

University
Transportation
Research Center

Mobility Trends in New York City During COVID-19 Pandemic:

Analyses of transportation modes throughout June 2020

About the University Transportation Research Center

The University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, UTRC is functioning as a consortium of eighteen major Universities throughout New York, New Jersey, and Puerto Rico. UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium.

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The first case of the coronavirus was confirmed in the State of New York in New York City on March 1st, since then panic buying for food and household products was reported. On March 7th, Governor Andrew Cuomo declared a state of emergency in New York State. A second case in the State was announced on March 10th, which was the first known case in the State to be caused through community spread. On March 16th, Governor Cuomo issued an executive order to close all public and private schools throughout the State, initially ordered to last until April 1 but which was later extended. On March 22nd, the New York State stay-at-home order took effect. The coronavirus cases in New York increased massively to the point that it became the epicenter of the country. As New Yorkers worked together and flatten the curve, the reopening strategies came into effect in June to let businesses start. New York City entered Phase 1 of the reopening on June 8th and Phase 2 on June 22nd.

The aggressive actions taken by the state and city governments and businesses to slow the spread of the coronavirus are reflected by the performance of the transportation system in New York City. Steep changes in the mobility indicators have been observed as non-essential workers were ordered to remain in their homes and to travel only when essential (summarized in the table below). Where there was a steep decline in March and April, the mobility pattern started to get back as social distancing flattened the curve and the news of reopening emerged.

This report presents preliminary analyses of transportation-related data publicly available as of June 30, 2020 for New York City transportation systems. This report will be regularly updated as data becomes available.

Summary of Transportation Trends across Modes in NYC

Mode	Percent Change in June (or available month) from 2019 to 2020
Subway	(-)80% ridership
Bus	(-)50% ridership
Metro North	(-)94% ridership (May)
LIRR	(-)94% ridership (May)
PATH	(-)92% ridership from Feb to May
Traffic	+26-100% average speed
Taxi	(-)91% trips (from March)
Bike	(-)41% ridership, +26.8% longer trips ridership (May)
Environment	(-)31.7% NO2 AQI. (-)57.9% CO AQI (May) (-)16% PM2.5 AQI (June)

New Yorker's Reaction on the Novel Coronavirus

In today's world of technology, there are many ways to capture people's viewpoints during this unexpected time. The number of web search hits is one way to do this. The interest and awareness of city travelers about coronavirus has been examined by Google Trends. This can be done by searching with keywords like "Covid-19" in "New York City" with data acquired from different Google portals like Web, News, Images, Froogle, and YouTube. Figure 1 shows the result of people's interest about "Covid-19" acquired from Google Trends from February to the end of June 2020. It is observable that there was a huge spike in March, and then it started declining in April, stayed at the same level in May as information on the coronavirus pandemic became widely available. Searches about the coronavirus increased slightly in June as there are hikes of the virus in about 35 states.

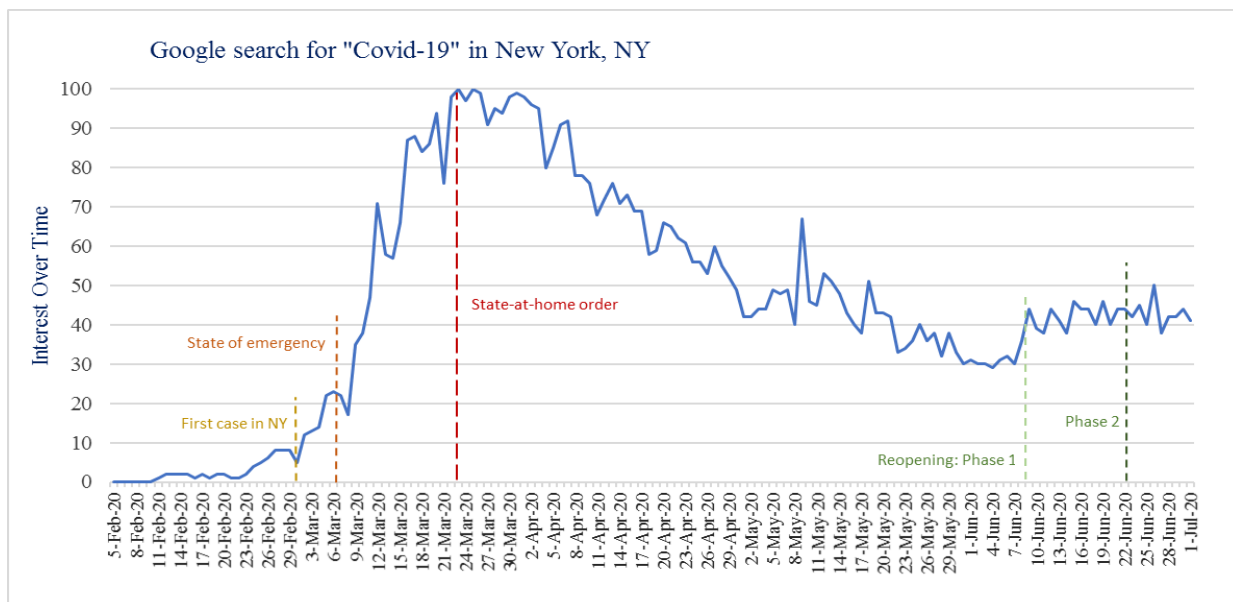


Figure 1: Interest of New Yorkers about coronavirus from February to May (Source: Google)

Meanwhile, Apple began to report about mobility trends in many cities all over the globe during this pandemic. This data was retrieved using search requests for directions on Apple Maps as a proxy for mobility. Figure 2 illustrates this trend in New York City split by three modes of transportation - driving, walking, and transit - up until July 2nd from the baseline of Jan 13th, 2020. One can visibly observe that there was a steep fall in directional requests for all three modes during March and April, and then, it bounced back in May and June as the state began reopening the businesses. Remarkably, in the social-distanced condition, driving direction requests have been peaking up quickly and more strongly, reaching to +35% at the end of June compared to the huge reduction of about 70% at the end of March. This indicates that as NYC is reopening, New Yorkers are going back on the road after two months of lockdowns.

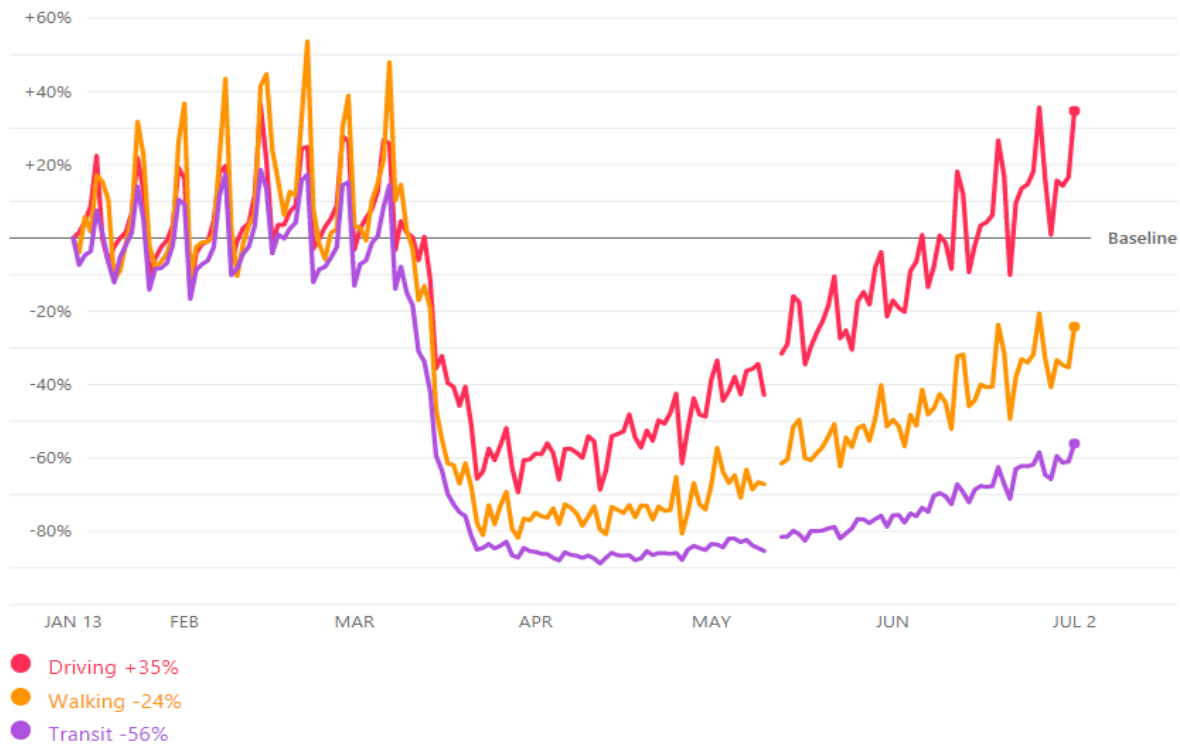


Figure 2: Requests for directions from Apple Maps up to July 2nd (Source: Apple)

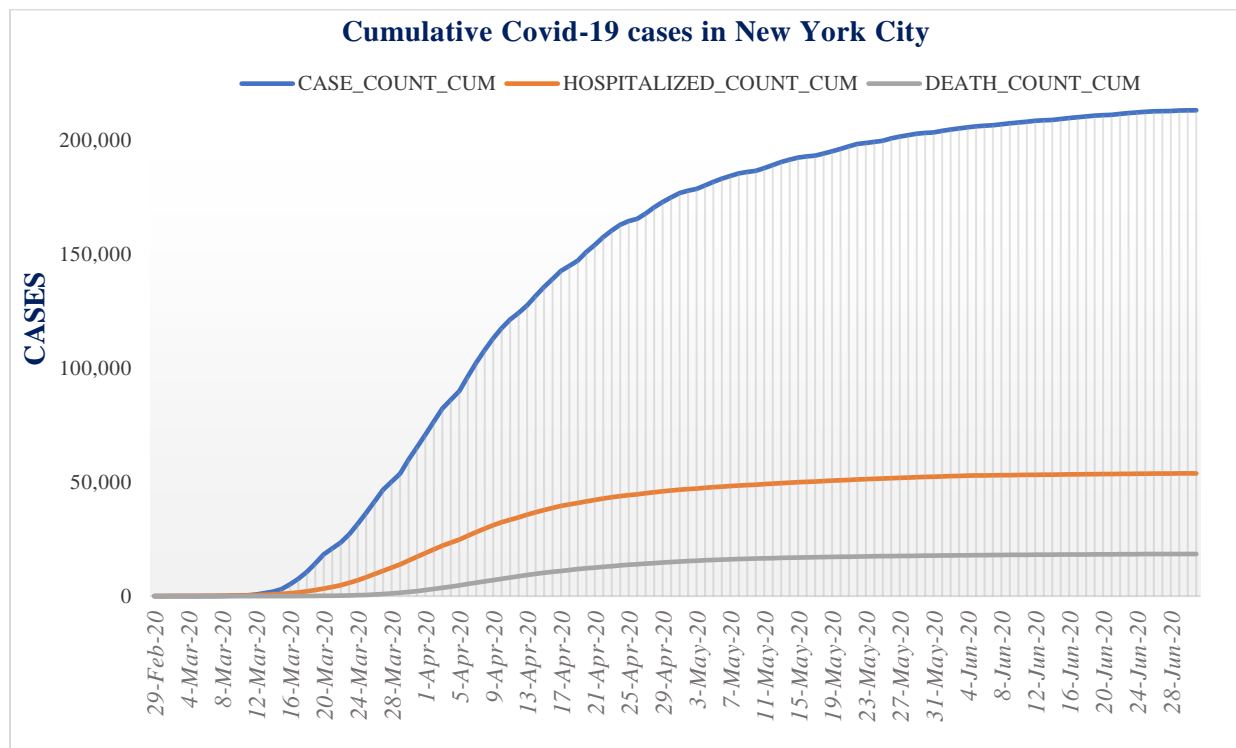


Figure 3: Cumulative Covid-19 cases in New York City up to June 28th

Figure 3 displays the cumulative distribution of infected cases up to June 28th by date of diagnosis, hospitalizations by date of admission, and death counts by date of death. Also, figure 4 reflects the spatiotemporal data for the total number of positive cases from COVID-19 per zip-code in New York City through June 9th, the latest date that positive cases per zip-code has been updated. Low income and older populations have been disproportionately impacted.

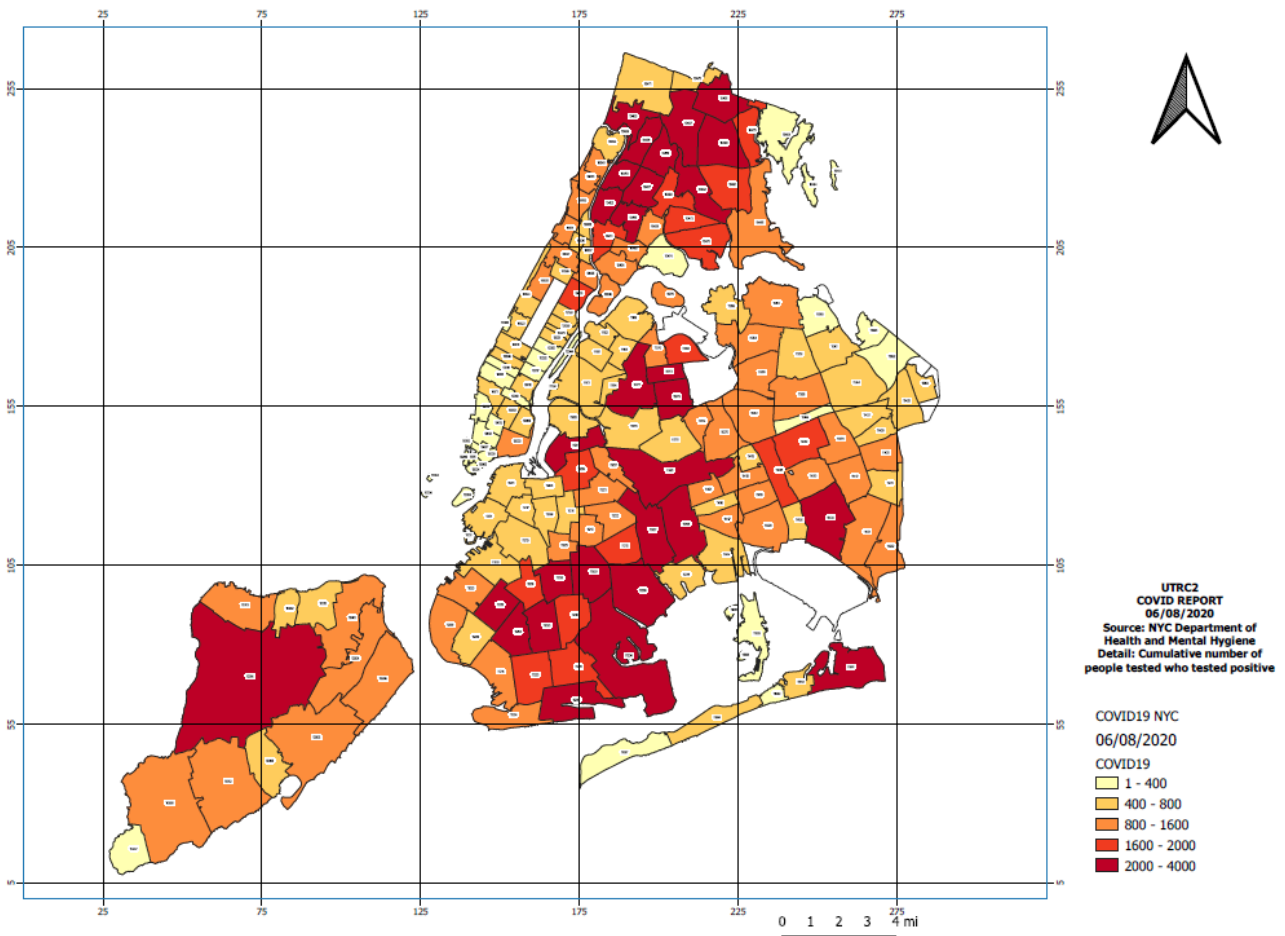


Figure 4: Total count of positive COVID-19 cases based on patient address by ZIP code (Source: NYC Health)

Public Transit

Public transit ridership was severely impacted by actions to slow the spread of COVID-19 viruses such as school closings, the shelter-at-home order, the closing of non-essential businesses, etc. Figure 5 displays the percentage of ridership declines by transit mode in New York City on March 12th, March 16th, March 23rd, April 2nd, April 17th, May 15th, and June 30th (available only for Subway and NYCT Bus), compared with similar dates in 2019 as reported by the Metropolitan Transportation Authority (MTA). It is apparent from the graph that transit ridership dropped on all transit modes operated by MTA which include: Subway, NYC Transit Bus, MTA Bus, Metro North Railroad (a.m. peak), and Long Island Railroad (a.m. peak). The declines in public transit ridership for most of the operators in May continued to be more than 90%, and still represent lower levels of transit ridership during this pandemic crisis. One can observe that ridership is improving on the subway and buses in June as NYC has entered into the Phase 2 of reopening.

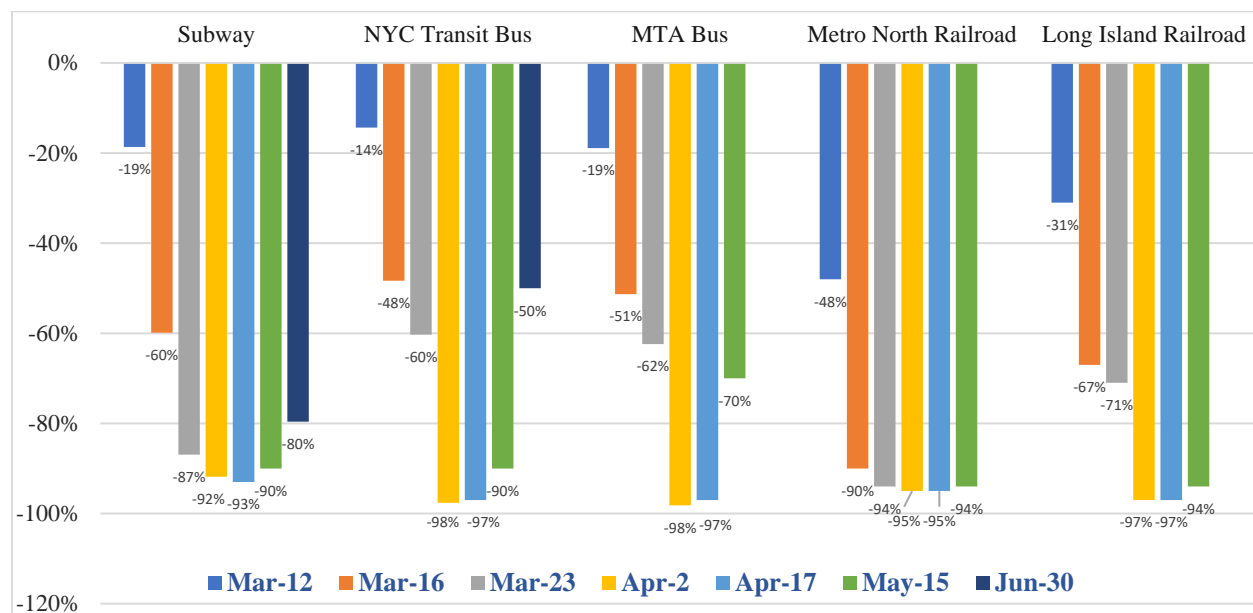


Figure 5: Transit ridership percentage reduction on March 12th, 16th, March 23rd, April 2nd, April 17th, May 15th, and June 30th from 2019 to 2020 (Source: MTA)

To understand the trends of subway ridership, the ridership data over time at South Ferry subway station is used for illustration. Figure 6 shows the daily turnstile entries and moving average of the mean over a seven-day rolling window at the South Ferry subway station, starting from January 1st in 2020 to June 19th in 2020. This ridership includes all turnstile entries of the subway station. The rolling average method reduces noise in time series data, enabling the ability to look at obvious trends. The subway ridership decreased gradually, then plunged suddenly in March 2020, and continued to perform with a very low ridership during April as shelter-in-place orders were mandated by state officials.

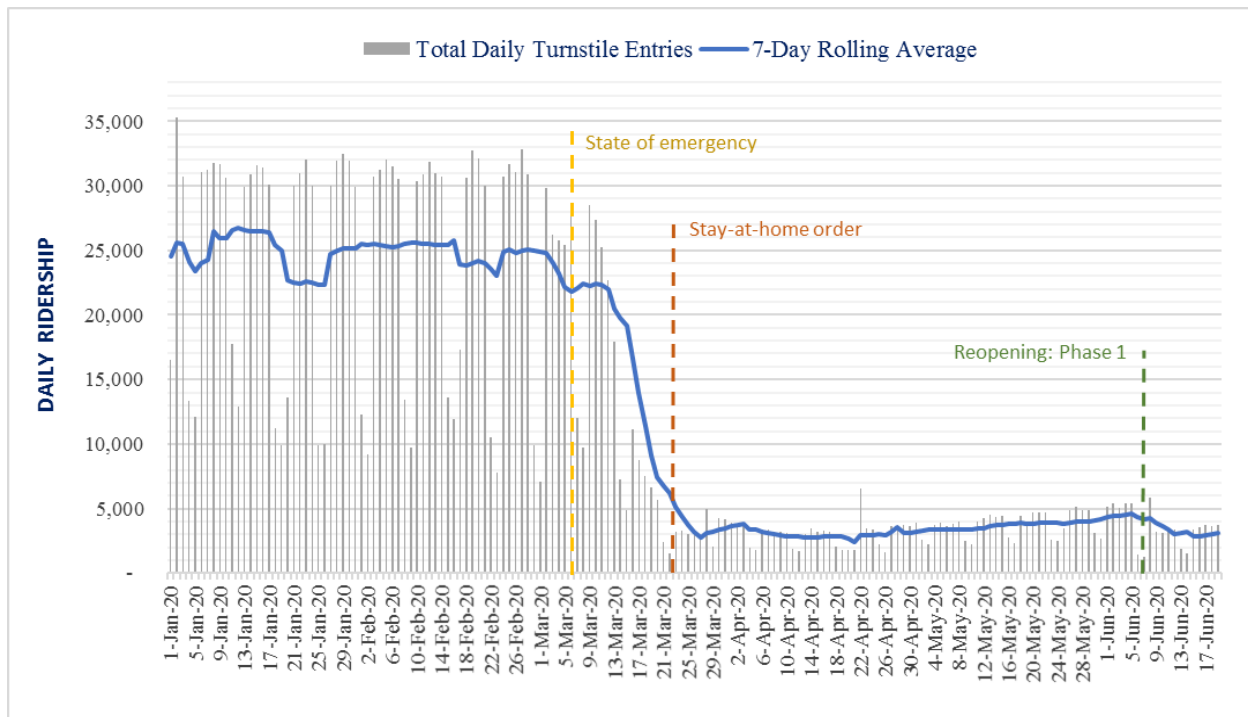


Figure 6: Daily entries and 7-day rolling average of the mean of South Ferry subway station

To better grasp the performance of public transit during Covid-19, figures below show the average of all subway and bus ridership in New York City day-by-day and grouped by month. Figure 7 summarizes the average of the total subway ridership on each day of a week which is categorized per month from March to June in 2020. It is evident that there was a huge drop in total subway ridership from March to April. The ridership started bouncing back in June, with the similar upward trends on all days of the week.

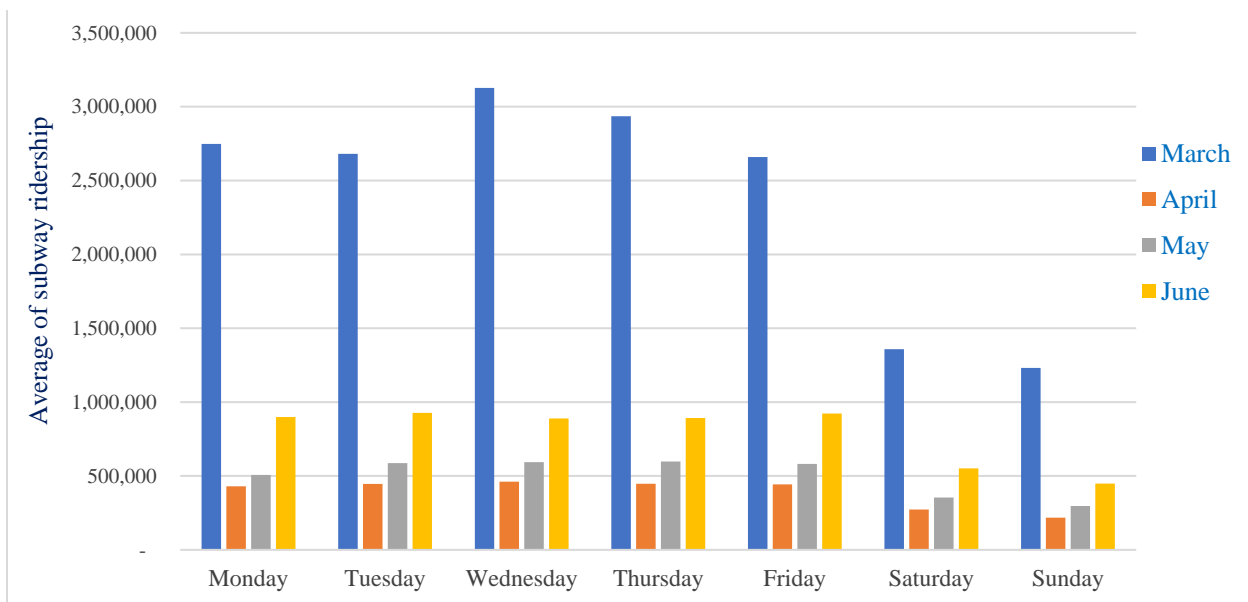


Figure 7: Day-by-day average subway ridership from March to June in 2020 (Source: MTA)

Figure 8 below displays the day-by-day average bus ridership from March to June in 2020. As seen in subway ridership, a similar pattern has been recognized in the bus ridership; after a plunge from March to April, the bus ridership followed an upward trend in May and June among all days.

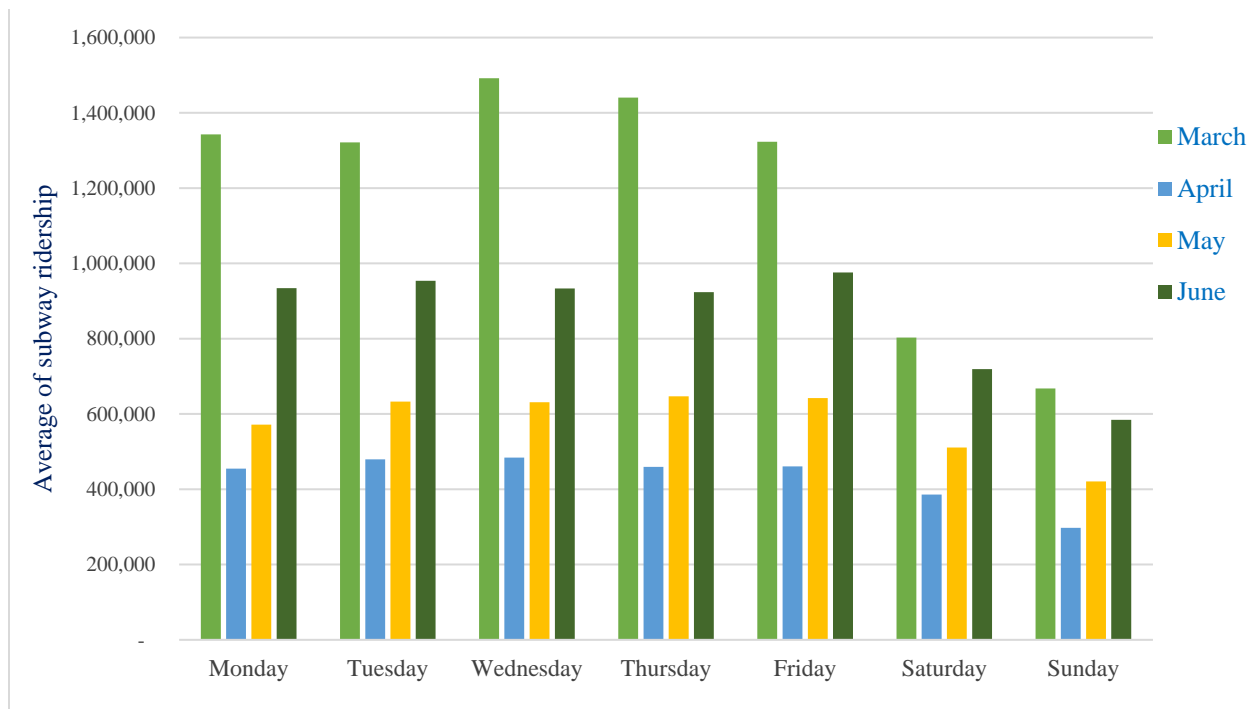


Figure 8: Day-by-day average us ridership from March to June in 2020 (Source: MTA)

PATH Train

The impact of Covid-19 on PATH train ridership has also been severe. Figure 9 illustrates the average daily ridership of PATH service in February, March, April, and May in 2020. Here, only ridership changes for stations located in New York City are reported. PATH train average daily ridership declined more than 50% at all NYC's stations from February to March. This ridership has fallen by more than about 95% from February to April. The total of New York subtotals were 2,806,746 in February, 1,390,259 in March, 157,669 in April, and 229,497 in May, representing 50% a reduction from February to March, a 94% drop from February to April, and 92% drop from February to May.

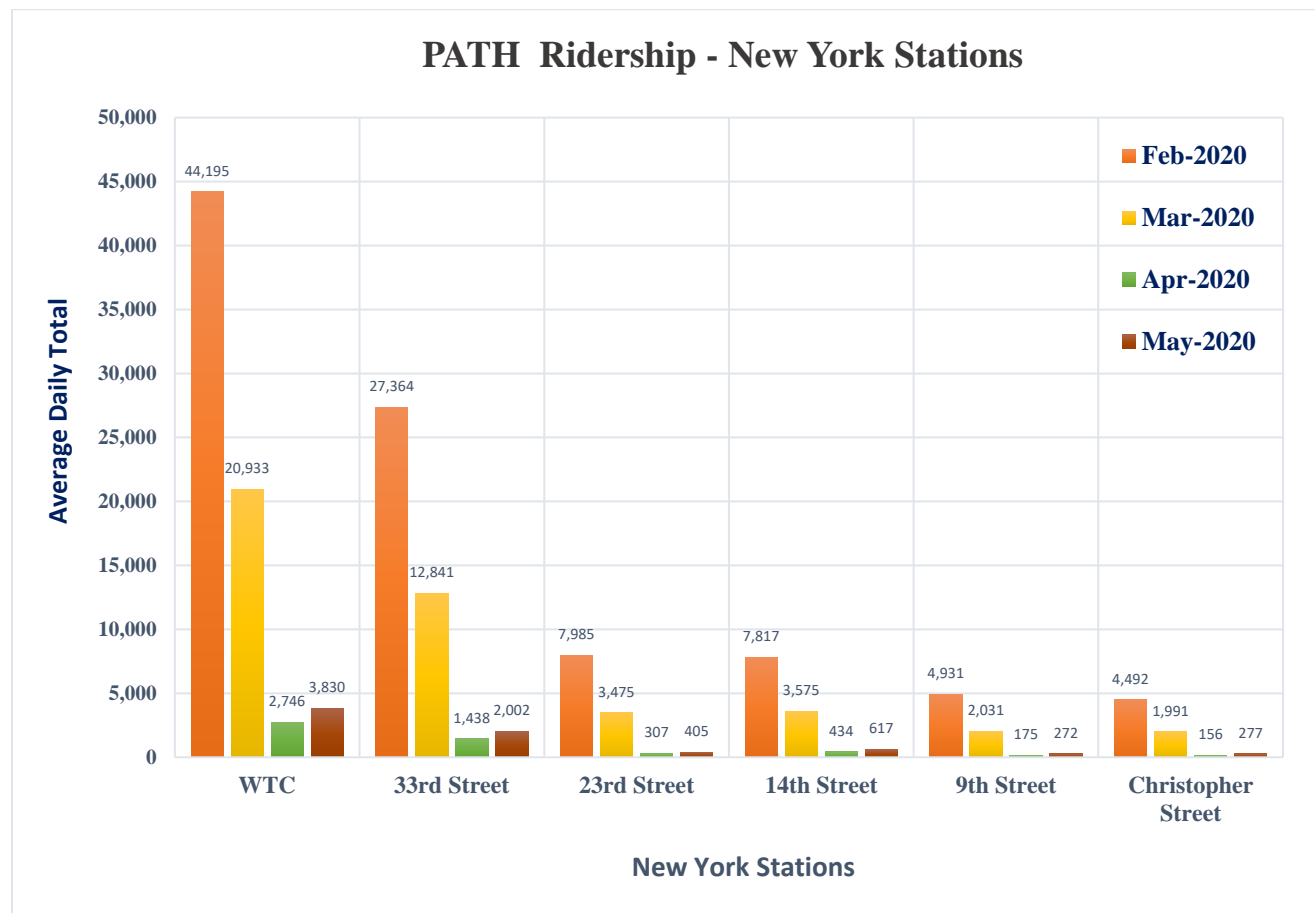


Figure 9: Average Daily of PATH ridership of New York stations in February, March, April, and May 2020
(Source: PANYNJ)

Vehicular Traffic Volume

Traffic volumes on bridge and tunnel crossings in and around NYC have changed significantly from one month to another during the pandemic. As shown in Figure 10, MTA's bridges and tunnels data on March 12th, 16th, 23rd, April 2nd, April 17th, May 17th, and June 30th showed a 9%, 21%, 60%, 65%, 62%, 53%, and 19% reduction respectively from the corresponding and comparable days in 2019. Traffic started to increase in April and we can observe a large volume of traffic in June although it is still 19% less than the volume of 2019.

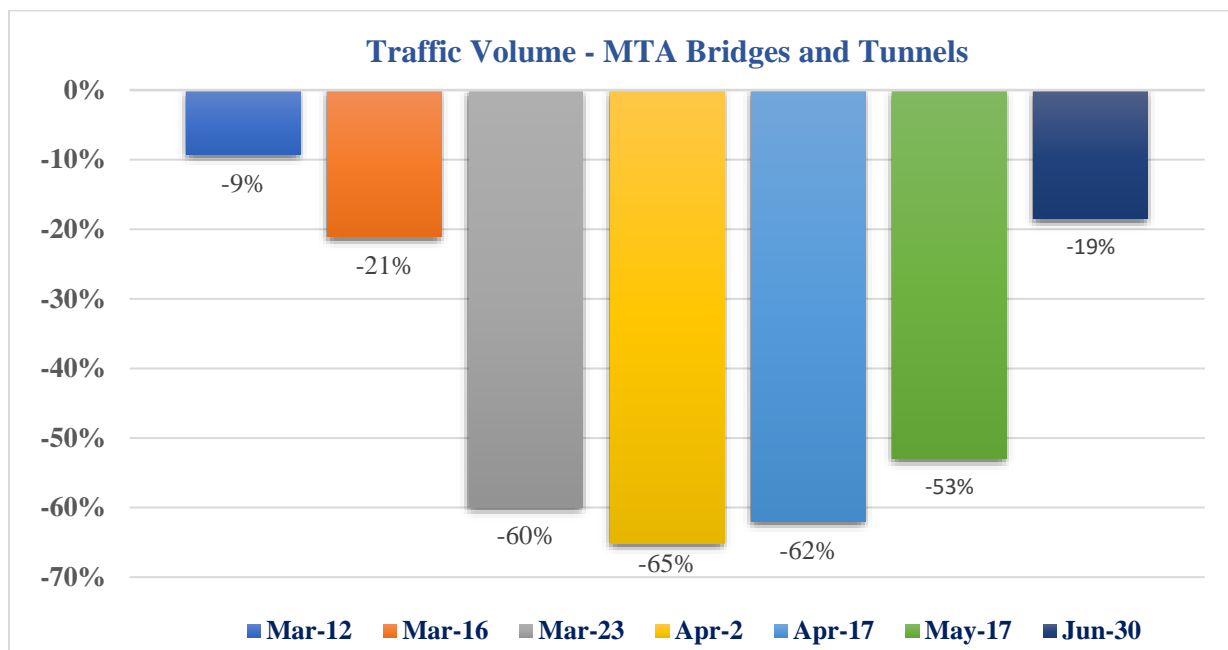


Figure 10: MTA Bridges and Tunnels percentage changes in volume on March 12th, 16th, March 23rd, April 2nd, April 17th, May 17th, and June 30th from 2019 to 2020 (Source: MTA)

Figure 11 illustrates the time series of daily total traffic volume on MTA bridges and tunnels. It is evident that the traffic volume on MTA bridges and tunnels was at its lowest values in April 2020. As lockdown measures started to be relaxed, traffic volume increased in May and surged in June. One can predict that it will continue to increase further in July 2020.

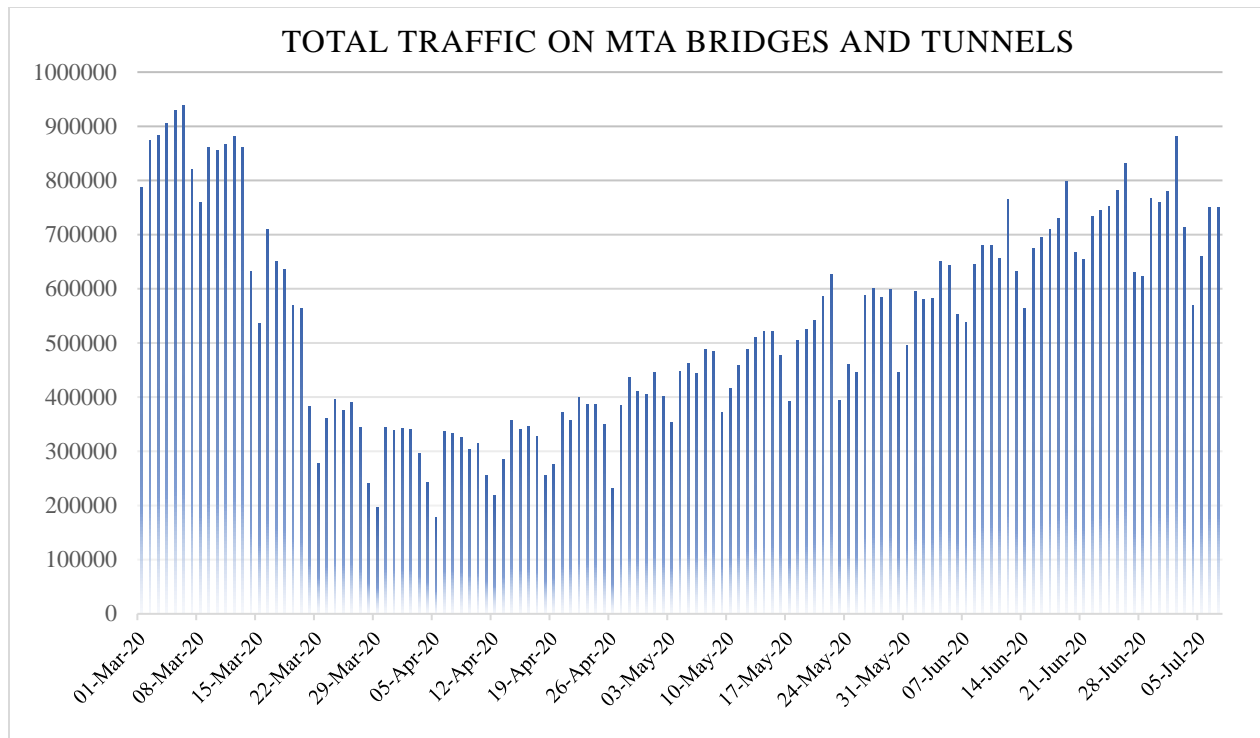


Figure 11: Day-by-day comparison of sum of total traffic on MTA bridges and tunnels from March to June (Source: MTA)

Taxi

As we continue to develop this report, the NYC Taxi and Limousine Commission has not released the yellow and green taxi trip records for the months of March, April, May, and June 2020. The largest taxi group of New York City which represents 5,500 yellow cabs, the Metropolitan Taxicab Board of Trade, provided an estimate. Comparing taxi trips that occurred on February 27-29, 2020 to three weeks later during the COVID-19 crisis, the March 17-19 Friday-Saturday-Sunday total dropped from 217,540 to 20,596. This indicates that there had been a plunge of 91 percent in taxi trips.

Vehicular Traffic Speed

With the limitation imposed on non-essential travel, together with the announcement of the state of emergency and stay-at-home orders, the volume of vehicles on roadways has decreased and the speed of vehicular traffic has increased during the covid-19 pandemic. In Figure 12, the average reported traffic speed on arterial roads in all NYC's five boroughs is displayed. The average speed was recorded at 5:00 PM on every Wednesday during the months of March, April, and May 2020. It is observed that the average speed surged gradually at the end of March, stayed about the same level during April, and then, it started declining slightly in May as traffic activities began to increase on NYC's arterials.

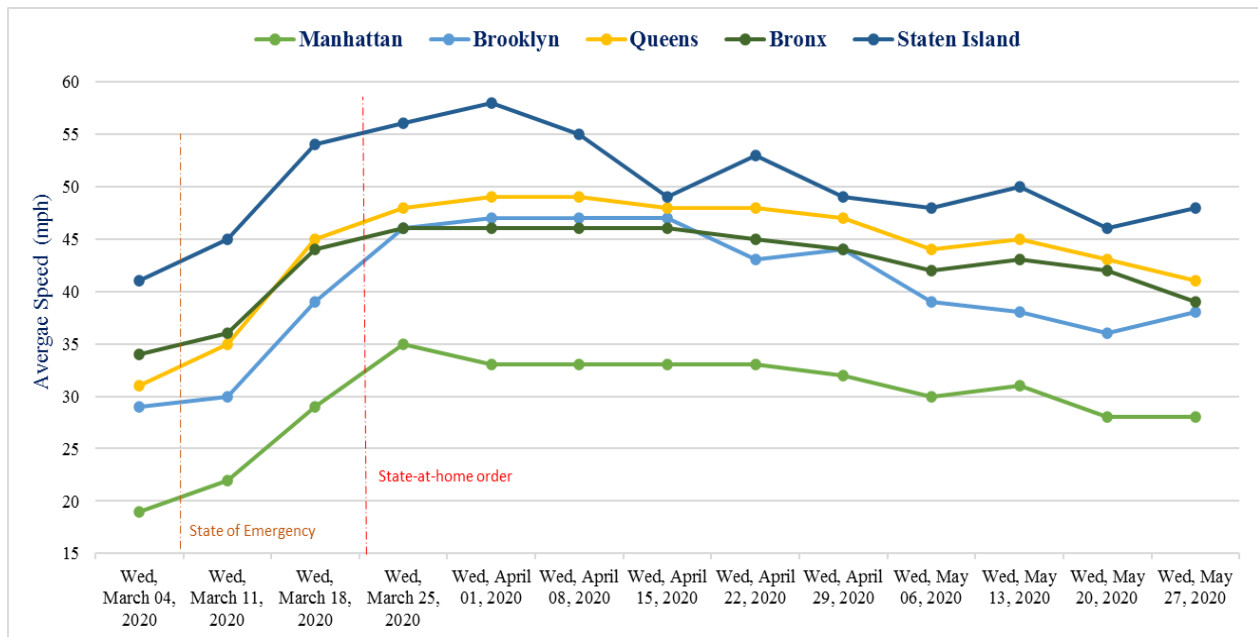


Figure 12: Average recorded speed during March, April, and May 2020 (Source: TRANSCOM)

In Table 2, the improvements of the recorded speeds during the three months of 2020 are compared to the corresponding average monthly values of March, April, and May in 2019. It is evident that from the third week of March, the average speeds in all five boroughs have increased significantly, passing over more than 20 MPH in speed improvement for some. This average speed improvement is more pronounced in Brooklyn and Queens, specifically during April and May.

Table 2: Speed changes (MPH) in New York City’s five boroughs during March, April, and May (TRANSCOM)

	4- Mar	11- Mar	18- Mar	25- Mar	1- Apr	8- Apr	15- Apr	22- Apr	29- Apr	6- May	13- May	20- May	27- May
Manhattan	-5	-2	+5	+11	+14	+14	+14	+14	+13	+16	+17	+14	+14
Brooklyn	-2	-1	+8	+15	+23	+23	+23	+19	+20	+16	+15	+13	+15
Queens	+1	+5	+15	+18	+21	+21	+20	+20	+19	+21	+22	+20	+18
Bronx	+2	+4	+12	+14	+16	+16	+16	+15	+14	+19	+20	+19	+16
Staten Island	-1	+3	+12	+14	+18	+15	+9	+13	+9	+10	+12	+8	+10

The improvement in average speed is associated with low traffic volumes on streets and highways during this pandemic. However, such improvements in traffic speed have caused some negative consequences on auto travelers. The New York City finance department reported that the City’s automated speeding cameras have issued nearly 24,000 speeding tickets in March, resulting in almost double the amount of tickets that were issued in February.

Travel Time

Travel time is one the major components for measuring the performance of transportation facilities like expressways, streets, tunnels, bridges, etc. In the following figures, we have shown the variability of travel time on expressways and in tunnels in New York City. Figure 13 displays the travel time performance of FDR/Harlem Drive northbound from Catherine Slip to the George Washington Bridge from 6 AM to 7 PM. It plots the averages Tuesdays from January 2020, February 2020, March 2020, April 2020, and May 2020 and compares it to Tuesday of June 30, 2020 (labeled “Selected Day’s TT” on the graph).

FDR/Harlem River Drive NB Catherine Slip to George Washington Bridge

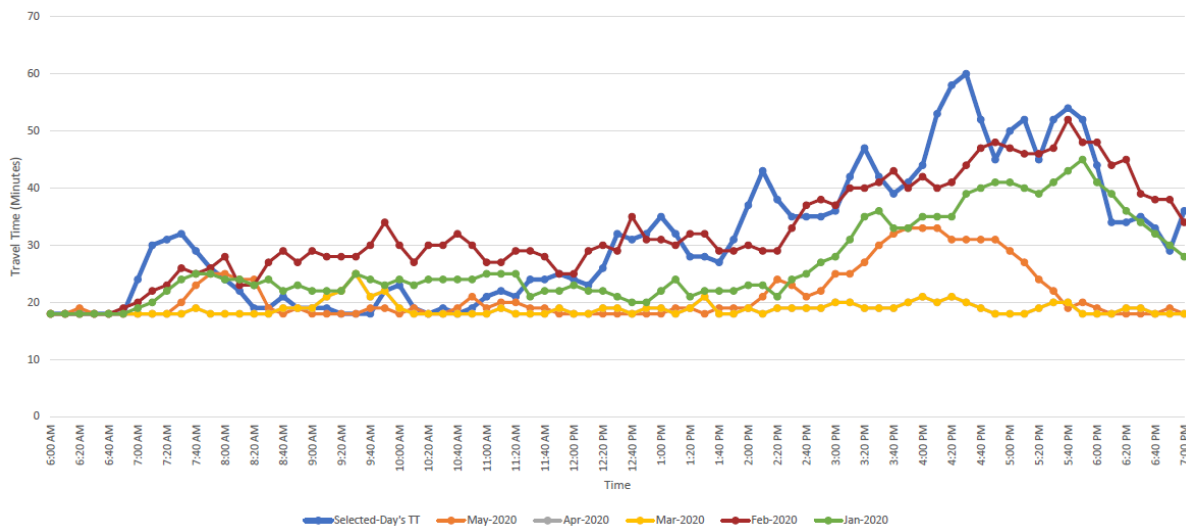


Figure 13: Travel time on FDR/Harlem River Drive, monthly average from 6 AM to 7 PM (Source: TRANSCOM)

Figure 14 shows the travel time performance of the Queens-Midtown Tunnel Exit 39 to Manhattan side. The graph compares travel times from June 17th, 2020 to the first Wednesday of Phase II in Long Island (June 10th, 2020), Phase I (May 27th, 2020), and full restrictions (March 25th, 2020) as well as Wednesday, June 19, 2019 and free flow for context. It is evident after phase 1 and phase 2 of reopening New York City, that the travel time has increased.

QMT WB LIE Exit 39 (Glen Cove Rd) to Manhattan Side

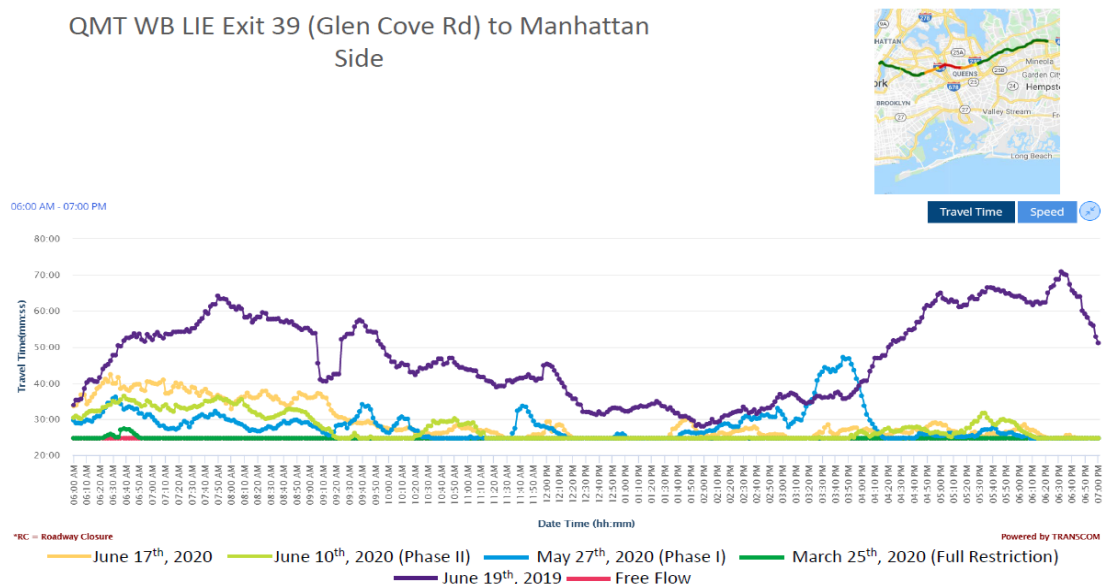


Figure 14: Travel time on QMT on different selected days from 6 AM to 7 PM (Source: TRANSCOM)

Freight

Figure 15 displays the inbound truck volume on PANYNJ crossings together with new daily COVID-19 cases in New York City, from the beginning of March to the end of May. It is evident that from the time NYS and NJ announced the closure of non-essential businesses, there was a sudden fall in truck volume. The fall in truck volume reached its lowest point in mid-April with a fall of 40% from 2019. Then, it reversed to an increasing trend as e-shopping behaviors have escalated and more businesses have come online.

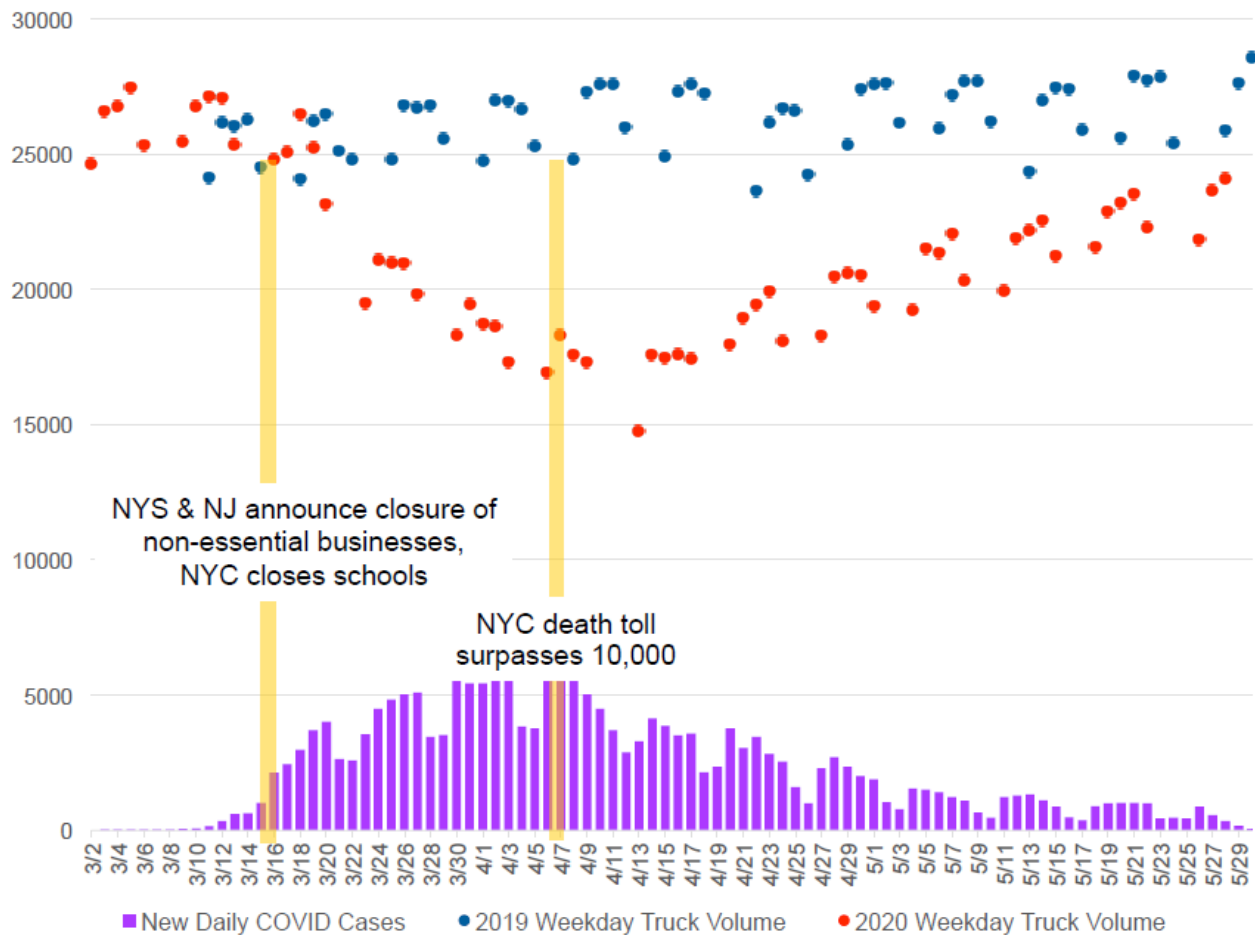


Figure 15: Inbound PANYNJ truck volume crossings and COVID-19 cases (Source: NYCODT and PANYNJ)

Parking Violation

Parking violation has been one of the major issues of congestion management in large cities like New York City. During the coronavirus pandemic, there has been less congestion in cities. It was anecdotally observed that a mode shift from transit to driving by essential workers occurred since roads were less congested and people tried to limit the risk of infection perceived in transit vehicles. At the same time, commercial vehicles moved actively to deliver goods to homes and businesses. Their importance has become more appreciable during this COVID-19 pandemic as reliance on e-commerce and home delivery accelerated. In this section, we analyze the parking violation data for passenger vehicles and commercial vehicles. Table 3 illustrates the number of parking violations during February, March, April, and May in 2019 and 2020. It is recognizable that while the number of parking violations increased in February when comparing values from 2019 to 2020- this number decreased in March and plummeted during April and May. For example, the parking violations for passenger vehicles fell by about 6% in March, plunged to approximately 37% in April, then plummeted about 51% in May. Such a change was more remarkable for commercial vehicles as the numbers of parking violations decreased by 20% in March and about 90% in April and May. Reasons for these declines in the number of parking violations may be related to less congestion in streets, availability of more curb parking spaces, and more lenient enforcement.

Table 3: Number of parking violations for passenger and commercial vehicles in 2019 and 2020

Parking Violation	Passenger Vehicle	Commercial Vehicle
February, 2019	610,964	158,093
March, 2019	699,562	177,079
April, 2019	635,555	175,507
May, 2019	698,764	168,414
February, 2020	855,200	195,283
March, 2020	657,057	141,338
April, 2020	397,841	15,877
May, 2020	341,446	16,208
February: change from 2019 to 2020	40%	24%
March: change from 2019 to 2020	-6%	-20%
April: change from 2019 to 2020	-37%	-91%
May: change from 2019 to 2020	-51%	-90%

To better grasp the trend in parking violations, Figure 16 and Figure 17 show the weekly pattern by passenger and commercial vehicles from week 7 to week 22 (from mid-February to end of May) of years 2019 and 2020. As shown, the parking violation of commercial vehicles started declining from week 12 or the end of April.

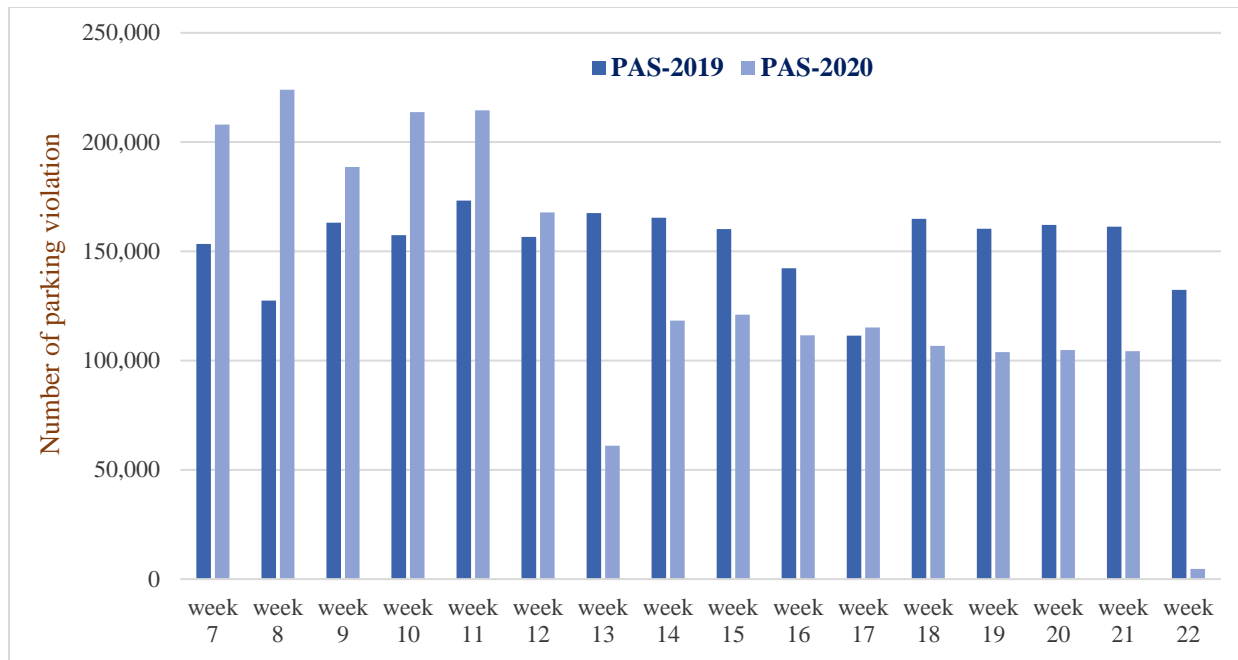


Figure 16: Number of parking violations for passenger vehicles, from week 7 (mid-February) to week 22 (end of May) (Source: NYC Open Data)

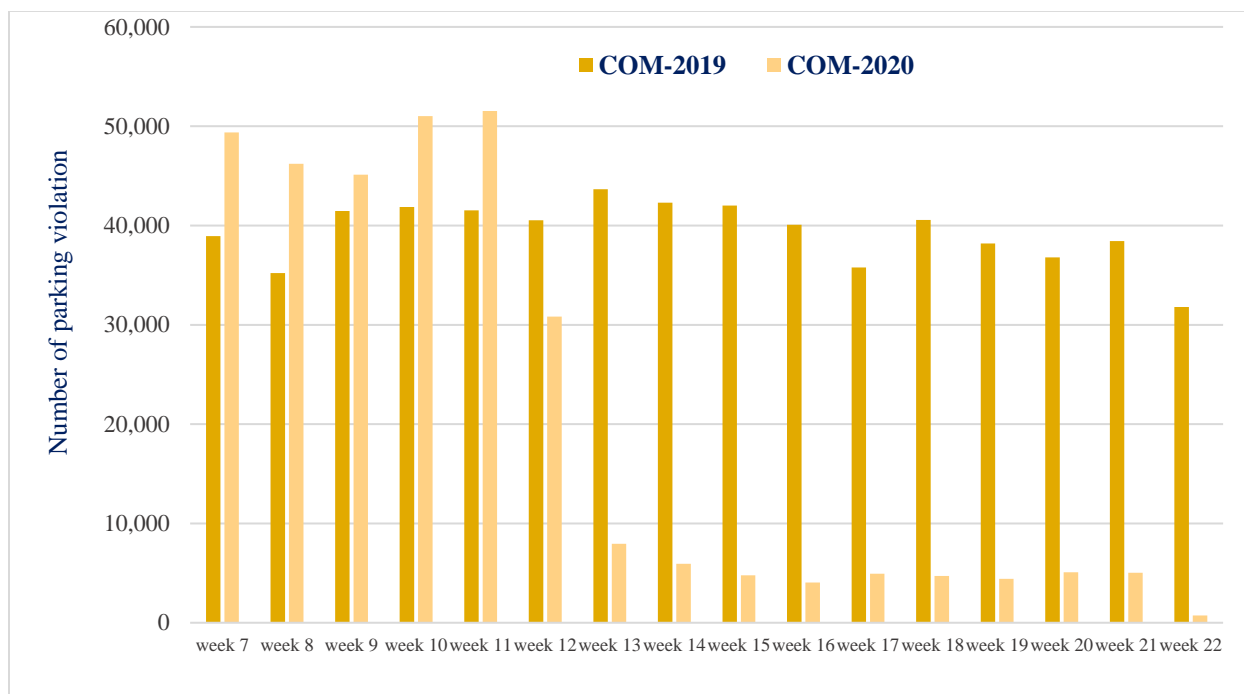


Figure 17: Number of parking violations for commercial vehicles, from week 7 (mid-February) to week 22 (end of May) (Source: NYC Open Data)

Safety

Motor Vehicle Accidents

To investigate the performance of traffic safety during the COVID-19 pandemic, the number of motor vehicle crashes in New York City are analyzed and compared. Figure 18 illustrates the total of motor vehicle crashes in New York City from February to June in 2019 and 2020. One can visibly observe that the total monthly crashes have significantly decreased from 2019 to 2020. This crash reduction is highly recognizable during April, May, and June 2020. The highest reduction in crash occurrence happened in April with a 75% drop, falling from 34,081 crashes in 2019 to 8,417 crashes in 2020. Such a percentage reduction has also been notable in May and June 2020, with drops of 68% and 65%, respectively. The reduction in total number of crashes shows a bright insight of this crisis. However, a major contributor for this reduction is due to low traffic volumes in New York City streets during this pandemic.

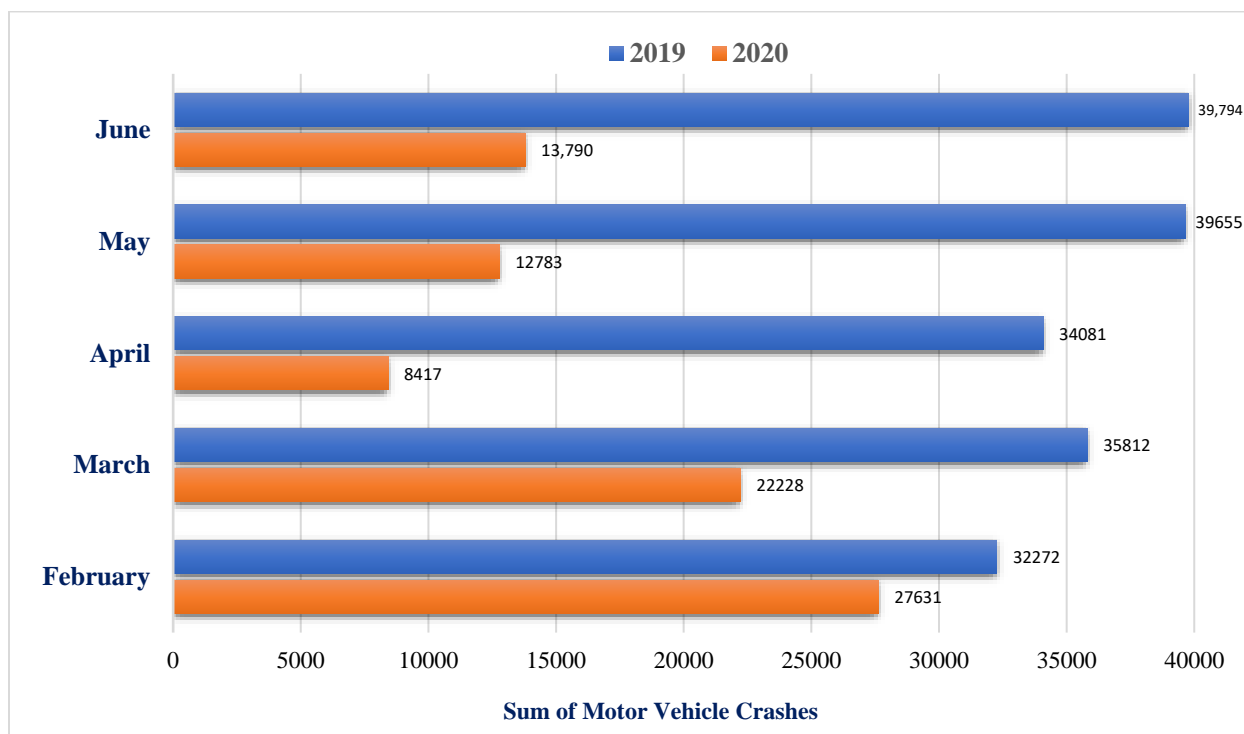


Figure 18: Sum of motor vehicle crashes from February to June in 2019 and 2020 (Source: NYC Open Data)

Roadway Incidents

In this section, the total number of incidents that occurred in the states of Connecticut, New Jersey, and New York, as reported by TRANSCOM, is presented. The total number of incidents is aggregated on a weekly basis during March, April, May, and June 2020. One can visibly observe that the number of weekly incidents in the tri-state region has declined gradually from mid-March; it hovered around the same level during April; and then it started toward an upward trend in May and June.

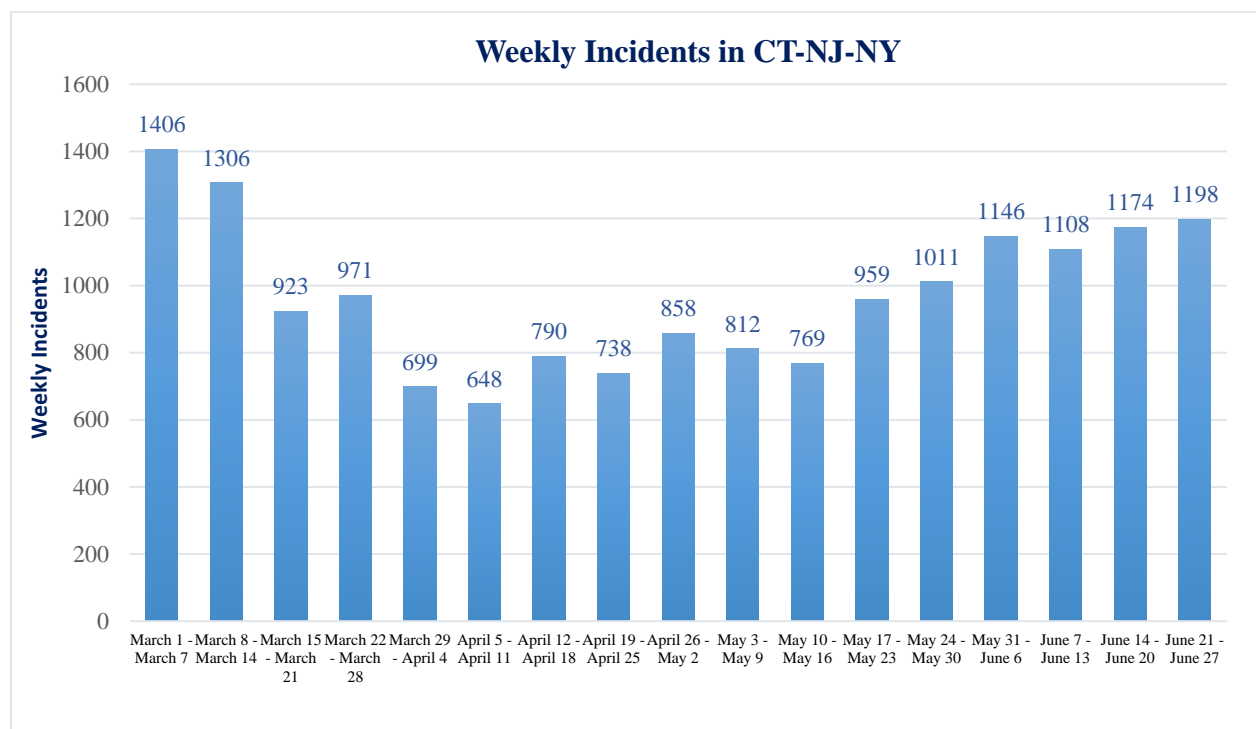


Figure 19: Total weekly incidents during March, April, May, June 2020 (Source: TRANSCOM)

Citi Bike

To understand the impact of COVID-19 on bike ridership, Citi Bike trips that were made in New York City from January 2019 to the end of May in 2020 are compared. Figure 20 illustrates the daily bike ridership (trip starts) in Manhattan, Brooklyn, and Queens. Since the ridership in Manhattan was significantly higher, the natural logarithm of the Citi Bike ridership is used to scale the data.

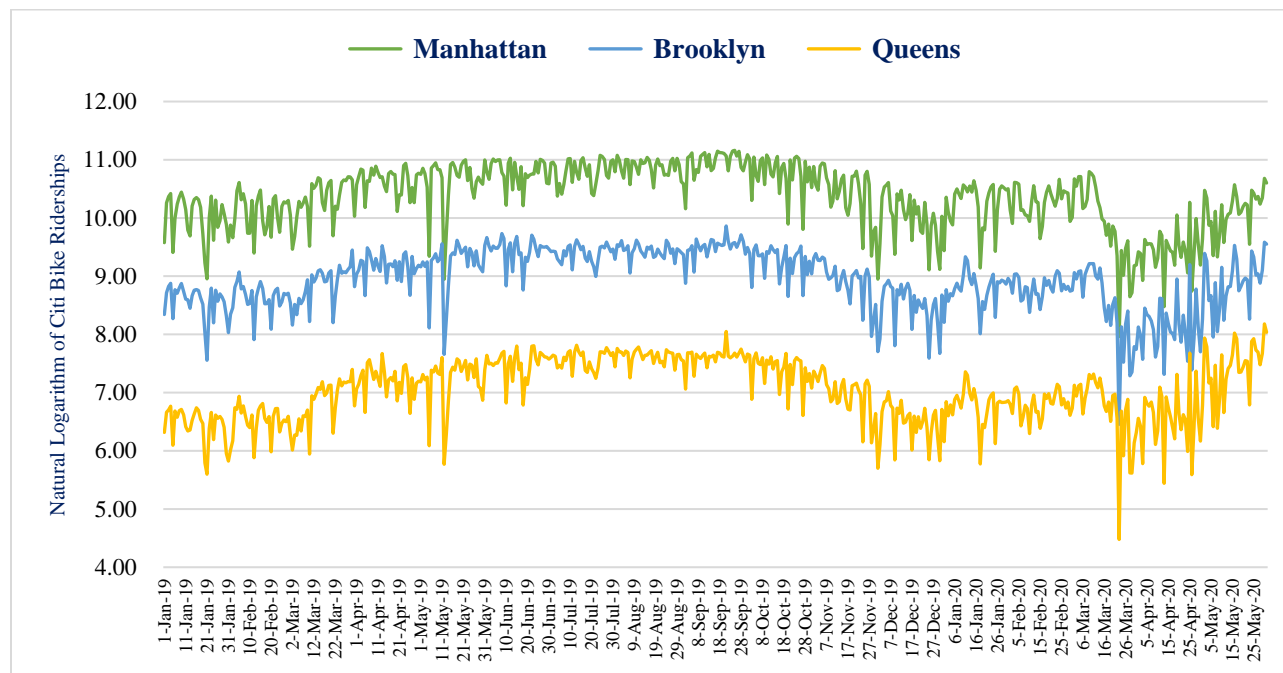


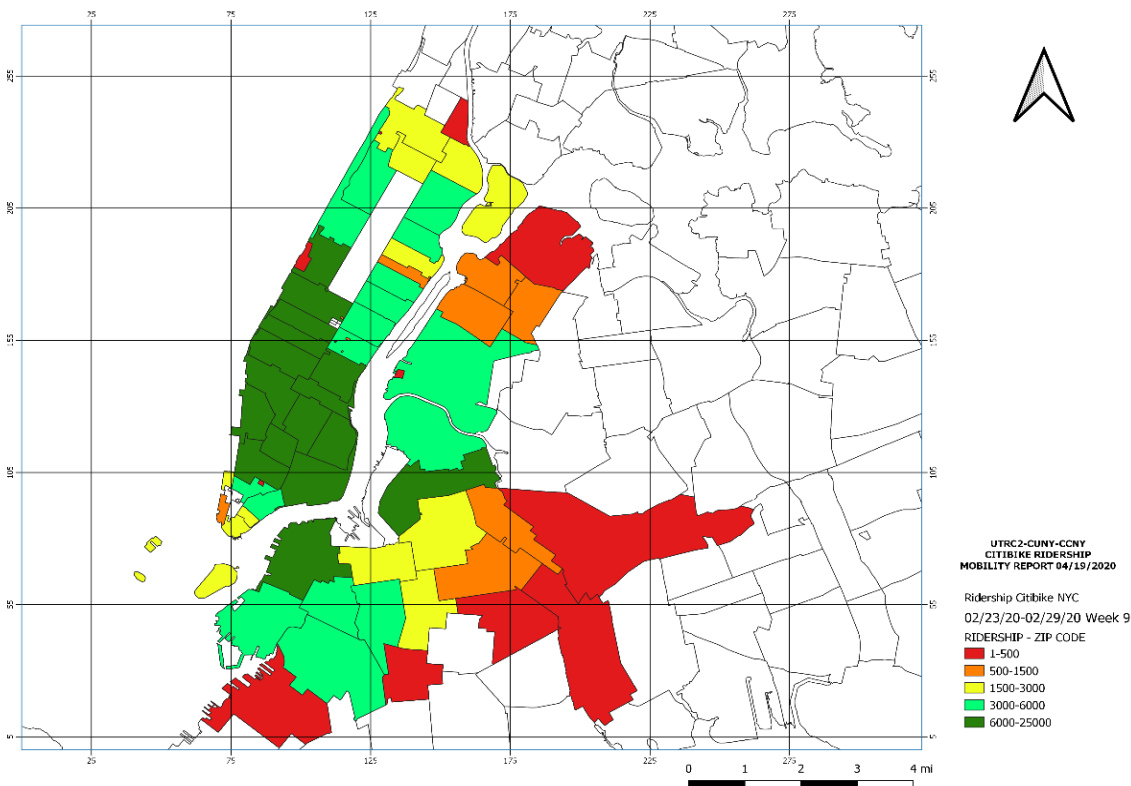
Figure 20: Natural logarithm plot of Citi Bike trips in three boroughs from Jan 2019 to May 2020

To compare the Citi Bike ridership trend from February to May in 2019 and 2020, Table 4 exemplifies the monthly change in Citi Bike ridership across three boroughs of Manhattan, Brooklyn, and Queens. The table shows that there was a significant ridership surge in February, and afterward, it was followed with a significant drop. This ridership drop became more noticeable in April 2020, falling 69%, 52%, and 43% in Manhattan, Brooklyn, and Queens, respectively. The bike ridership in Manhattan has been affected more during this pandemic. In May the change of ridership is less as compared to April, and surprisingly such a ridership has surged in Queens with an increase of 30% from 2019 to 2020.

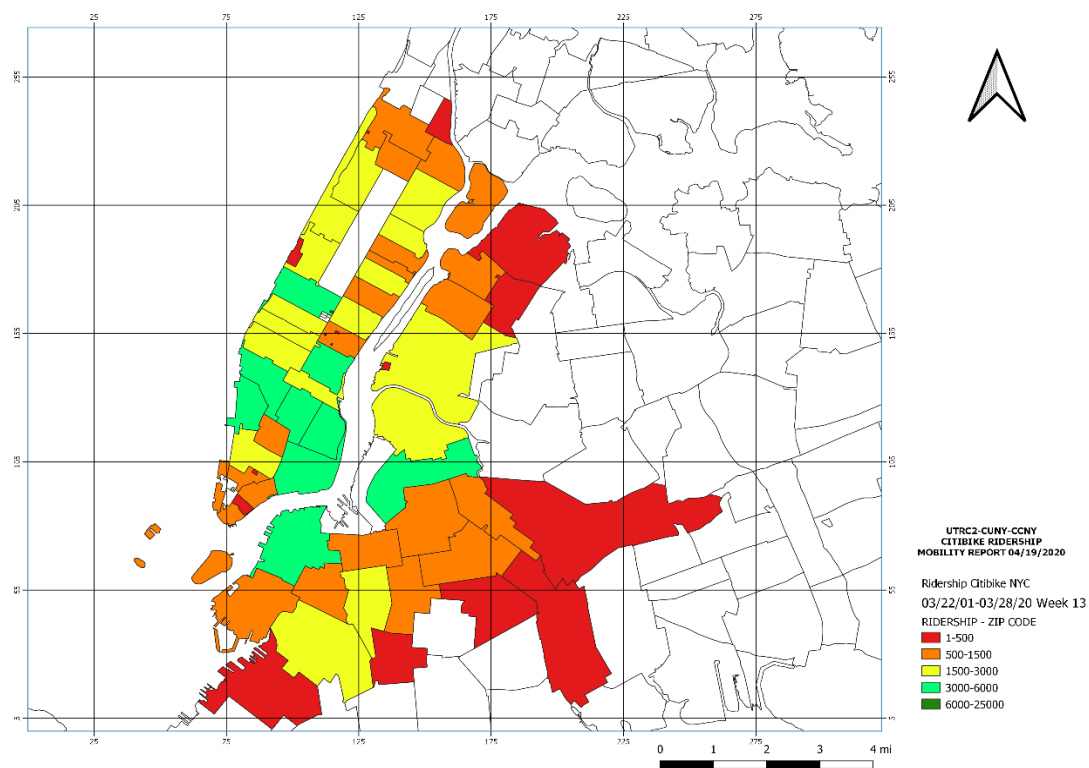
Table 4: Citi Bike monthly trips in three boroughs during February, March, April, and May in 2019 and 2020

	Manhattan	Brooklyn	Queens
February: change from 2019 to 2020	+22%	+21%	+34%
March: change from 2019 to 2020	-25%	-20%	-5%
April: change from 2019 to 2020	-69%	-62%	-43%
May: change from 2019 to 2020	-41%	-24%	+30%

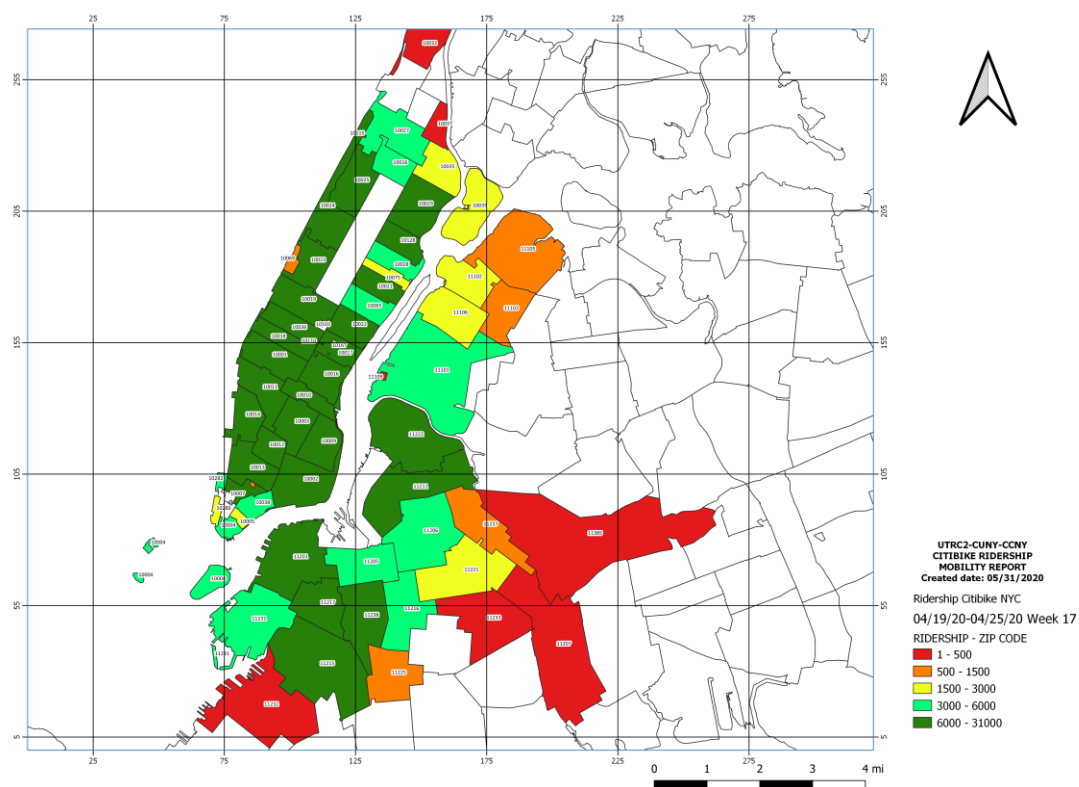
Figure 21, also shows the weekly Citi Bike ridership in New York City, aggregated at the zip-code level. The spatial and temporal maps in Figure 15 show the Citi Bike ridership for the last week of February, March, and April in 2020. More specifically, the three maps are for: *a)* February 23rd to 29th, *b)* March 22nd to March 29th, *c)* April 19th to April 25th, *d)* May 24th to 30th. All bike trips less than “30 minute trip length” have been visualized in the figures. As shown in the figures, the borough of Manhattan and more specifically, Midtown Manhattan and some parts of Lower Manhattan had the highest bike ridership in February and March. This high bike ridership expanded to all parts of Manhattan in the last week of April. Also, zip-codes for Downtown Brooklyn and East Williamsburg show a high range of bike ridership. The bike ridership has decreased significantly at almost all zip-codes during the last week of March and May, the 13th and 17th weeks of 2020.



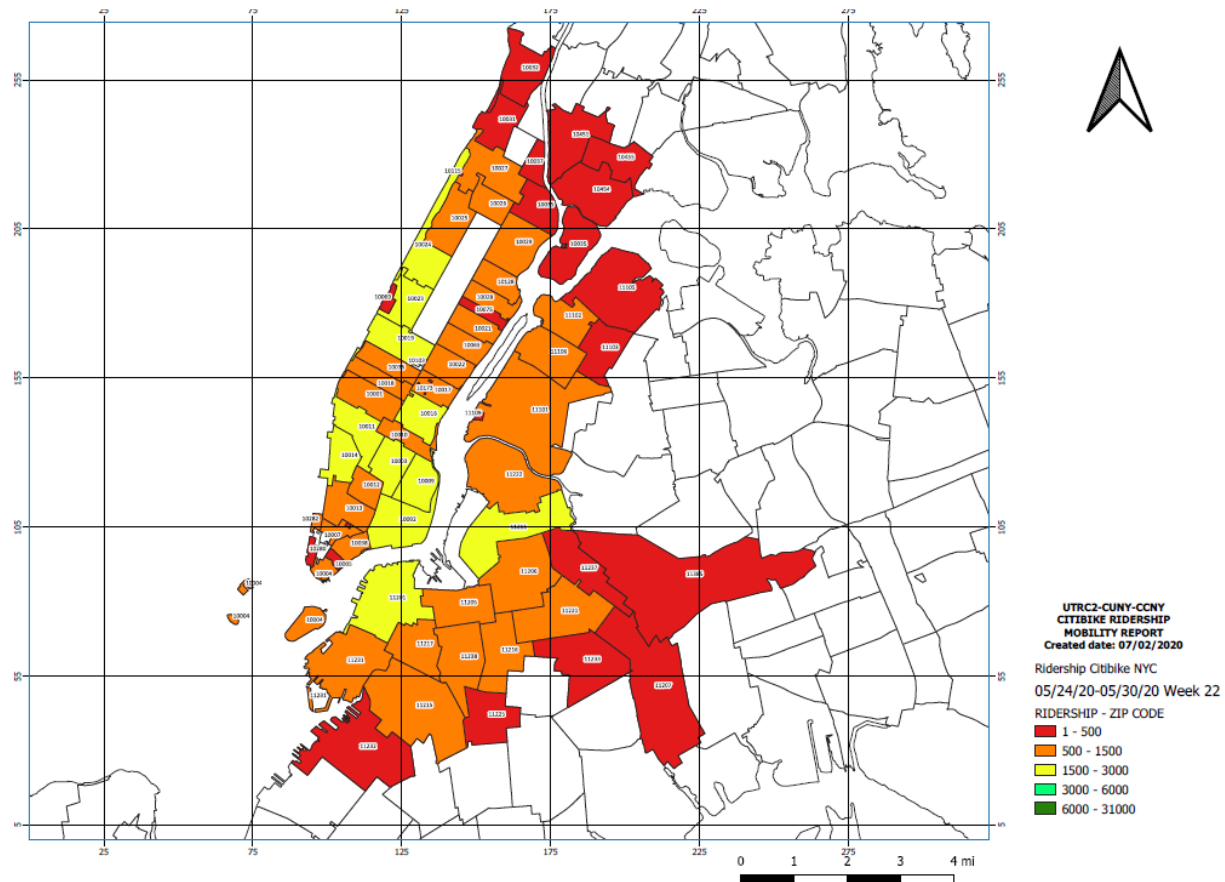
(a) From February 23rd to 29th 2020 (week 9 in 2020)



(b) From March 22nd to 28th (week 13 in 2020)



(c) From April 19th to 25th (week 17 in 2020)



(d) From May 24th to 30th (week 21 in 2020)

Figure 21: Citi Bike weekly ridership maps for the last week of February (a), March (b), April (c) and May (d) in 2020

Table 5 explains the number of bike trips with duration less than 30 minutes and those between 30 minutes and 60 minutes. A comparison of bike trips during February, March, and April in 2019 and 2020, was performed. Due to COVID-19 related restrictions taking effect in March 2020, the total number of Citi Bike trips of less than 30 minutes decreased in March and April of 2020 as compared to the corresponding values in 2019; but the number of bike trips with duration between 30 and 60 minutes (longer trip) increased respectively from 79,340, 131,393, and 157,972 trips in March, April, and May in 2019 to 111,831, 123,484, and 300,306 trips in March, April, and May in 2020. Remarkably, the ratio of longer trips has almost doubled in March, surged from 6.4% in 2019 to 11.88% in 2020, and has almost tripled in April and May, skyrocketed from 8.1% and 9.1% in 2019 to 23.0% and 26.8% in 2020. Noteworthy, we have noticed that the ratio of longer trip has almost quadrupled in Queens borough during May, a 184% surge from 2019 to 2020. This obviously demonstrates that many New Yorkers have been showing more interest in bike ridership for their daily trips, either for recreational or work purposes. Such a mobility trend would give a nudge to city planners to provide more bike facilities during this coronavirus pandemic or even in the aftermath of this crisis.

Table 5: Number of Citi Bike trips classified by trip length during February, March, April in 2019 and 2020

	Month	Number of trips less than 30 min	Number of trips between 30 min and 60 min	Ratio of longer trip
2019	February	891,196	47,905	5.4%
	March	1,239,029	79,340	6.4%
	April	1,615,010	131,393	8.1%
	May	1,745,308	157,972	9.1%
2020	February	1,085,319	55,630	5.1%
	March	940,962	111,831	11.9%
	April	535,789	123,484	23.0%
	May	1,122,525	300,306	26.8%

Air Quality

The effect of COVID-19 has been positive for the quality of air as indicated by the air quality indexes (AQI). In this section, the changes in air quality indexes of fine particulate matter (PM2.5), Nitrogen Dioxide (NO₂), and Carbon monoxide (CO) before and during this pandemic are reported. PM2.5 is one of the pollutants included in air quality reports from environmental authorities and companies. Figure 22 illustrates the PM2.5 AQI in New York-Newark-Jersey City, NY-NJ-PA geographical areas, for three months of February, March, April, May, and June in 2019 and 2020. The difference in the air quality from 2019 to 2020 was non-significant in February, this difference increased remarkably in March, April, and May, representing a significant improvement in air quality during Covid-19 pandemic.

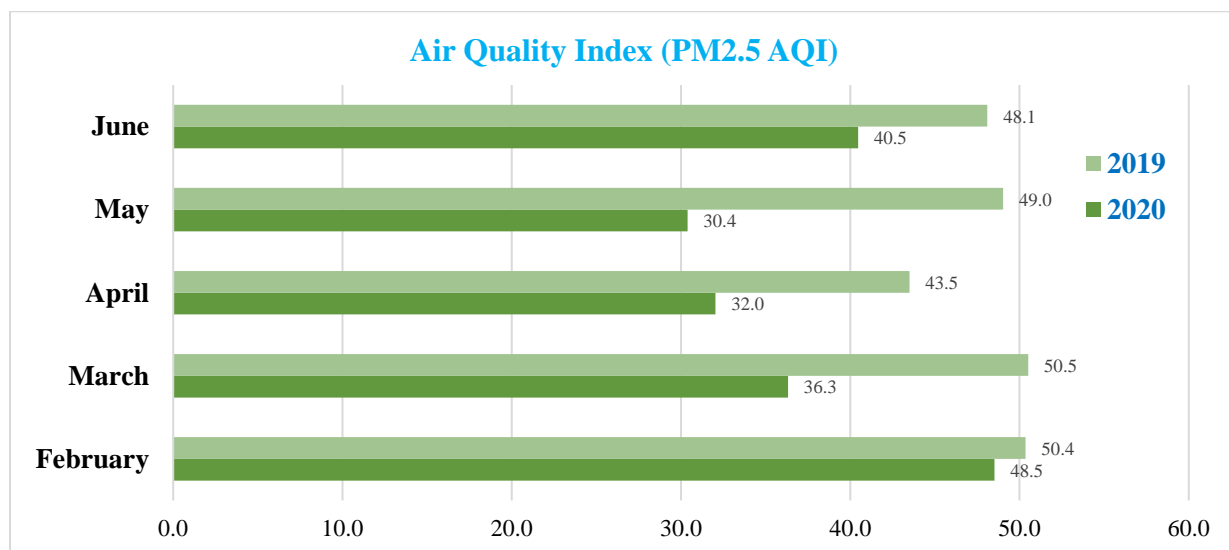


Figure 22: Pm2.5 Air Quality index in New York-Newark-Jersey City, NY-NJ-PA geographical area in 2019 and 2020 (Source: EPA.gov)

Table 6 explains the air quality index of NO₂ and CO for February, March, April, and May in 2019 and 2020 in the New York-Newark-Jersey City, the NY-NJ-PA geographical areas. The air quality indexes are significantly down in 2020 compared to 2019. Surprisingly, the NO₂ AQI and CO AQI have plunged to 31.7% and 57.9%, respectively, from May 2019 to April 2020.

Table 6: NO₂ and CO air quality index in 2019 and 2020 (Source: EPA.gov)

	NO ₂ AQI	CO AQI
February 2019	48.6	8.6
March 2019	47.5	8.2
April 2019	41.2	7.7
May 2019	35.7	7.4
February 2020	40.3	8.7
March 2020	36.7	7.7
April 2020	25.3	3.6
May 2020	24.4	3.1
February: change from 2019 to 2020	-17.1%	+0.6%
March: change from 2019 to 2020	-22.7%	-5.9%
April: change from 2019 to 2020	-38.6%	-53.7%
May: change from 2019 to 2020	-31.7%	-57.9%

To further evaluate the performance of PM_{2.5}, Figure 23 displays PM_{2.5} in a weekly average, at Midtown and Queens College sites in New York City. One can visibly observe that the PM_{2.5} was reduced from 16.61 and 11.32 micrograms per cubic meter to 5.27 and 5.08 micrograms per cubic meter from February 1st to May 16th at Midtown and Queens College sites. Then from the second half of May, the PM_{2.5} trend started bouncing higher as the states of New Jersey and New York commenced to relax the lockdown together with issuing the Phase One of Restarting NYC on June 8th. It is worth noting here that the huge reduction in fine particulate matter was welcomed by environmentalist advocates as a bright side of the Covid-19 pandemic.

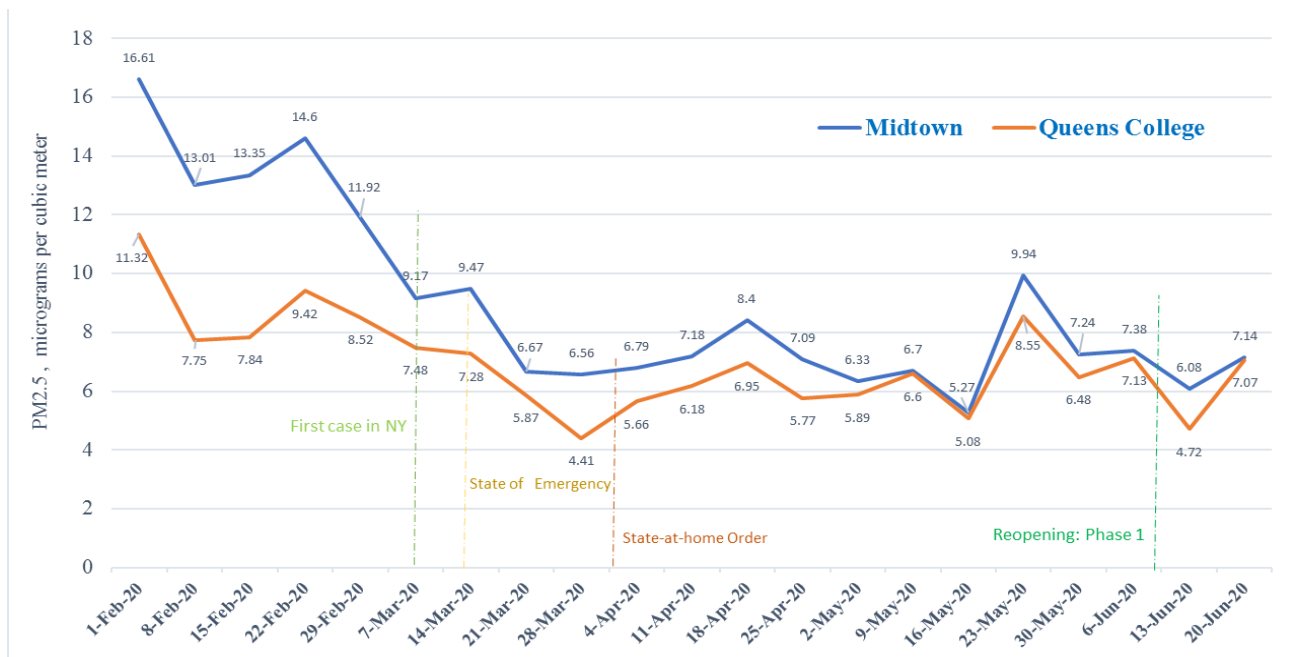


Figure 23: PM2.5 weekly average at two sites: Midtown and Queens College (Source: NYC.gov)

In the following figure, the air quality index of NO₂ is shown in the weekly average, from 2019 to 2020, at the Horace Harding Expressway & 153rd street location in Queens, NY. It is a weekly-based comparison, starting from week 6 to week 26 in 2019 and 2020. From week 12, the NO₂ air quality index in 2020 has been lower than those corresponding values in 2019. It should be mentioned that the NO₂ data is missing for weeks 23 and 26 in 2020.

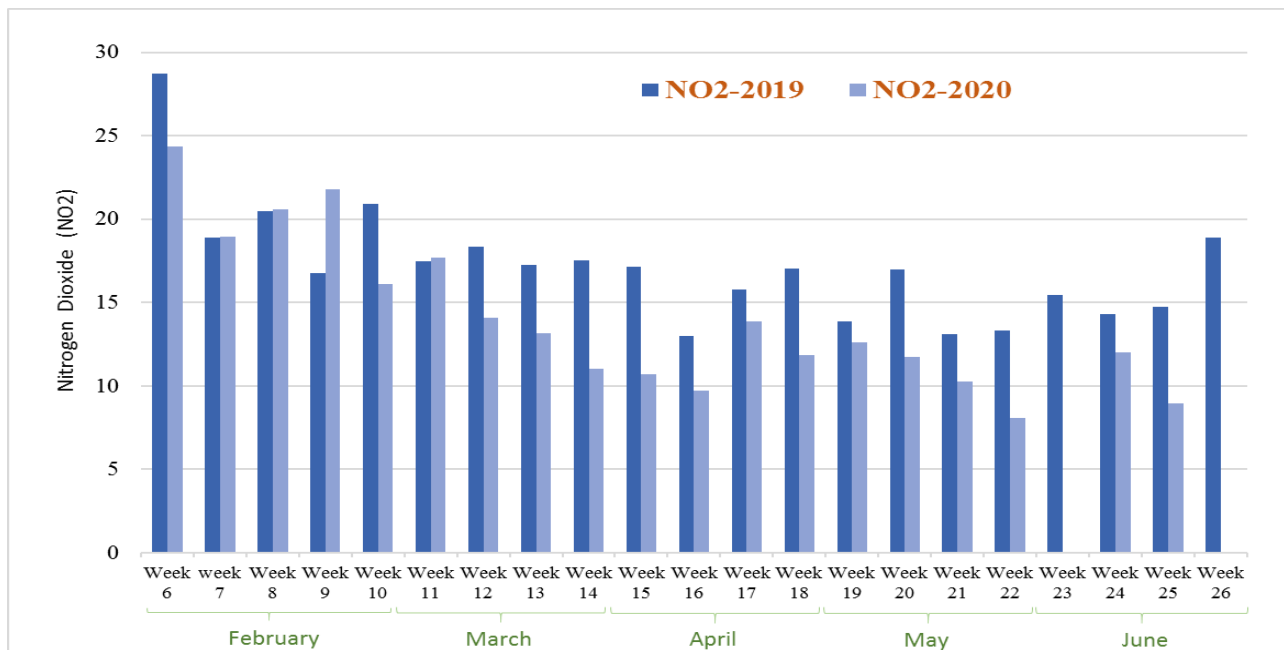


Figure 24: NO₂ weekly average in 2019 and 2020 at Horace Harding Expressway & 153rd St, Queens, NY (Source: NYC.gov)