TRACKING COVID-19 & TRANSIT:

An Examination of COVID-19 Clusters in NYC

CONTENTS

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ACKNOWLEDGEMENTS

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A special thanks to the Transit Innovation Partnership
for their assistance on this report.

Our work is supported by funding from The New York Community Trust.

INTRODUCTION

Commuters, elected officials, and business leaders have expressed concerns about the safety of riding public transit since March 2020, when the COVID-19 pandemic forced the New York City region to shut down non-essential business and travel. Recent public debate is largely centered on how to best keep transit fleets clean, reduce overcrowding, and enforce mask mandates.

Paranoia over the city's subway system acting as a superspreader of the coronavirus is fueling misinformation about the risks of riding transit, which could have long-term implications for regional travel behavior and the cash-strapped Metropolitan Transportation Authority. The pandemic wiped out the MTA's traditional funding streams (tolls, taxes, and fares), which means riders can expect service cuts and fare hikes in the near future, especially if ridership levels do not quickly—and safely—rebound. Given the MTA's dependence on a positive public perception for attracting riders and generating revenue, it's crucial that the risks of riding transit are based on the most recent science, not speculation.

No other city in the country has a transit system as robust as New York City's, or such a high percentage of the population depending on public transit as a primary mode of travel. At the height of the pandemic last spring, bus and subway ridership plummeted from 8 million daily trips to less than a million. Throughout the summer and fall, the city managed to keep transmission rates low, yet transit ridership rebounded only slightly, holding steady at roughly 3 million daily trips. The remaining riders include many essential and frontline workers who continue to travel to work and help combat the spread of the virus, allowing many others in the workforce to work remotely and still have access to essential services.

During the low-transmission period, the city relaxed some of its restrictions, which allowed most non-essential businesses to reopen once proper public health measures were implemented. For the MTA's part, the authority is conducting frequent and thorough cleanings of transit fleets and stations, has implemented a mask mandate for riders, installed safety barriers for bus drivers, and reduced the maximum passenger capacity on buses.[1] Transit ridership increased as many people went back to work, however COVID-19 infections did not.[2]

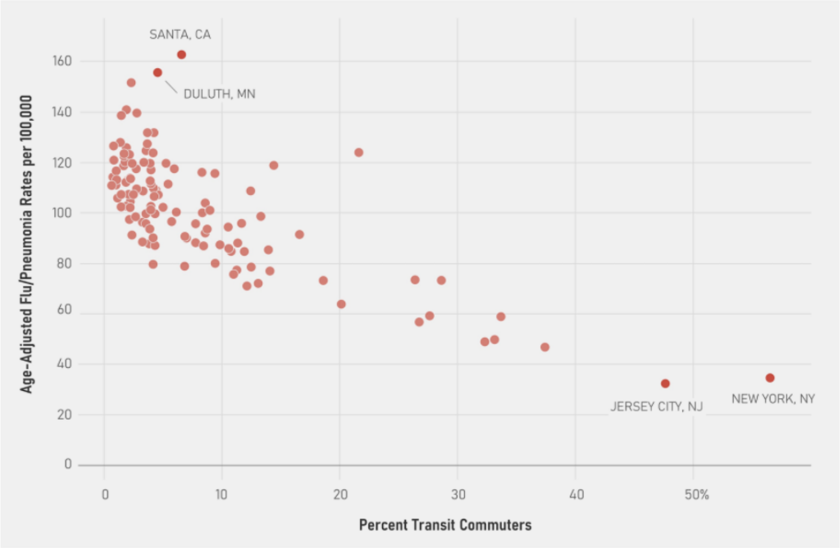
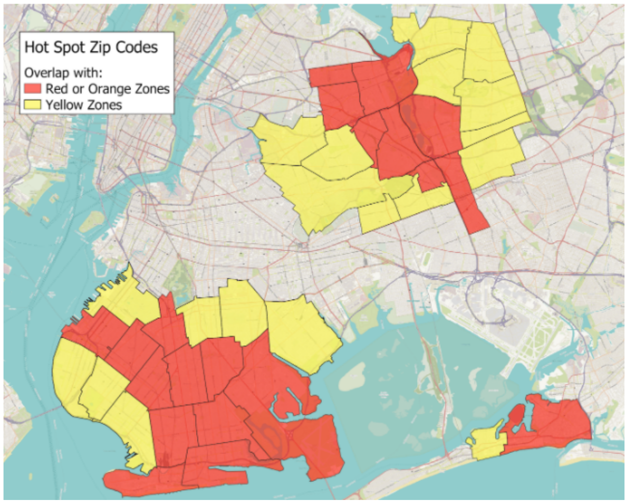


Figure 1. Rates of a respiratory infectious disease such as flu/pneumonia are actually lower in areas with high proportions of transit commuters. This suggests that the possibility that coronavirus data, another such respiratory infectious disease, could follow a similar trend.

When cases began to climb again in the fall of 2020, data from New York's contact tracing program reported that 70% of new COVID-19 cases occurred from households and small gatherings, whereas less than 0.96 percent came from public or private transit.[3] This is consistent with contact tracing results from France, where only 1% out of 531 clusters traced back to a mode of transportation, a category that includes public transit, airplanes, boats, and cars.[4] Furthermore, a recent NYU study looking at data from 121 cities found no evidence of a positive relationship between public transit usage and influenza/pneumonia mortality rates of the city (figure 1), suggesting that "population level rates of transit use are not a singularly important factor in the transmission of influenza."[5]

While it is challenging to conclusively prove there is absolutely no elevated risk of COVID-19 outbreaks due to transit use, this report aims to show that transit systems are not a major source of person to person transmission of coronavirus with proper precautions in place (ubiquitous mask compliance, sufficient ventilation and air filtration systems, and lack of crowding). To further assess the safety of New York City's transit system, we examined ridership and case patterns from the beginning of the micro-cluster strategy that Governor Cuomo announced on October 6, 2020. [6] The Governor's strategy identified clusters of cases and designated Red, Orange, and Yellow levels of restrictions based on case levels, with Red Zones having the highest case rate and therefore the tightest restrictions.

When looking at these microclusters in Brooklyn and Queens (figure 2) we can determine if ridership is a driving factor behind spikes of the novel coronavirus by comparing subway turnstile data with rates of COVID cases throughout the city.



Type of Activity	RED	ORANGE	YELLOW
Worship	25% capacity	33% capacity	50% capacity
Mass Gathering	Prohibited	10 people max	25 people max
Businesses	Only essential businesses open	Closing high-risk non-essential businesses	Open
Dining	Takeout only	Outdoor dining only, 4 person max per table	Indoor and outdoor dining, 4 person max per table
Schools	Closed	Closed	Open

Figure 2: Approximation of zip codes in the restricted areas on 10/8/2020. This approximates which zip codes overlap with the Governor's targeted zones, with red representing zip codes overlapping with Red and Orange Zones, and yellow indicating those zip codes overlapping with Yellow Zone restrictions summarized in the table above.

If public transit were a major factor in the spread of the novel coronavirus, we would expect to see sustained higher rates of transmission in areas with significant transit use and lower rates in places with little or no transit ridership. This is simply not the case—COVID-19 rides the air, not the subway.

APPROACH

To conduct this study, we utilized public datasets from two sources: the Metropolitan Transportation Authority and the New York City Department of Health. We used the turnstile entry counts from the MTA as a proxy for ridership: while these counts exclude anyone who evades the fare, they will record someone's trip in both directions and work well to illustrate relative changes in subway usage over time. We compared this ridership data to the New York City Department of Health's coronavirus dataset, which includes daily cases, hospitalizations, deaths, and other relevant data broken down by borough. For our geographic analysis, we calculated weekly subway turnstile averages to establish high traffic station totals within NYC neighborhoods, defined by modified Zip Code Tabulation Areas used by the NYC Department of Health for their case number reports.

For the analysis, we focused on the microclusters in New York City preceding the fall season's spike in cases, as identified by Governor Cuomo on October 8, 2020. These microclusters were geographically defined by streets and addresses that we approximated to predefined geographies such as neighborhoods and zip codes. In order to complete an analysis, we approximated the zip codes that contained hotspot clusters. The ridership analysis focused on the two weeks preceding the October 8th announcement, during the buildup of the local cases in the hotspot. Focusing on these hotspots and this time period just before the start of the winter spike of COVID-19 cases allowed us to avoid certain confounding factors from increased indoor gatherings. Indoor dining had just restarted on September 30, 2020, so any cases spread through restaurants are likely not reflected in the case numbers until one or two weeks into October. Examining this time period in late September also precedes the holiday season where household "living room spread" have contributed to roughly 74% of cases in New York, according to Governor Cuomo's December 11, 2020 press conference.[7]

ANALYSIS

There has been little relation, temporally or spatially, between subway use and identified COVID-19 cases in New York City. The following graphs depict turnstile entries and COVID-19 case counts from February 29th to October 31st. The blue highlights on each graph show the period of September 13th to October 8th, the two-week period leading up to the announcement of the hotspots.

As shown in Figure 3, subway ridership plummeted in early March as a vast majority of daily subway commuters began to work from home or lost work entirely. Once restrictions began to lift, ridership began increasing again, and there was a slow but steady upwards trajectory which essentially plateaued at a ridership rate of approximately 70% of normal across the system beginning in the summer of 2020. Despite the increased ridership, coronavirus cases remained low until winter. Figure 4 depicts the COVID-19 case count for the entire city: after the spring peak, cases stayed relatively low throughout the summer. Case numbers then began rising again in late September and early October, leading to hotspot restrictions being announced on October 8th.

In the two weeks leading up to Governor Cuomo announcing the COVID-19 hotspots and related restrictions, there was nothing particularly different about ridership that would indicate an anticipated increase in Coronavirus cases. Data from the MTA indicates that proper mask usage on transit during this time period averaged around 82%.

NYC RIDERSHIP AND COVID-19 CASES AT A GLANCE

Rolling 7-Day Average Turnstile Counts

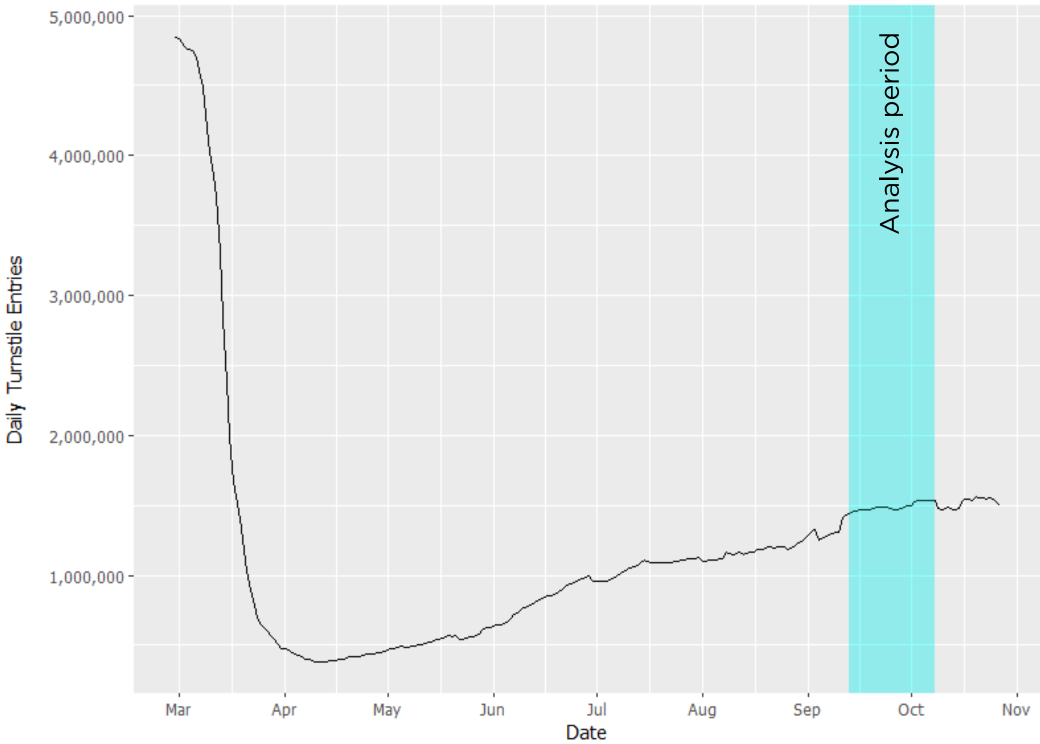


Figure 3: After an initial steep drop in subway ridership, trips have been slowly but steadily increasing since mid-April. There was no change in this trend in the two-week period leading up to the hotspot restrictions.

Rolling 7-Day Average COVID-19 Cases

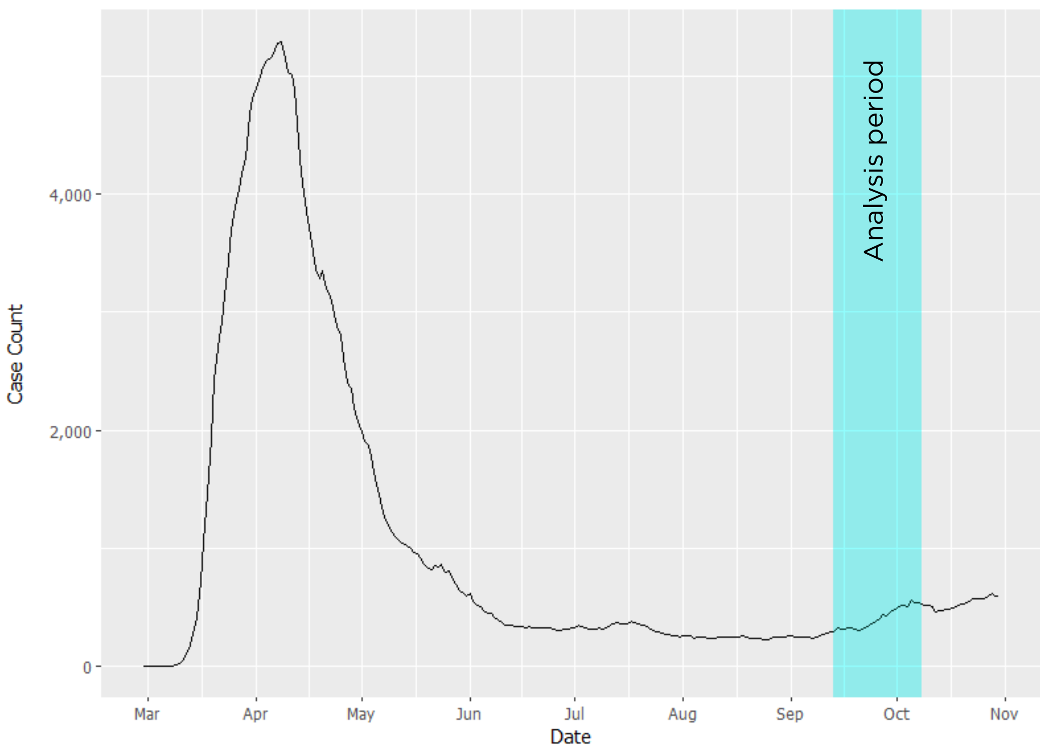


Figure 4: COVID-19 case numbers in New York peaked in early April, then declined dramatically and stayed relatively low throughout the summer despite steadily increasing subway ridership starting in mid-April. Case numbers then began rising again in late September and early October, leading to hotspot restrictions being announced on October 8th.

While these numbers provide context for total cases and ridership in New York City, COVID-19 is a disease that demonstrates stark geographical distinctions. As such, citywide aggregates can often obscure other trends and factors. Figures 5 and 6 show turnstile entries and COVID-19 cases broken down by borough. The worst devastation during the peak of the pandemic in New York City occurred in low-income communities and communities of color that are home to many essential workers. By contrast, in the borough of Manhattan, wealthier commuters largely ceased riding public transit when lockdowns began. When cases began to rise again in September, they were mainly concentrated in Queens and Brooklyn, despite subway ridership increasing most in Manhattan. The cultural and socioeconomic differences between boroughs must be taken into account when understanding the prevalence of COVID-19 in each area.

Rolling 7-Day Average Turnstile Counts

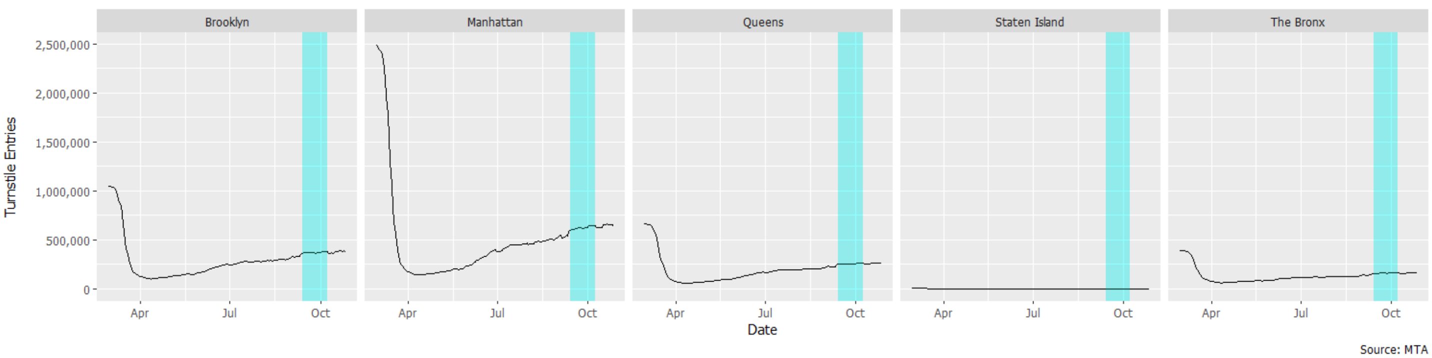


Figure 5: Other than in Staten Island, which does not have any subway stations, each borough showed similar trends as the city as a whole. Manhattan had the most trips before the pandemic, saw the steepest drop, and by October had significantly higher station traffic than the other boroughs.

Rolling 7-Day Average COVID-19 Cases

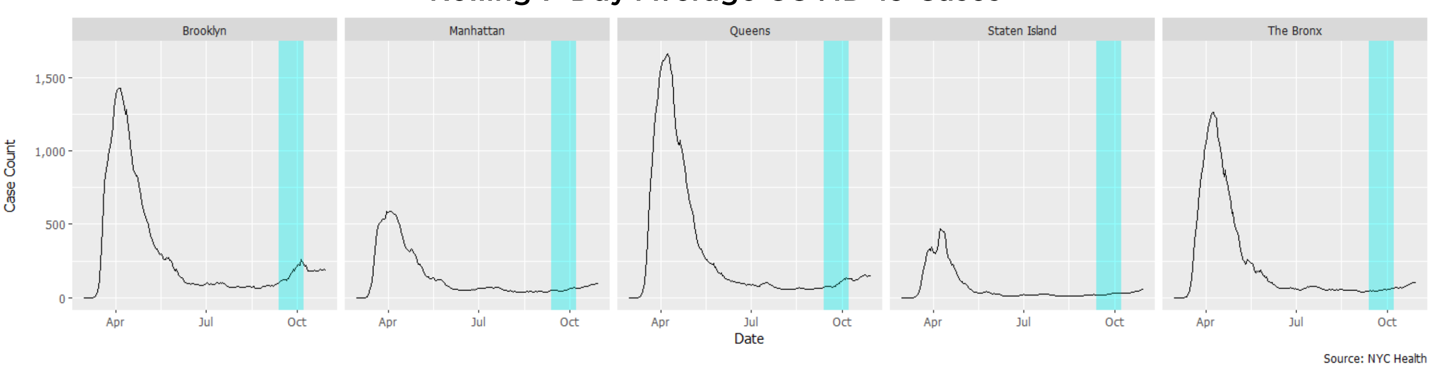


Figure 6: All of the boroughs had steadily low case counts throughout the summer, and all but Staten Island began to see increases in the fall. The increase in cases in the weeks leading up to the hotspot restrictions was most pronounced in Brooklyn, followed by Queens, where the restrictions were placed.

Subway ridership and stations are not evenly distributed throughout the city, so even borough-level aggregations can obscure whether or not a relationship exists between subway ridership and COVID-19. Therefore, we mapped the geographic distribution of cases and station activity to further examine the relationship between station activity and COVID-19 cases.

GEOGRAPHIC DISTRIBUTION OF COVID-19 AND RIDERSHIP

In order to get a better sense of spatial relationships between subway use and COVID-19 cases, we took the turnstile counts for individual stations and compared them to the COVID-19 hotspots[8] Governor Cuomo singled out for October 8th restrictions under guidance issued via Executive Order No. 202.68 (Figures 7a to 7c). We identified the zip codes that were within or intersected with the designated hotspots (Figure 2) because the clusters the Governor identified did not align with any established geographical boundaries. We use the assumption that people will utilize the subway stations based in their home neighborhoods, and that anyone coming from other areas of the city could also potentially bring the virus there. Therefore, stations that see high ridership would indicate that many residents use the subway, and subway riders travel to those neighborhoods.

Our findings show that neighborhoods with higher case rates are not associated with high ridership stations. Conversely, areas that contain busy subway stations do not have disproportionate numbers of COVID-19 cases. This strongly suggests that COVID-19 outbreaks bear very little to no relation to subway ridership.

COVID-19 Clusters

COVID-19 cases tend to propagate in clusters, as shown in figures 5 through 7. New York State health officials began to classify micro-cluster zones in areas that have high cases as yellow, orange, or red, with red as the most restricted, as shown in figures 5a through 5c. [9] We overlaid these zones with zip codes to allow for easier comparisons with other data. Those results are shown in figure 2.

Our analysis for the week of September 20th to 26th found the same clusters that the state reported during that month. The area highlighted red (figure 7b) in southern Brooklyn was declared a ‘red zone’ on October 8th, 2020. Other ZCTA in dark green such as the Rockaways (10/8/2020) and Central Queens were later declared to be microclusters by the state.

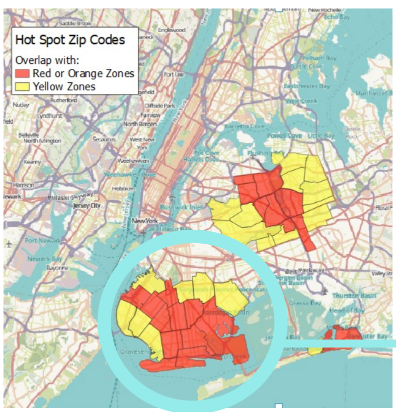


Figure 2: Approximation of zip codes within the restricted areas, 10/8/2020.

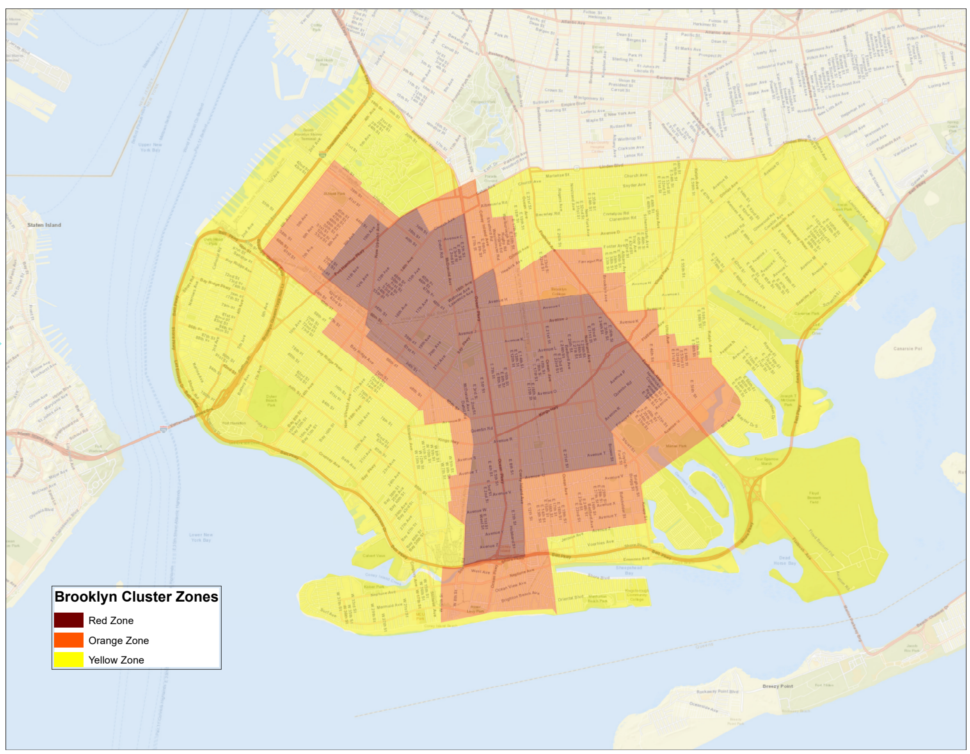
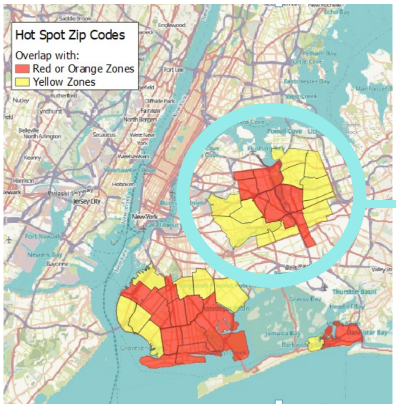


Figure 7a: Targeted restriction cluster in Brooklyn, 10/8/2020. Red is the epicenter of cases and most restricted area, followed by orange and yellow as defined by the New York State Governor’s Office.



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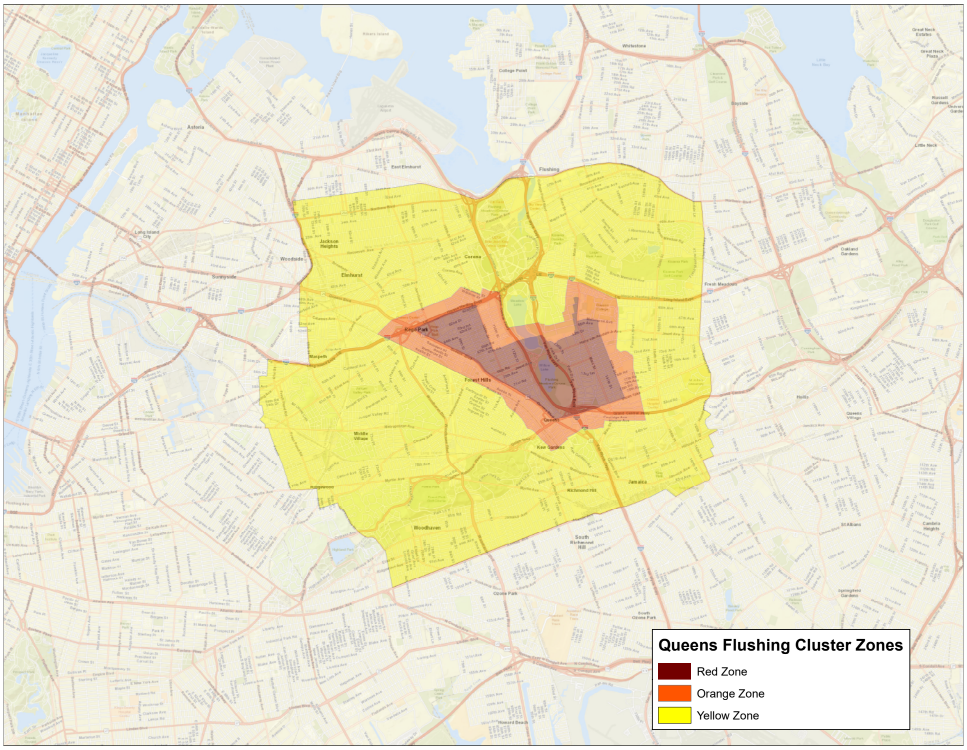
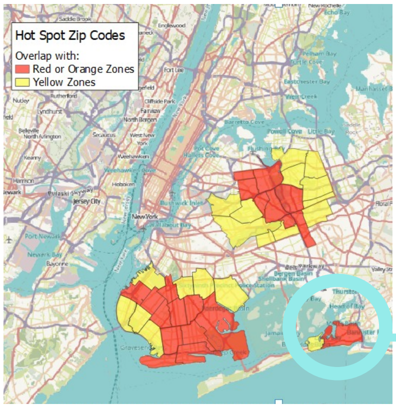


Figure 7b: Targeted restriction cluster in near Flushing, Queens, 10/8/2020



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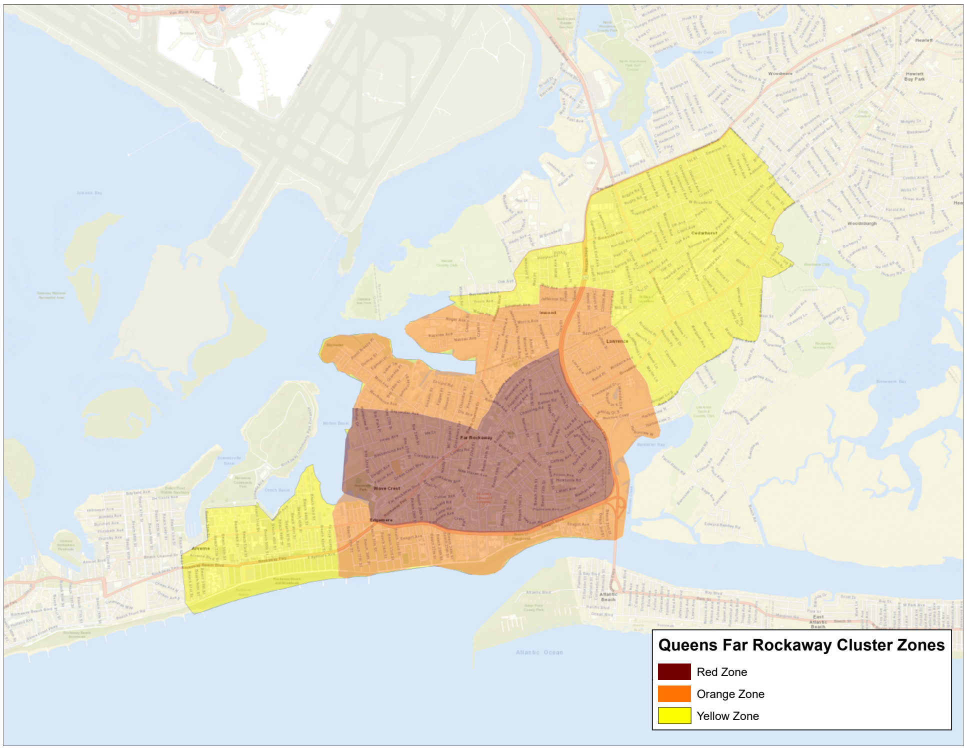


Figure 7c: Targeted restriction cluster in Far Rockaway, Queens 10/8/2020

One of the earliest defined micro-clusters appeared in Southern Brooklyn (highlighted in red in figure 8b) in October 2020. During the week of September 27th, the percentage of people testing positive had reached 6.69 percent.[10]

COVID-19 Cases in New York City by Zip Code, September 20th-26th 2020

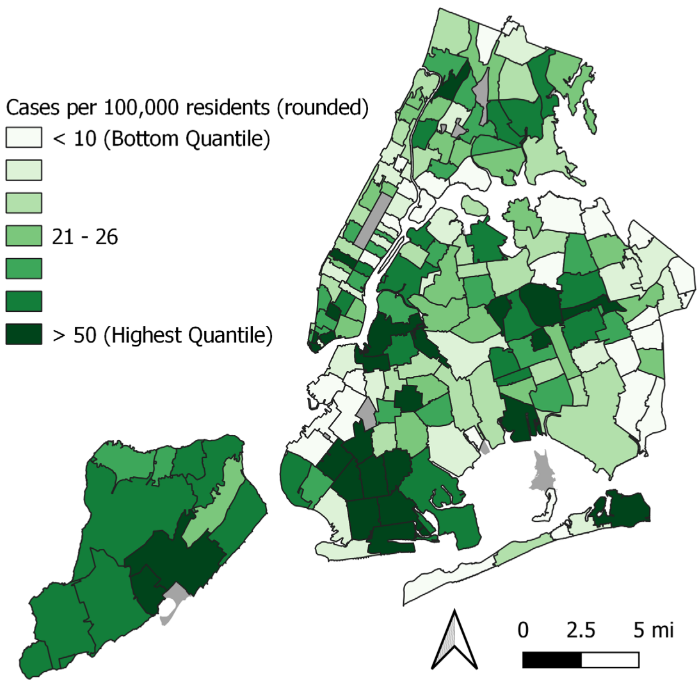


Figure 8a: The total number of confirmed COVID-19 cases per 100,000 residents by modified Zip Code Tabulation Areas (ZCTA), for the week of September 20th to 26th.

COVID-19 Clusters in New York City

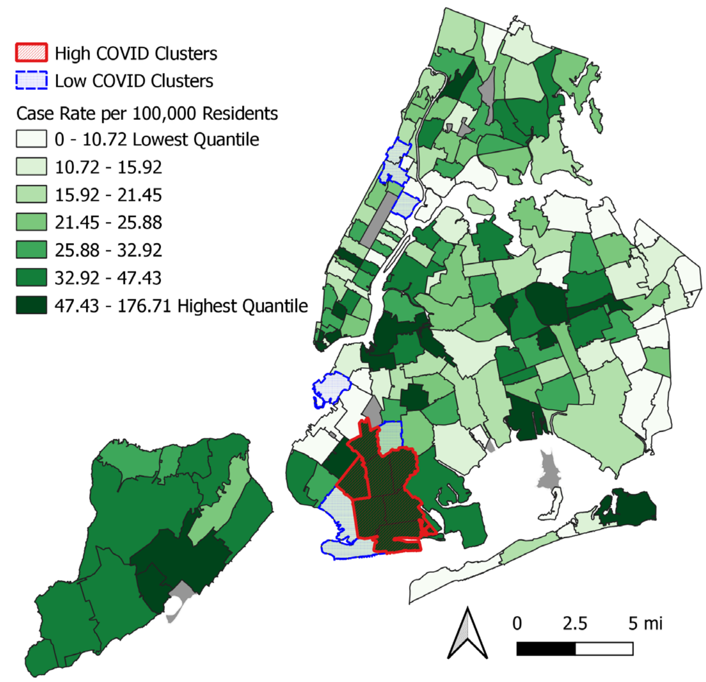


Figure 8b: Areas of high rates of COVID-19 cases from the week of September 20th to the 26th. Statistically significant clusters are outlined red as areas with high rates of coronavirus. Notable areas of low rates of coronavirus are outlined in blue. All clusters are statistically significant ($p<0.05$).

Ridership Distribution

To arrive at a robust analysis of the busiest stations in the NYC subway system, turnstile entries were averaged over the period of a week and totaled by DOH's modified Zip Code Tabulation Areas (ZCTAs)[11], which provided a basis of comparison against COVID-19 case rates. While the busiest of the 472 stations are dispersed throughout the five boroughs, Midtown Manhattan still remains the city's most notable cluster of ridership density (figure 9a).

For this analysis we focused on ridership outside of Manhattan's Central Business District and in the residential areas of New York City. By removing the ridership from a commuter-heavy destination such as the Central Business District, we can see more origin trips, specifically trips from a place of residence rather than a trip from a destination such as a commute back home from the workplace. The distinction between trips from a residence is necessary to match how COVID cases are counted—by place of residence. The resulting areas of high ridership outside the urban core can be found in (figure 9b).

Subway Ridership in New York City by Zip Code, September 20th-26th 2020

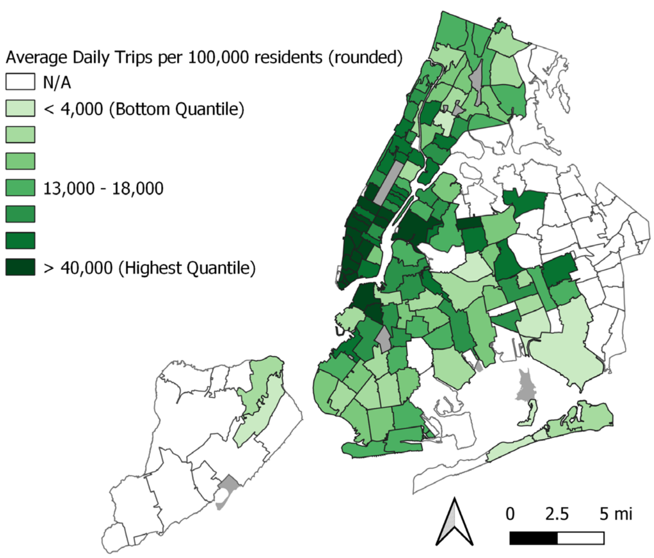


Figure 9a: The average daily turnstile count for the week of September 20th to 26th for the subway stations within each ZCTA, per 100,000 residents in that ZCTA.

COVID-19 Clusters in New York City

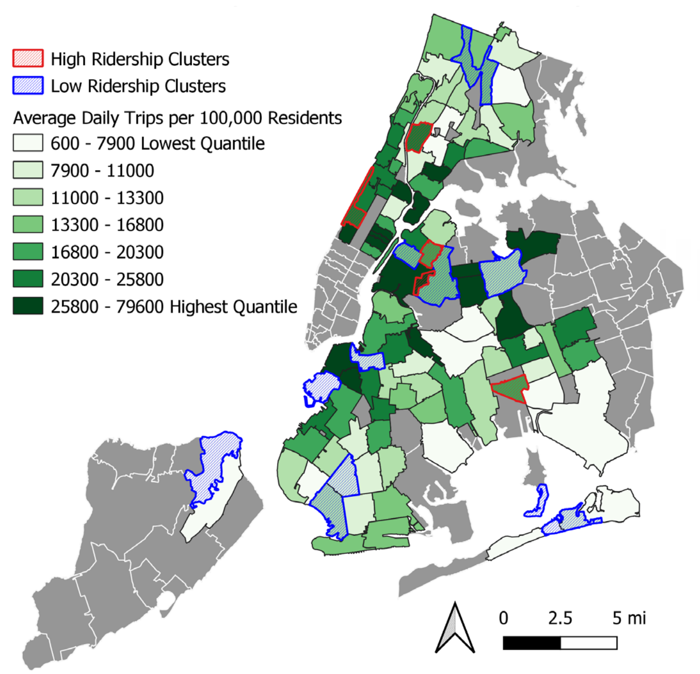


Figure 9b: NYC ridership outside of the Central Business District. Outside the Central Business District NYC ridership shows areas with high ridership and pockets of statistically significant clustering in neighborhoods (Moran's I: 0.226). Significant clusters of ridership are highlighted with high areas in red and low areas in blue (p-value > 0.05).

A SUMMARY OF COVID-19 CLUSTERS AND RIDERSHIP

COVID-19 Clusters in New York City

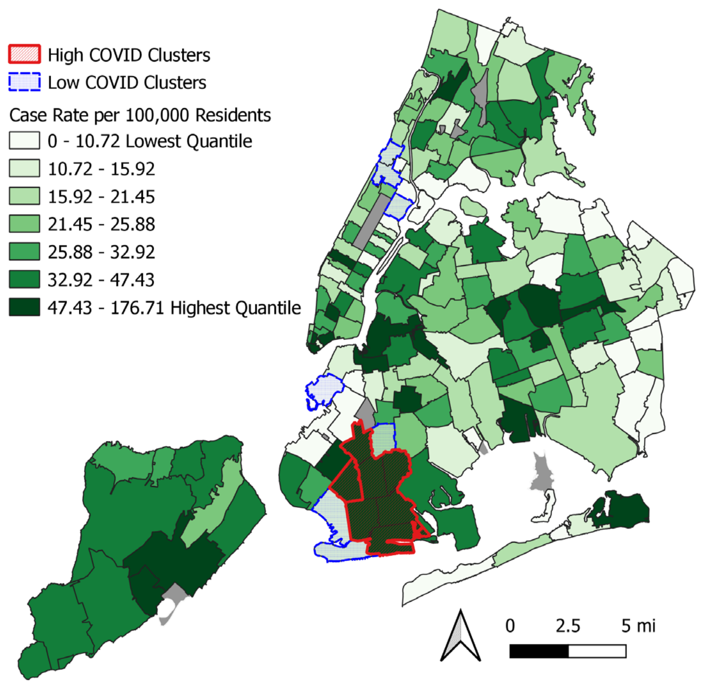


Figure 10a: Areas of high rates of COVID-19 cases from the week of September 20th to the 26th. Statistically significant clusters are outlined red as areas with high rates of coronavirus. Notable areas of low rates of coronavirus are outlined in blue. All clusters are statistically significant ($p<0.05$).

Clusters of Subway Ridership and COVID-19 cases in New York City

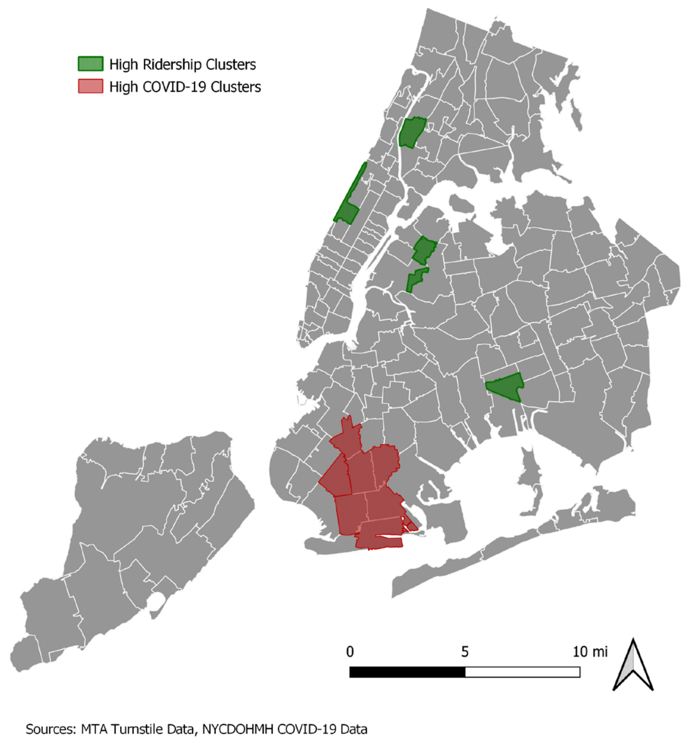


Figure 10b: Clusters of high subway ridership (green) and high COVID-19 case rates (red).
There is no geographic overlap of ZCTAs or clusters of high ridership and high cases in the week ending 9/26/20, one week preceding the announcements of the 10/8/20 COVID hotspots in Brooklyn and Queens.

COVID-19 Clusters in New York City

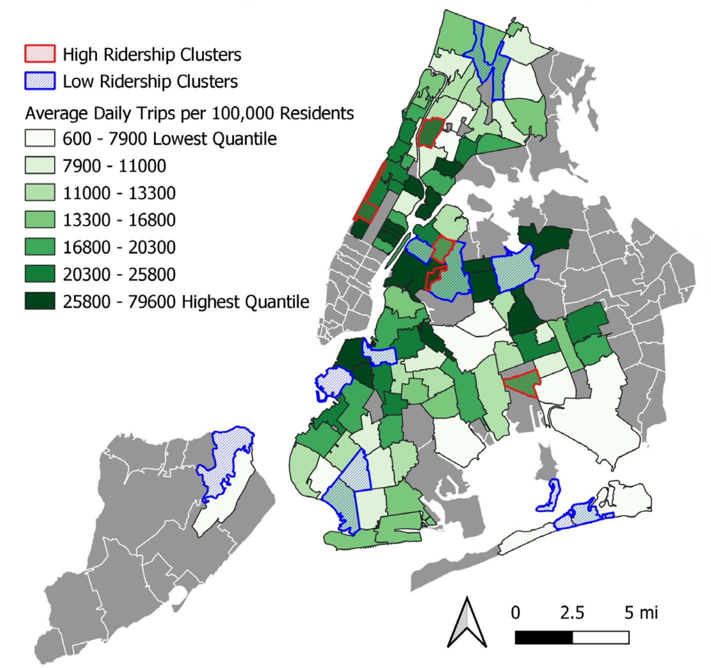


Figure 10c: NYC ridership outside of the Central Business District. Outside the Central Business District NYC ridership shows areas with high ridership and pockets of statistically significant clustering in neighborhoods (Moran's I: 0.226). Significant clusters of ridership are highlighted with high areas in red and low areas in blue (p-value > 0.05).

While ridership is still dramatically lower than the eight million daily riders seen at the start of 2020, even in the midst of a pandemic, weekday subway ridership remains at about 1.5 million, according to the MTA estimates.[12] Public transit remains an essential and vital service for residents, from shopping for essentials to enabling front line workers to providing access to medical facilities. Thus, while usage has decreased, there is still a substantial amount of people and potentially vectors for transmission on the system. If riding the subway is a major risk factor in the transmission of COVID then we would see a pattern of overlap between high ridership and high cases in our analysis. However, there is none. To examine why transit might not be a major factor in transmission, we can look at the mitigation measures taken by transit agencies and riders to create a safer environment.

Mitigation Measures

A possible reason that ridership activity does not directly reflect case numbers is due to the significant amount of masking on the system. Transit is actively seeking ways to keep riders safe by promoting masking, improving filtration, and seeking out innovative solutions to combat the spread of coronavirus.

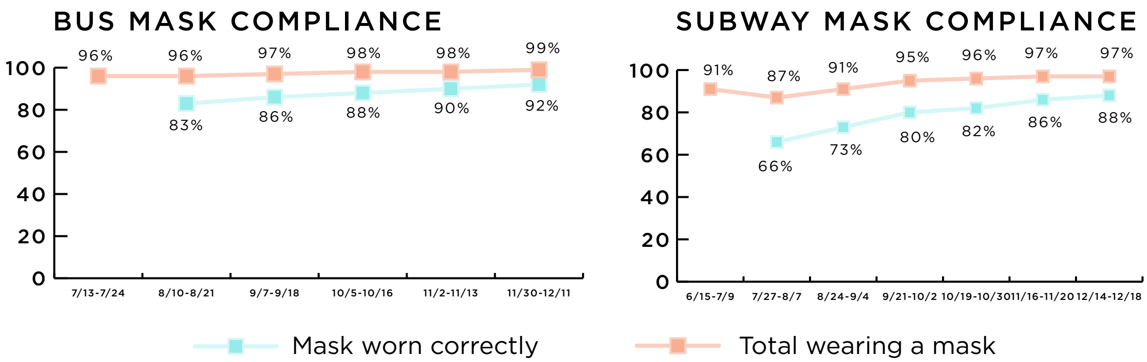
Proper usage of masks while on the system is a key factor in risk reduction for riders, staff, and the public. Mask compliance has remained high since the summer throughout the MTA's subway and bus system. Proper mask usage was around 80 percent of riders at the time of the Brooklyn cluster in late September and early October, and has improved to nearly 90 percent during the winter. The MTA reported at their January 21, 2021 board meeting a positivity rate of 2% among MTA staff, while the rate for NYC as a whole at that time was around 6%.[13] This statistic suggests that mitigation measures taken by MTA are effective in reducing the risk of transmission in a public transit environment. Proper masking will continue to play an important role through the winter peak of cases and the vaccination rollouts.

Transit agencies and public health experts have long advocated for masking to mitigate person to person transmission and as necessary safety measures. The prolonged debate over the efficacy of masks under the previous federal administration, as well as the lack of a federal directive to require masking, undermined guidance from the CDC and cast doubt on the ability of mask usage to dramatically slow the spread of COVID. In fact, in October of 2020, the Trump White House blocked the CDC [14] from requiring masks on public transportation.

Locally, the MTA required masks on transit beginning April 17, 2020.[15] In July 2020 the MTA launched its first Mask Force campaign to distribute masks to riders across the system to stress rider safety and promote mask usage in the system.[16] An executive order requiring passengers to wear face coverings during interstate travel finally came after President Biden took office.[17] On January 29, 2021 the CDC announced that mask-wearing will be mandatory across all modes of interstate transportation. It is estimated that this long-awaited mandate will save 50,000 lives from February to April 2021. Finally, the federal government's actions are in line with what the science and local transit agencies have already known.

While proper mask compliance is a cornerstone to addressing the spread of COVID-19, transit is also looking to innovation to advance ever safer and more layered pandemic interventions into our transportation systems. Technological solutions and recommendations provided in TSTC's 2020 report, Back on Board: A Guide to Safe(r) Transit in the Era of COVID-19,[18] are taking root at the agency level, further spurred by the Transit Innovation Partnership, a public-private initiative formed by the Metropolitan Transportation Authority and the Partnership for New York City to incubate and test solutions that address top-priority challenges posed by COVID-19.

In July 2020, the Transit Innovation Partnership launched The COVID-19 Response Challenge Transit Tech Lab, building on the MTA's improved ventilation and mask mandate to combat the virus and to contribute to riders' ability to safely return to transit en masse.[19] Choosing from a pool of more than 200 submissions, eight promising technologies were selected for a rapid proof-of-concept pilot testing over the course of eight weeks. [20] The proposed solutions include integration of micro-mobility, integrating crowd size data with station and platform wayfinding, improved air filtration, and new cleaning methods for facilities, buses and subway cars. Many of these pilot innovations address primary factors of spread via aerosolization. If proven effective, they may lead to solutions that build public health resilience and confidence in transit, as well as improve the overall rider experience.



BUS MASK COMPLIANCE

Survey Period	No. of observations	Mask worn correctly	Mask worn incorrectly	No mask	Total wearing a mask
11/30-12/11	76,780	92%	7%	1%	99%
11/2-11/13	62,793	90%	8%	2%	98%
10/5-10/16	60,773	88%	10%	2%	98%
9/7-9/18	57,168	86%	11%	3%	97%
8/10-8/21	57,437	83%	13%	4%	96%
7/13-7/24	47,945	n/a*	n/a*	4%	96%

SUBWAY MASK COMPLIANCE

Survey Period	No. of observations	Mask worn correctly	Mask worn incorrectly	No mask	Total wearing a mask
12/14-12/18	65,845	88%	9%	3%	97%
11/16-11/20	98,420	86%	11%	3%	97%
10/19-10/30	75,999	82%	14%	4%	96%
9/21-10/2	93,221	80%	14%	5%	95%
8/24-9/4	41,993	73%	18%	9%	91%
7/27-8/3	18,077	66%	22%	13%	87%
6/15-7/9	124,345	n/a*	n/a*	9%	91%

*The MTA mask compliance survey initially only recorded if passengers were wearing a mask or not.

Figure 11: Mask compliance has remained high since the summer throughout the subway and bus system. Proper mask usage (fully covering both the nose and mouth) was around 80 percent around the time of the Brooklyn cluster in late September and early October and has improved to nearly 90 percent. Proper masking will continue to play an important role as cases climb during the winter. Source: MTA Subway and bus mask compliance statistics

The following are the eight companies that were chosen to complete the Transit Tech Lab's eight-week proof of concept alongside the health and safety recommendations TSTC released with our original Back on Board Report:

Company	Technology	Related recommendation from Back on Board
Beyond (Brooklyn, NY)	Individually leased folding electric bikes and scooters to expand public transit access. Will work with NYC DOT to comply with safety guidelines.	Integrate micromobility transportation options.
CASPR Group (Dallas, TX)	Disinfection technology that works with ambient air to provide continuous air and surface protection without harmful chemicals or an operator.	Improve air quality by upgrading ventilation systems in vehicles and indoor spaces.
City Swift (Galway, Ireland)	Provides riders and train operators with capacity levels on trains and buses.	Aggregate and make public stations and train crowding data in real time using proprietary and third-party data.
Kinnos (Brooklyn, NY)	Visualizes disinfection through a colorized powder formula that dissolves into liquid bleach.	Improve cleaning protocols and practices.
Knorr Merak (Munich, Germany)	Air filtration and purification solution.	Improve air quality by upgrading ventilation systems in vehicles and indoor spaces.
Piper (San Diego, CA)	Collects real time passenger crowding data from trains and platforms for integration with mobile apps and in-station digital communication.	Develop a smart messaging system for real-time crowding alerts.
Strongarm (Brooklyn, NY)	Wearable technology to promote worker safety and social distancing.	Train and continually update all transit staff on disease transmission and protocols to reduce its spread.
Vyv (Troy, NY)	Continuous non-ultraviolet antimicrobial light to reduce bacteria/microbes from surfaces.	Explore far-UVC sanitization for stations, trains, buses, and air ventilation systems.

Successful companies may be chosen for a year-long pilot to deploy their tools at scale. Learn more at www.transitinnovation.org.

CONCLUSION

If the premise that public transit is a major driver of COVID-19 outbreaks were true, then we would find a correlation between subway ridership counts and COVID-19 cases. Given that this correlation is not evident from the data, a causative link cannot be conclusively established. Based on our analysis, there is no geographic association between subway ridership and COVID-19 case rates. There are additional factors that affect this relationship, including high mask compliance levels (between 80 and 90 percent), lower than normal ridership allowing for proper social distancing, and the subway's ventilation system (which undergoes more air changes than the standard office building and other enclosed settings).[21] Surface cleaning by the MTA may also ameliorate the spread of COVID-19,[22] although the latest scientific consensus now shows that surface transmission is limited and rare.

We speculate that the spike in positive COVID-19 cases in October, 2020 may have been caused by factors other than transit use. These factors include social gatherings, especially indoor gatherings, associated with various religious and secular holidays during the time period we analyzed. Governor Cuomo in his December 11, 2020 press conference cited data showing that "living room spread" made up 74% of cases in New York at that time.[23]

While the movement of people has clearly played a role in the global spread of COVID-19, this does not necessarily mean that transmission from person to person while on transit is a major vector of COVID-19 transmission. When blame for COVID-19 spread is erroneously focused on transit, that public narrative not only harms transit's recovery from the pandemic, it artificially limits commutation options and distracts from the real drivers of infection.

Given the dramatic rise in transmission and positivity rates across the country over the course of the winter, including in suburban and rural communities and areas where transit usage per capita is minimal compared with New York City, the argument that public transit is a primary vector of infection loses its potency. Public resources should be devoted to effective practices such as masking, social distancing, and proper ventilation, ensuring that all innovative mitigation efforts are focused on preventing the root causes of spread and on an efficient vaccination campaign.

New York City needs transit ridership to rebound for the economy to recover—essential workers rely on transit to reach work and other critical destinations. If workers turn away from transit and to cars to commute to work, a glut of vehicles on our roads will clog our city and hamper our recovery just as vaccine uptake begins to make the reopening of workplaces and commercial facilities viable. If farebox revenue continues to be depressed, even federal rescue aid will be insufficient to stave off massive cuts to bus and subway service just as riders return to work in larger numbers. Unwarranted fear of COVID-19 transmission risk on buses and subways will undermine our ability to resume pre-pandemic economic activity. The city and state must do more to reassure residents that they are not putting themselves at risk by using transit.[24]

Along with a campaign to inform New Yorkers of transit's safety, the MTA must ensure there is adequate service frequency to prevent overcrowding on the trains or buses until vaccine uptake rises to levels necessary to generate herd immunity. Crowded indoor spaces create some measure of risk no matter where they are, and the MTA must continue to use best practices to keep riders safe by providing the service frequency needed to facilitate safe distancing, as well as by promoting new and innovative measures such as those being tested by the Transit Innovation Partnership to combat the spread of COVID-19.

Like many public authorities, COVID-19 stretched the MTA's resources and staff to their limits, shifting the foundations of general operating assumptions and procedures. Practices such as increased sanitization, maintaining service frequency, and piloting pandemic interventions, combined with decreased farebox revenue, mean the MTA is in desperate need of further federal funding. The aid will have far-reaching benefits for the region, as every $1 invested in public transportation generates $5 in economic returns, according to APTA. Without it, the MTA—the backbone of the city and region's economy—could face a death spiral of service cuts, layoffs, and fare hikes, reducing service quality and frequency, and ultimately further depressing both ridership levels and the economy through lack of access to employment.

APPENDIX I

GEOGRAPHIC ANALYSIS METHODS: COMPARING SUBWAY ACTIVITY AND CASE CLUSTERS DISTRIBUTION

If subway activity was a major factor in the spread of COVID-19 cases, then we would expect clusters of cases to align with clusters of ridership. To assess if there are overlaps of clusters, we used a local indicator of spatial association (LISA) statistical test via a local Moran statistic as a way to identify local clusters and local spatial outliers and to assess spatial dependency and a local spatial autocorrelation of ridership and COVID-19 cases.[25] In other words, the Moran's I statistic paints a picture of how randomly geographically distributed clusters are distributed on a scale of -1 to 1; a value of 1 represents the strongest clusters spatial nonrandom distribution, 0 as completely random, and -1 as the most dispersed or evenly distributed.

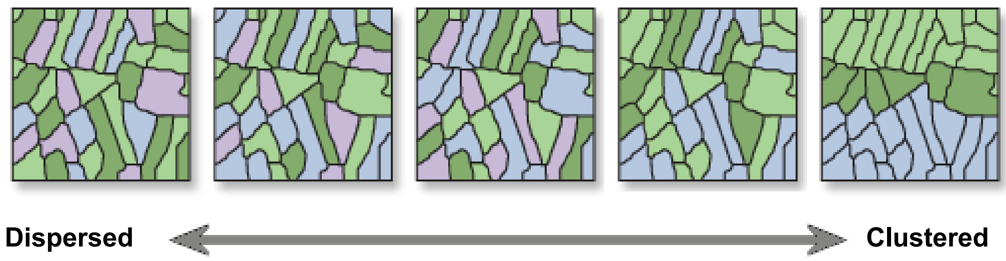


Image source: ESRI ArcGIS

We undertook an analysis of ridership and COVID-19 clusters using only modified ZCTA ("MODZCTA") with subway access, removing areas that don't have turnstiles for our analysis. We also focused on the area outside of the central business district of Manhattan (defined as the area south of 59th Street) which is known to have ridership that overwhelmingly exceeds the residential population and was the strongest cluster of ridership in the city. By subtracting out this outlier of high ridership and low population we were better able to zero in on clusters outside of the core of the city.

At a city-wide level, we find a small but significant positive spatial dependence exists between MODZCTA and ridership clusters outside of the Central Business District (Moran's I = 0.191, p-value 0.008). In other words, throughout the city subway ridership activity is not randomly distributed by geography and has a noticeable pattern. We ran the same analysis for clusters of COVID-19 case rates and found a stronger and significant spatial dependency of case rates (Moran's I = 0.434, p-value = 0.001). The COVID case clustering patterns are consistent with the 10/8/20 COVID hot spot zones that health officials announced a week later. Using this method, we highlight significant clusters of local areas with high values of cases and riders in red (figure 9) and clusters at low values in blue (figure 9). There is no geographic overlap of clusters of high ridership and high cases in the week ending 9/26/20, one week preceding the announcements of the 10/8/20 COVID hotspots in Brooklyn and Queens. The lack of a distinct overlapping patterns of clusters or even overlapping areas of high ridership and high COVID prior to the winter surge of cases suggests that subway use alone is not the major driving factor in how a microcluster of COVID-19 grows.

APPENDIX II

THE TRANSIT INNOVATION PARTNERSHIP

The Transit Innovation Partnership is a public-private initiative formed by the Metropolitan Transportation Authority and the Partnership for New York City with the mission to make New York the global leader in public transit. A board of leaders from academia, business, labor, civic organizations and government guides the Transit Innovation Partnership, which brings together diverse stakeholders to realize public-private projects that address top-priority challenges.

The COVID-19 Challenge was launched in July 2020 by the Transit Tech Lab, building on MTA's unprecedented cleaning measures to help riders return confidently to transit. More than 200 submissions were submitted by companies across the globe. Five transit agencies participated, including the Metropolitan Transportation Authority, the Port Authority of New York & New Jersey, NJ TRANSIT, New York City Department of Education, and New York City Department of Transportation. Solutions range from micromobility and improved air filtration to new cleaning solutions for facilities, buses and subway cars. More than 50 public and private sector evaluators reviewed submissions. Transit agencies then selected the eight most promising technologies for a rapid proof-of-concept over the course of eight weeks.

The following are the eight selected companies that completed the Transit Tech Lab's eight-week proof of concept offering promising results.:

Company: Beyond (Brooklyn, N.Y.)
Technology: Individually leased folding electric bikes and scooters to expand public transit access. Will work with NYC DOT to comply with safety guidelines.

Company: CASPR Group (Dallas, Texas)
Technology: Disinfection technology that works with ambient air to provide continuous air and surface protection without harmful chemicals or an operator

Company: CitySwift (Galway, Ireland)
Technology: Provides riders and train operators with capacity levels for trains and buses

Company: Kinnos (Brooklyn, N.Y.)
Technology: Visualizes disinfection through colorized powder formula that dissolves into liquid bleach

Company: Knorr Merak (Munich, Germany)
Technology: Air filtration and purification solution

Company: Piper (San Diego, Calif.)
Technology: Collects real time passenger crowding data from trains and platforms for integration with mobile apps and in-station displays

Company: Strongarm (Brooklyn, N.Y.)
Technology: Wearable technology to promote worker safety and social distancing

Company: Vyv (Troy, N.Y.)
Technology: Continuous non-UV antimicrobial light to reduce bacteria/ microbes from surfaces

Successful companies may be chosen for a year-long pilot to deploy their tools at scale. Learn more at https://transitinnovation.org.

ENDNOTES

1. https://new.mta.info/coronavirus
2. https://www.nytimes.com/interactive/2020/nyregion/new-york-city-coronavirus-cases.html
3. https://www.rochesterfirst.com/coronavirus/watch-live-gov-cuomo-updates-new-yorkers-on-covid-19-pandemic-2/
4. https://www.scientificamerican.com/article/there-is-little-evidence-that-mass-transit-poses-a-risk-of-coronavirus-outbreaks/
5. https://wagner.nyu.edu/impact/research/publications/public-transportation-and-transmission-viral-respiratory-disease
6. https://twitter.com/NYGovCuomo/status/1313588620264124416?s=20
7. https://www.governor.ny.gov/news/video-audio-photos-rush-transcript-governor-cuomo-updates-new-yorkers-states-progress-during-8
8. https://esd.ny.gov/ny-cluster-action-initiative-guidance, https://forward.ny.gov/micro-cluster-strategy
9. https://www.governor.ny.gov/news/governor-cuomo-announces-new-cluster-action-initiative
10. Coronavirus Updates: COVID-19 Cases In Brooklyn's Red Zone Drops As Queens Sees An Uptick
11. https://github.com/nychealth/coronavirus-data#geography-zip-codes-and-zctas
12. Day-by-day ridership numbers
13. https://www.youtube.com/watch?v=wy7pRsuAoIs&list=PLZHkn788ZQJOFAVMHgiIcAZxcr8AFZCJB
14. https://www.nytimes.com/2020/10/09/health/coronavirus-covid-masks-cdc.html
15. https://www.mta.info/press-release/mta-headquarters/statement-mta-chairman-and-ceo-patrick-j-foye
16. https://www.mta.info/press-release/mta-headquarters/mta-launches-%E2%80%98operation-respect%E2%80%99-promote-universal-mask-compliance
17. https://www.npr.org/2021/01/21/959398694/no-mask-no-fly-biden-signs-order-requiring-face-coverings-on-planes
18. http://www.tstc.org/wp-content/uploads/2020/06/06162020_-back-on-board.pdf
19. https://transitinnovation.org/challenge/covid

20. https://transittechlab.medium.com/update-on-covid-19-response-challenge-ba911630acc
21. https://www.nytimes.com/interactive/2020/08/10/nyregion/nyc-subway-coronavirus.html
22. https://new.mta.info/coronavirus/cleaning
23. https://www.governor.ny.gov/news/video-audio-photos-rush-transcript-governor-cuomo-updates-new-yorkers-states-progress-during-8
24. https://nyc.streetsblog.org/2020/12/14/mayor-i-accept-the-streetsblog-challenge-to-ride-the-subway/
25. https://geodacenter.github.io/workbook/6a_local_auto/lab6a.html#lisa-principle