

University
Transportation
Research Center

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

Analyses of transportation modes throughout May 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.

For more information about UTRC, please visit www.utrc2.org

Email: <a href="mailto:utrc@utrc2.org">utrc@utrc2.org</a>
Telephone: 212-650-8050

## **Authors:**

Camille Kamga, PhD, Director

**Bahman Moghimi**, Ph.D. Fellow Post-doc Research

Patricio Vicuna, Doctoral Student and Research Associate

**Sandeep Mudigonda**, Ph.D. Senior Post-doc Research

**Rodrigue Tchamna**, Ph.D. Senior Post-doc Research

June 13 2020 The City College of New York 160 Convent Avenue, New York, NY 10031



The first case of the coronavirus was confirmed in the State of New York in New York City on March 1<sup>st</sup>, since then panic buying for food and household products was reported. On March 7<sup>th</sup>, Governor Andrew Cuomo declared a state of emergency in New York State. A second case in the State was announced on March 10<sup>th</sup>, which was the first known case in the State to be caused through community spread. On March 16<sup>th</sup>, 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 22<sup>nd</sup>, 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.

The aggressive actions taken by the state and city governments and businesses in order 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 flattered the curve and the news of reopening emerged.

This report presents preliminary analyses of transportation-related data publicly available as of May 31, 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 May (or April) from 2019 to 2020
Subway	(-)90% ridership
Bus	(-)70% ridership
Metro North	(-)94% ridership
LIRR	(-)94% ridership
PATH	(-)95% ridership from Feb to April
Traffic	+26-100% average speed
Taxi	(-)91% trips (from March)
Bike	(-)69% ridership, +23% longer trips ridership (April)
Environment	(-)38.6% NO2 AQI. (-)53.7% CO AQI (from March) -38% PM2.5 AQI (from April)



## 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 May. It is observable that there was a huge spike in March, and then it started declining in April and May as information on the coronavirus pandemic became widely available.

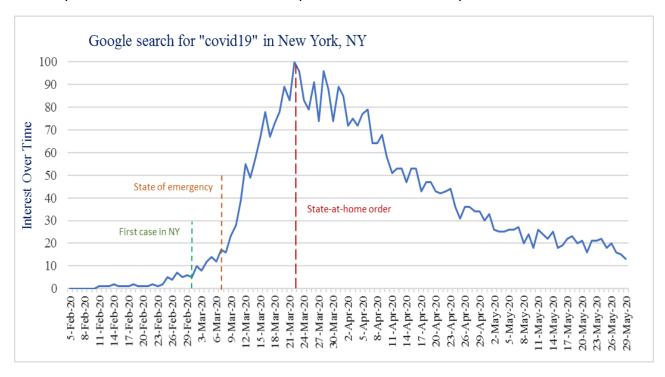


Figure 1: Interest of New Yorkers about coronavirus from February to May (Source: Google)

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 May 30<sup>th</sup> from the baseline of Jan 13<sup>th</sup>, 2020. One can visibly observe that there was a steep fall in directional requests for all three modes during March and April, and then, an uptick in May as the state began reopening. Remarkably, driving direction requests have been peaking up more strongly, reaching to -4% at the end of May compared to the huge reduction of about 70% at the end of March. This indicates that driving mode is getting get back sooner, representing that New Yorkers are back on the road after two months of lockdowns.



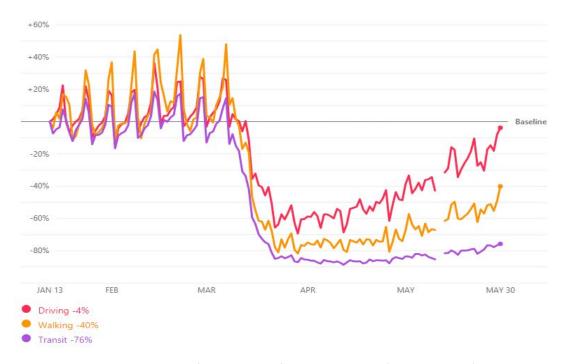


Figure 2: Requests for directions from Apple Maps (Source: Apple)

Figure 3 displays the cumulative distribution of infected cases by date of diagnosis, hospitalizations by date of admission, and deaths 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 May 31<sup>st</sup>. Low income and older populations have been disproportionally impacted.

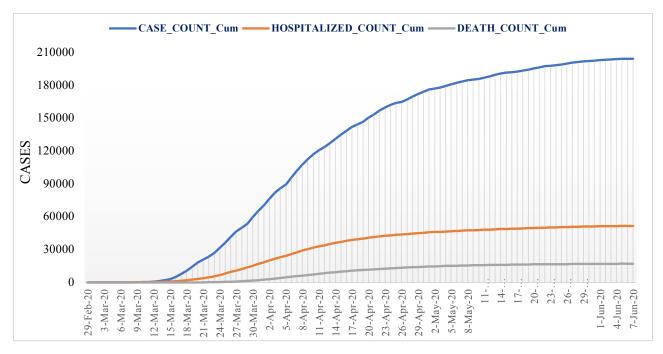


Figure 3: Cumulative Covid-19 cases in New York City



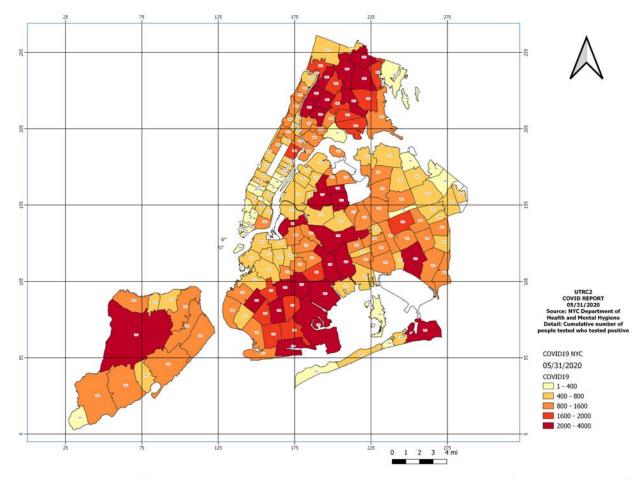
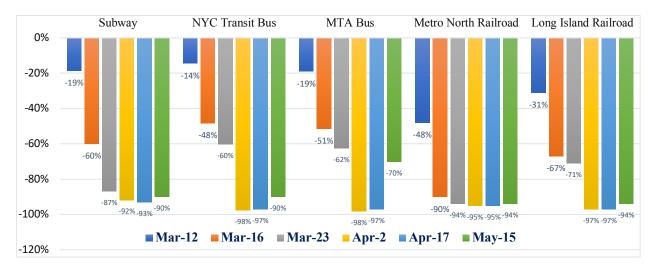


Figure 4: Total count of positive COVID-19 cases based on patient address by ZIP code (Source: NYC Health)

## **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 12<sup>th</sup>, March 16<sup>th</sup>, March 23<sup>rd</sup>, April 2<sup>nd</sup>, April 17<sup>th</sup>, and May 15<sup>th</sup>, 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.





**Figure 5:** Transit ridership percentage reduction on March 12<sup>th</sup>, 16<sup>th</sup>, March 23<sup>rd</sup>, April 2<sup>nd</sup>, April 17<sup>th</sup>, and May 15<sup>th</sup> 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 1<sup>st</sup> in 2020 to April 17<sup>th</sup> 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.

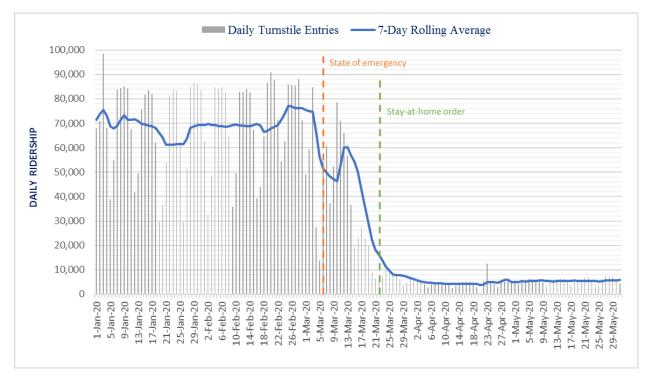


Figure 6: Daily entries and 7-day rolling average of the mean of South Ferry subway station



#### **PATH Train**

The impact of Covid-19 on PATH train ridership has also been severe. Figure 7 illustrates the average daily ridership of PATH service in February, March, and April 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, and 157,669 in April, representing 50% a reduction from February to March and a 94% drop from February to April.

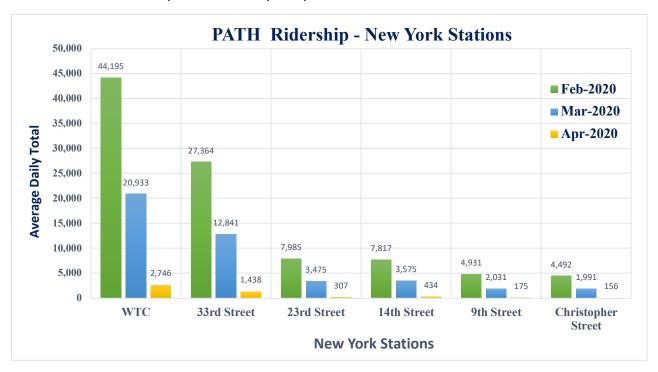
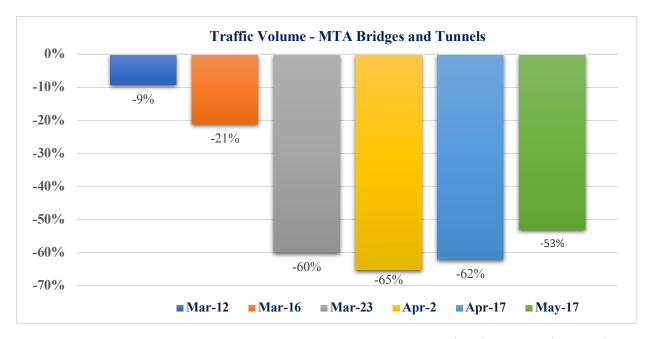


Figure 7: Average Daily of PATH ridership of New York stations in February, March, and April 2020

## Vehicular Traffic Volume

Traffic volumes on bridge and tunnel crossings in and around NYC have also decreased significantly. MTA's bridges and tunnels data on March 12th, 16<sup>th</sup>, 23<sup>rd</sup>, April 2<sup>nd</sup>, April 17<sup>th</sup>, and May 17<sup>th</sup> showed a 9%, 21%, 60%, 65%, 62% and 53% reduction respectively from the corresponding and comparable days in 2019. The traffic volume on MTA bridges and tunnels was at its lowest values in April 2020, and as lockdown measures started to be relaxed, traffic volume also increased slightly in May 2020.





**Figure 8:** MTA Bridges and Tunnels percentage changes in volume on March 12<sup>th</sup>, 16<sup>th</sup>, March 23<sup>rd</sup>, April 2<sup>nd</sup>, April 17<sup>th</sup>, and May 17<sup>th</sup> from 2019 to 2020 (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, and May 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 9, 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 are increasing on NYC's arterials.



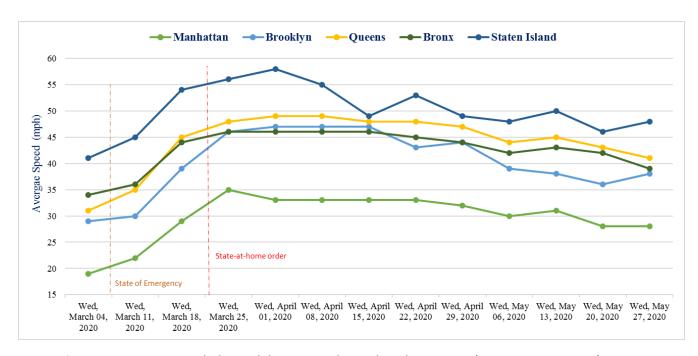


Figure 9: Average recorded speed during March, April, and May 2020 (Source: TRANSCOM)

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.

## Freight:

Figure 10 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 has 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.

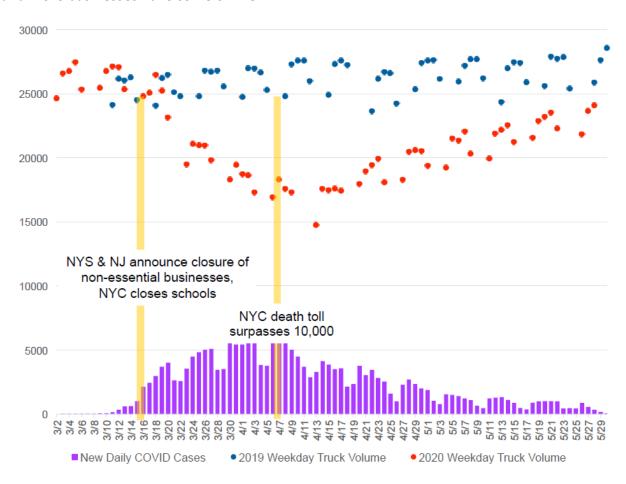


Figure 10: Inbound PANYNJ truck volume crossings and COVID-19 cases (Source: NYCODT and PANYNJ)



## **Parking Violation**

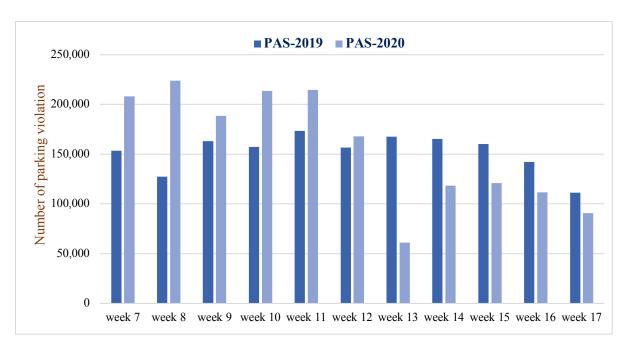
Parking violation has been one of the major issues of congestion management in cities like New York. During the coronavirus pandemic, there has been less congestion in cities. It was anecdotally observed that a mode shift from transit to driving by essential workers occurred since roads were less congested and people tried to limit the risk of infection perceived in transit vehicles. At the same time, commercial vehicles are moving 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 accelerate. 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, and April 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 significantly during March and April. For example, the parking violations for passenger vehicles reduced by about 6% in March, then plunged to approximately 37% in April. Such a change was more remarkable for commercial vehicles as the numbers of parking violations decreased by 20% in March and 90% in April. 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

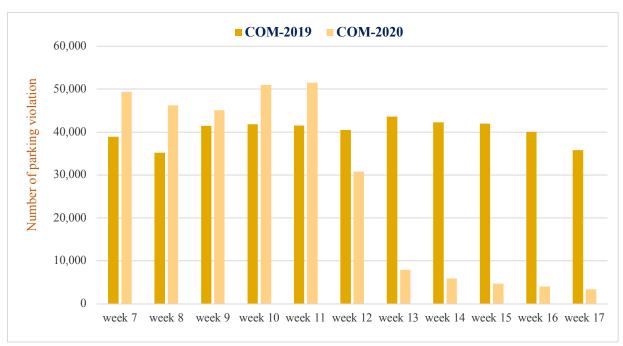
Parking Violation	Passenger Vehicle	Commercial Vehicle
February, 2019	610,964	158,093
March, 2019	699,562	177,079
April, 2019	635,555	175,507
February, 2020	855,200	195,283
March, 2020	657,057	141,338
April, 2020	397,841	15,877
February: change from 2019 to 2020	40%	24%
March: change from 2019 to 2020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

To better grasp the trend in parking violations, Figure 11 and Figure 12 show the weekly pattern by passenger and commercial vehicles from week 7 to week 17 (from mid-Feb to end of May) of years 2019 and 2020. As shown, the parking violation of commercial vehicles started declining from week 12, the end of April.





**Figure 11:** Number of parking violations for passenger vehicles, from week 7 (mid-February) to week 17 (end of May)



**Figure 12:** Number of parking violations for commercial vehicles, from week 7 (mid-February) to week 17 (end of May)



# **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 13 illustrates the total of motor vehicle crashes in New York City from February to May 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 and May 2020. The highest reduction in crash occurrence happened in April with a 75% drop, falling from 34,081 crashes in 2019 to 8417 crashes in 2020. Such a percentage reduction has also been notable in May 2020, a drop of 72%. 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.

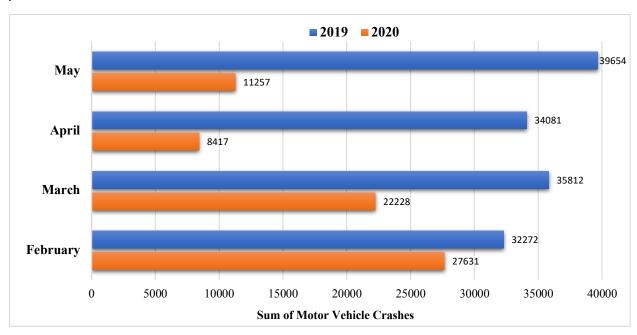


Figure 13: Sum of motor vehicle crashes from February to May in 2019 and 2020 (Source: NYC Open Data)

#### **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, and May 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 bouncing back at the end of May.



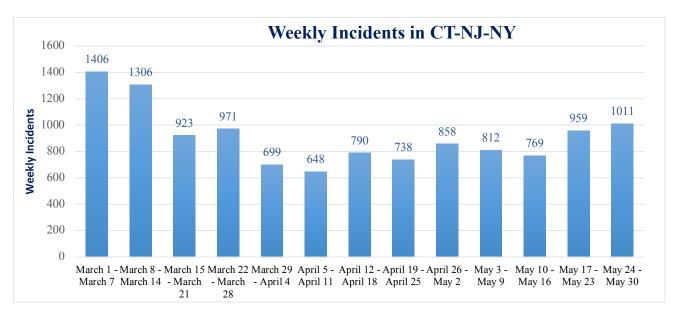


Figure 14: Total weekly incidents during March, April, and May 2020 (Source: TRANSCOM)

## 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 April in 2020 are compared. Figure 15 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.

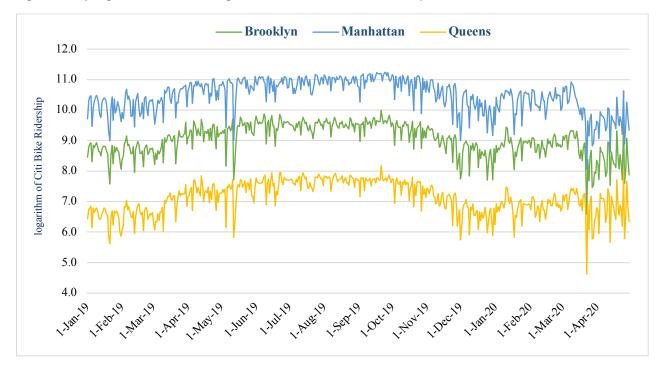


Figure 15: Semilog plot of Citi Bike trips in three boroughs from Jan 2019 to April 2020



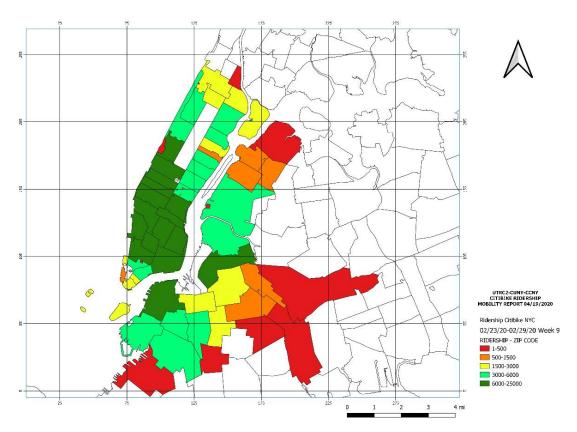
To compare the Citi Bike ridership trend from February to April in 2019 and 2020, Table 4 exemplifies the shift in bike trips during this time. Although, the total bike trips increased gradually from February to April in 2019 across all three boroughs, it decreased from February to April in 2020. It is shown in the table that there was a significant ridership drop during March and April, from 2019 to 2020, in all three boroughs. 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.

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

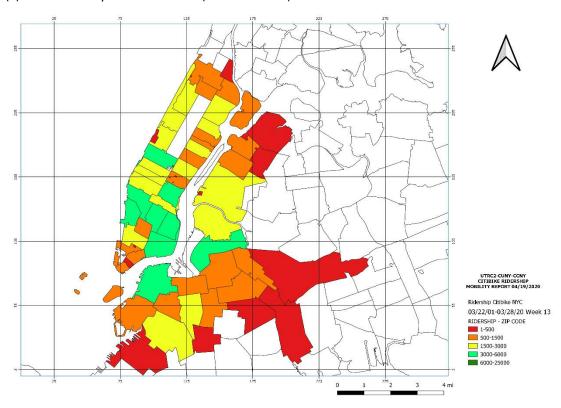
	Manhattan	Brooklyn	Queens
<b>February:</b> change from 2019 to 2020	+22%	+21%	+34%
March: change from 2019 to 2020	-25%	-20%	-5%
April: change from 2019 to 2020	-69%	-62%	-43%

Figure 16, 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 23<sup>rd</sup> to 29<sup>th</sup>, *b)* March 22<sup>nd</sup> to March 29<sup>th</sup>, *c)* April 19<sup>th</sup> to April 25<sup>th</sup>. All bike trips less than "30 minute trip length" have been visualized in the figures. As shown in the figures in 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, the 13<sup>th</sup> week of 2020.



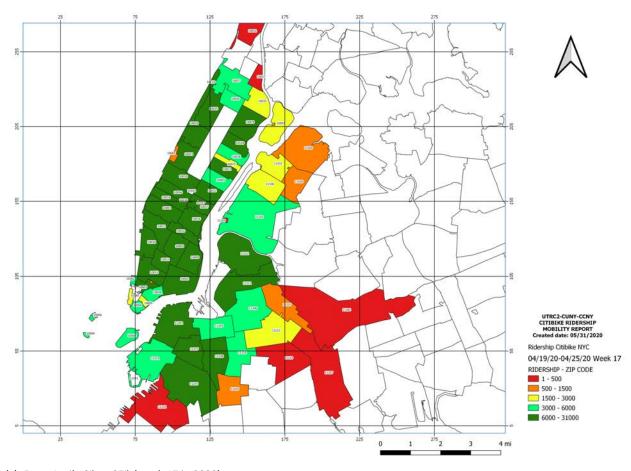


## (a) From February 23<sup>rd</sup> to 29<sup>th</sup> 2020 (week 9 in 2020)



(b) From March 22<sup>nd</sup> to 28<sup>th</sup> (week 13 in 2020)





(c) From April  $19^{th}$  to  $25^{th}$  (week 17 in 2020)

Figure 16: Citi Bike weekly ridership maps for the last week of February (a), March (b), and April (c) 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 trips in March and April in 2019 to 111,831 and 123,484 trips in March and April 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, skyrocketed from 8.14% in 2019 to 23.05% in 2020. This obviously demonstrates that many New Yorkers have been showing more interests to bike 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 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
	February	891,196	47,905	5.38%
2019	March	1,239,029	79,340	6.40%
	April	1,615,010	131,393	8.14%
	February	1,085,319	55,630	5.13%
2020	March	940,962	111,831	11.88%
	April	535,789	123,484	23.05%

# **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 17 illustrates the PM2.5 AQI in New York-Newark-Jersey City, NY-NJ-PA geographical areas, for three months of February, March, April, and May in 2019 and 2020. The difference in the airy 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 17**: 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, and April 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 38.6% and 53.7%, respectively, from April 2019 to April 2020.

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

	NO2 AQI	CO AQI
February 2019	48.6	8.6
March 2019	47.5	8.2
April 2019	41.2	7.7
February 2020	40.3	8.7
March 2020	36.7	7.7
April 2020	25.3	3.6
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%

To further evaluate the performance of PM2.5, Figure 18 displays PM2.5 in a weekly average, at Midtown and Queens College sites in New York City. One can visibly observe that the PM2.5 was reduced from 16.61 and 11.32 micrograms per cubic meter to 5.27 and 5.08 micrograms per cubic meter from February 1<sup>st</sup> to May 16<sup>th</sup> at Midtown and Queens College sites. Then, during the second half of May, from May 16<sup>th</sup> to May 30<sup>th</sup>, the PM2.5 trend started bouncing higher as the state of New Jersey and state of New York commenced to relax the lockdown. It is worth noting here that the huge reduction in fine particulate matter was welcomed by environmentalist advocates as a positive effect of the Covid-19 pandemic.





Figure 18: PM2.5 weekly average at two sites: Midtown and Queens College (Source: NYC.gov)

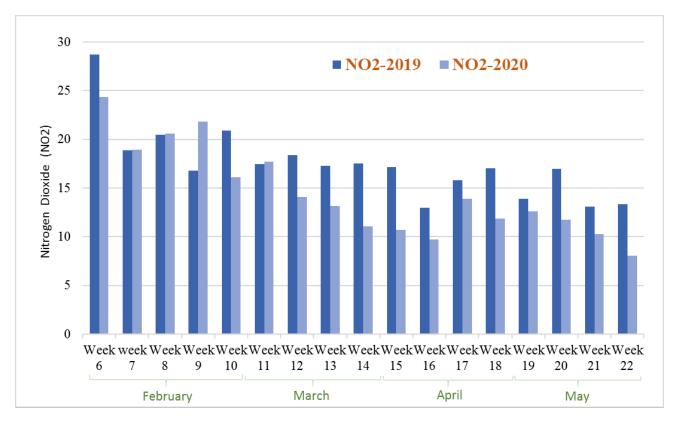
Also, the daily maximum 8-hour CO concentration has been reported at some sites in New York City. These sites are City College in Upper Manhattan, Queens College, and Bronx PRIZER LAB. Table 7 reports the maximum 8-hour CO concentration (in ppm) at these three sites in February, March, and April 2020. At all sites, the air quality value has dropped more than 30% from February to March, and more than 40% from February to April, explaining how the air becomes cleaner during this pandemic.

**Table 7:** Daily max 8-hour CO concentration at three sites of NYC during February, March, and April in 2020 (Source: EPA.gov)

Daily Max 8-hour CO Concentration (ppm)	City College of NY	Queens College	Bronx PFIZER LAB
February 2020	0.60	0.51	0.42
March 2020	0.35	0.35	0.29
April 2020	0.28	0.29	0.23
Change (%): Feb to Mar 2020	-41%	-31%	-30%
Change (%): Feb to Apr 2020	-54%	-43%	-46%

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 & 153<sup>rd</sup> street location in Queens, NY. It is a weekly-based comparison, starting from week 6 to week 22 in 2019 and 2020. From week 12, the NO2 air quality index in 2020 has been lowered than those corresponding values in 2019.





**Figure 19:** NO2 weekly average in 2019 and 2020 at Horace Harding Expressway & 153rd St, Queens, NY (Source: NYC.gov)