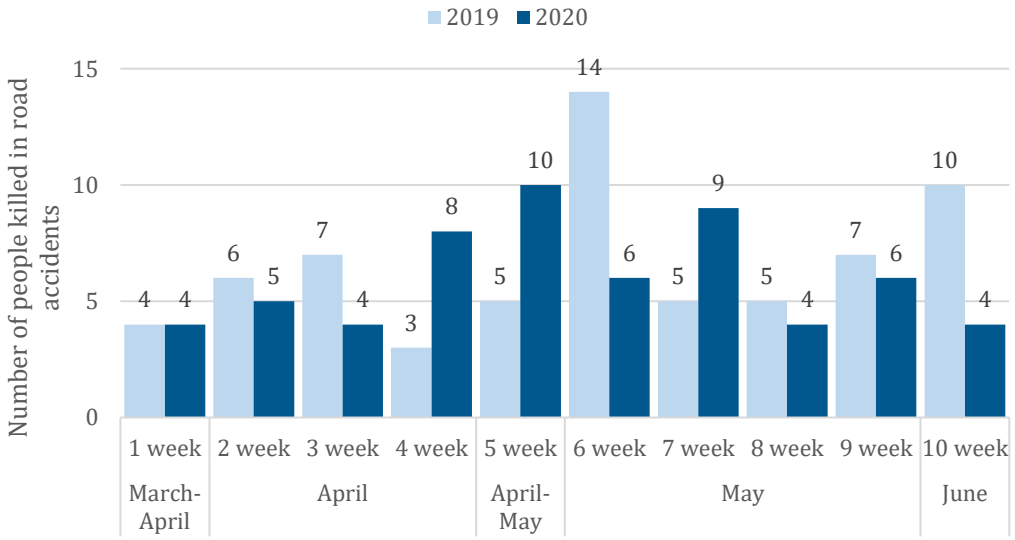

Figure 18
Dynamics of number of people killed in road traffic accidents by weeks of lockdown

During the sixth of ten lockdown weeks, the number of people killed was higher than in 2019; during the third of ten lockdown weeks, the number of people killed was higher than in the previous year; in the first lockdown week, the number of people killed was the same both in 2020 and in 2019. In the fourth lockdown week of 2020, eight people were killed in the roads (three people were killed in 2019); in the fifth lockdown week, ten people were killed (five people were killed in 2019); in the seventh lockdown week, nine people were killed (five people were killed in 2019) (Fig.18).

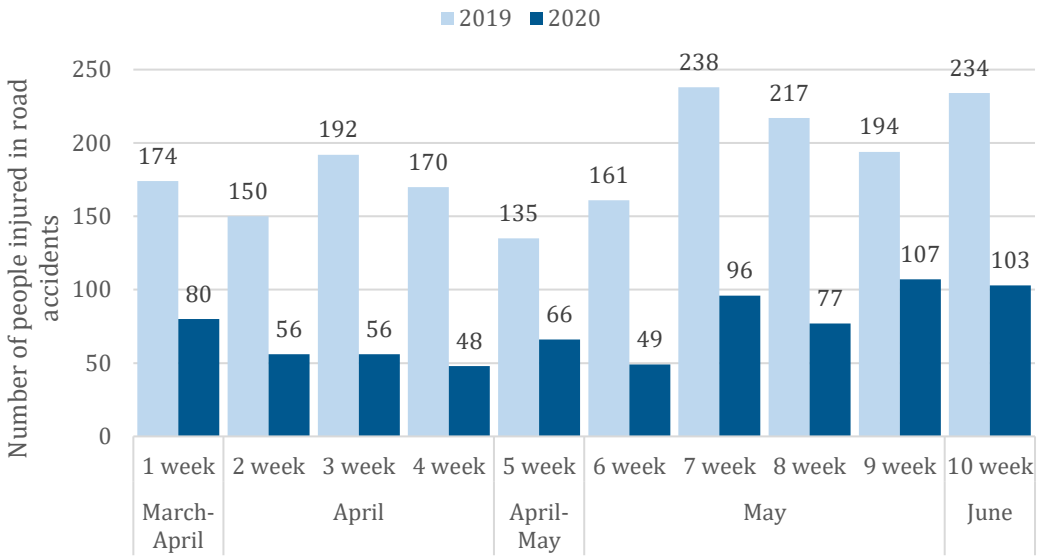

Figure 19
Dynamics of people injured in road traffic accidents by weeks of lockdown

In 2020, the highest number of people injured was recorded in the ninth lockdown week (from May 25 to May 31, 2020), the number of people killed was 107. During all the lockdown weeks, the number of people injured on the roads was lower than in the previous year. The most significant decrease in the number of people injured was recorded in the fourth lockdown week (April 20-26, 2020), the decrease was 72% (Fig.19).

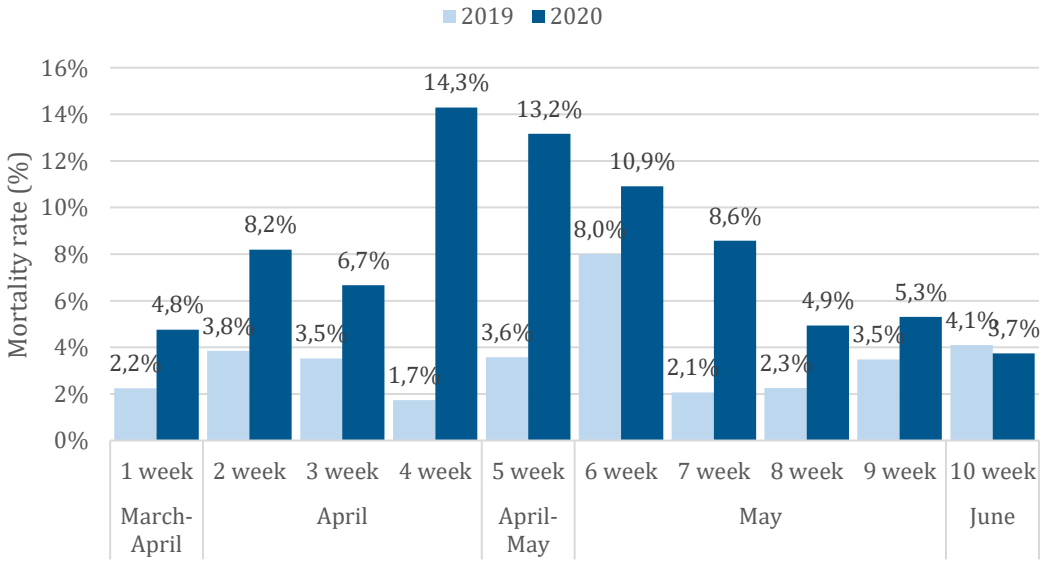

Figure 20
Dynamics of mortality rate by weeks of lockdown.

During the ninth of ten lockdown weeks, the mortality rate was higher in 2020 than in 2019. The highest mortality rate was recorded in the fourth lockdown week (April 20-26, 2020), it was 14.3%, i.e. every seventh victim of road traffic accidents died. In the fifth lockdown week, the mortality rate was 13.2% (in 2019 - 3.6%). In the sixth lockdown week, the mortality rate was high both in 2019 and in 2020 (8% in 2019, 10.9% in 2020).

In the tenth lockdown week, the mortality rate in 2020 for the first time became lower than the mortality in 2019 (4.1% in 2019 and 3.7% in 2020).

Discussion

Introduction of restrictions for movements and social distancing are an important tool to prevent propagation of COVID-19. In this work, the authors studied the data of traffic complex, determined the decrease in the number of vehicles on the roads and the increase in speeds. The data of road traffic injuries reflected the influence of the number of vehicles and their speed on the number of road traffic accidents, the number of people injured and killed.

As a result of the introduced measures of social distancing, the demand for trips decreased, many countries had already witnessed obvious drop of road traffic (significant decrease in loads and air pollution), as well as passenger traffic in public transport (often resulting in less frequent transportations)[43]. One of the consequences of social distancing, i.e. decreased interactions between people aiming at hindering of the virus propagation, was significant decrease in the number of city trips. For instance, restrictions of public transport in Great Britain resulted in decrease in the number of trips by subway in London by 95%. In addition, people can avoid public transport, since it is considered as a center of viruses and a place, where contact with other passengers can hardly be avoided. Even after removal of the restrictions people will use public transport less frequently[44].

Conclusion

During the lockdown in Moscow (from March 30 to June 9, 2020), the most noticeable changes of traffic mobility and city activity were observed in April. The number of vehicles on the roads decreased significantly and the speed sharply increased. The number of trips by public transport decreased; even at the end of June it was by 32% lower than usual. During the lockdown, especially in April, there were few people in the Moscow streets. Nevertheless, mortality in the fourth week of April reached 14.3%, i.e. it was by 8.4 times higher than in 2019. In April 2020, seven people more were killed on the roads of Moscow than a year earlier.

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