



Public Transit and COVID-19 Pandemic:

Global Research and Best Practices



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Disclaimer: The global COVID-19 pandemic is an emerging, rapidly evolving situation; as such, re-search on the subject is in its initial stages and continuously developing. Many scientific studies available about the virus are pre-prints and not yet peer reviewed. As new evidence emerges, it may affect the information contained in this document.

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Executive Summary

The coronavirus pandemic struck major cities across the world quickly and with devastating impacts. Within three months of the first recorded case, many major cities were shut down, with residents forced to stay at home. In the United States, New York City became the epicenter for cases and deaths. At first, rural areas and less-dense cities saw few infections. This led some researchers and media pundits to proclaim that public transit was a major cause for the severity of urban outbreaks. Since then, however, the disease has spread to nearly every corner of the country and world and is widespread in many communities where public transit ridership is low or non-existent. Recent analyses, and a growing number of experts, have now concluded that public transit had little or no role in the spread of the disease.

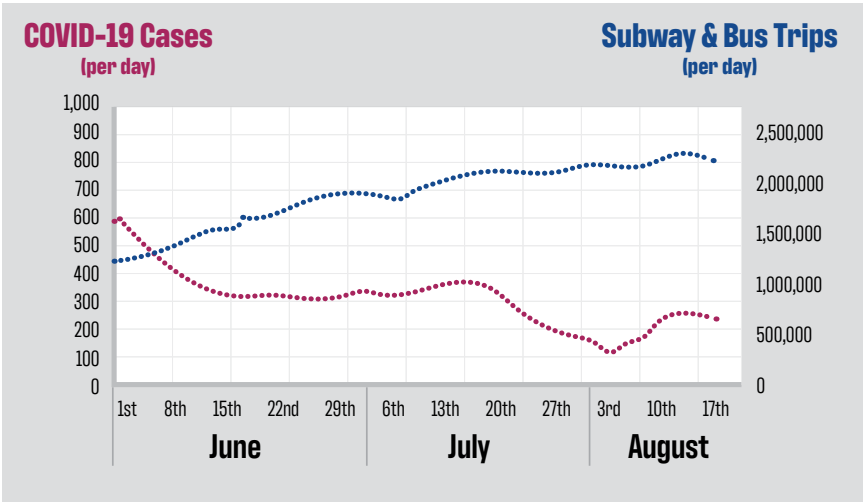
This report is based on a comprehensive review of United States and global research regarding COVID-19 transmission and public transit, interviews with public health experts, and our own analysis of various data sources. These are our principal findings:

- 1. **No direct correlation has been found between use of urban public transit and transmission of COVID-19.** A review of studies from around the world indicate minimal risk from using public transit, especially where specific safeguards are in place, such as face coverings, well-functioning ventilation systems, and minimal talking by riders.

- 2. **An analysis of public transit ridership in multiple cities over the past three months shows no correlation with the rise or fall of local COVID-19 cases. Case studies underscore that case rates are tied primarily to local community spread, rather than correlated to public transit ridership rates.**

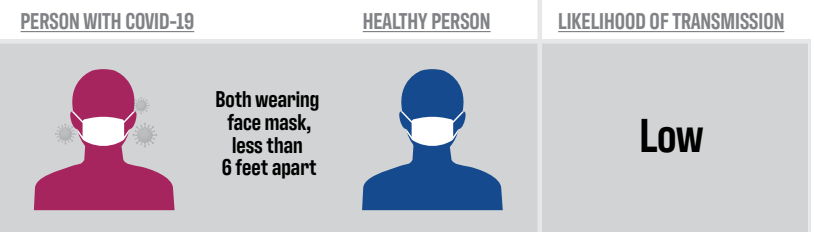
- In Hartford, Connecticut, public transit ridership has remained nearly constant in recent months, while COVID-19 cases have fallen.
- More than 150 million rides have been taken on New York City subways and buses between June 1 and August 18, yet the positive test result rate has dropped by 70%, from 3.3% positive to 1.0%.^{1,2}
- In San Francisco, California, Salt Lake City, Utah, Columbus, Ohio, and Austin, Texas, public transit ridership has remained mostly constant in recent months, but COVID-19 cases have skyrocketed.

In New York City, from June 1 to August 18, more than 76 million rides were taken on the subway system and close to 79 million taken on city buses. During that time the case count for city residents dropped from an average of over 600 per day to approximately 250 per day.



Data source: MTA, New York City Department of Health; Daily numbers represent 7-day rolling averages.

3. Mask wearing has been shown to be effective at reducing person-to-person transmission by blocking droplets from spreading from an infected person, controlling the source; consequently, public transit systems are requiring riders to wear masks. Public transit agencies also have aggressively been cleaning their train systems and have or are developing airflow improvements to meet or exceed air quality recommended levels of 12 fresh air exchanges/hour.³ Trains and many bus fleets achieve or exceed that level. In addition, many buses increase ventilation rates by opening windows and may also benefit by frequently opening doors to allow passengers to board and alight.⁴



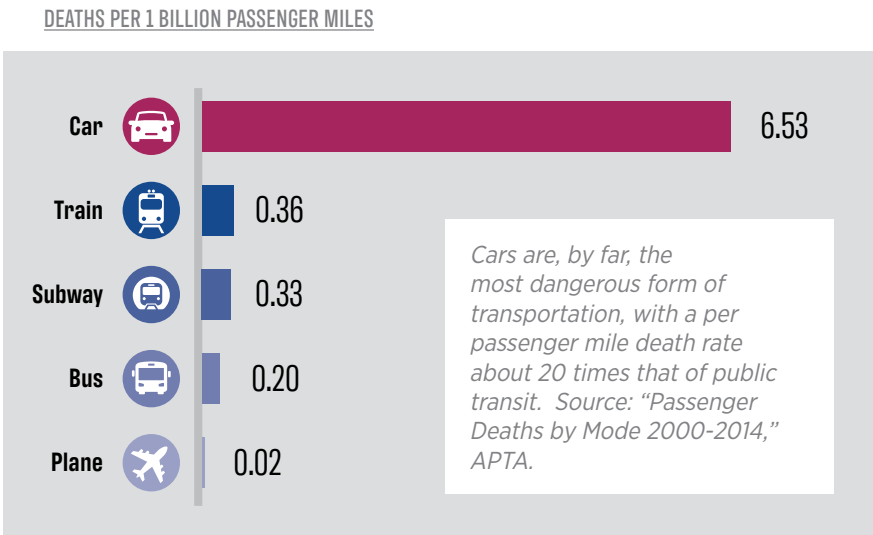
Source: Based on infographic prepared by Washington State Department of Health

4. There are several possible explanations for the lack of correlation between the increase in public transit ridership and increasing COVID-19 cases.
- Public transit riders generally talk little while using public transit. Scientists have linked many clusters to bars, indoor restaurants, and houses of worship where loud talking and singing may occur.
 - On many urban public transit systems, air flow is enhanced, compared to other indoor locations, as ventilation systems run efficiently and doors frequently open and close.⁵
 - Time spent exposed to an infected person impacts the likelihood of infection.⁶ Many intraurban trips are of relatively short duration.



The New York City subway systems exchanges its air 18 times/hour, well above the recommended flow rate for many other indoor settings. (Image source: The New York Times)

5. It appears that what you do at the end of a trip affects the probability of contracting the virus far more than the mode of travel. Many people who have continued to travel, by car or public transit, over the past few months are essential workers, who have had higher case rates regardless of their commute mode.^{7,8}
6. There will be long-term health consequences if people in large numbers switch from public transit to private cars. On a per mile basis, passengers are about 20 times more likely to experience a fatal crash in a car than when using public transit.⁹ In addition, more time spent in a car can lead to inactivity diseases, including obesity, diabetes, and high blood pressure.¹⁰ On an environmental basis, cars pollute far more than public transit and increase a traveler's carbon footprint.¹¹



While the evidence indicates that the probability of transmission on public transit is low, public transit agencies can take steps towards further reducing the risk of transmission. This report includes practices that have been implemented by public transit agencies across the globe and found to be to be the most actionable, impactful, and financially feasible for public transit agencies.

Introduction

With the onset of the global COVID-19 pandemic in early 2020, mobility plummeted as governments issued stay-at-home orders and most people, with the exception of essential workers, avoided any non-essential travel. This abrupt pause in activity was experienced around the world, with transit service disproportionately affected. Ridership in many places dropped by 90% or more, as many commuters began working from home, unemployment grew, and both leisure and business travel almost entirely stopped.

In response to the crisis, transit providers were forced to quickly adapt to new and rapidly evolving conditions. Many cut services due to the drop in ridership but continued operations for the critical purpose of transporting essential workers and those making essential trips. Very rapidly, transit providers have adapted by increasing cleaning procedures, issuing new regulations for riders (such as mask mandates), and implementing various worker protections, all while revenue plummeted due to the loss of farebox revenue. In addition, agencies adjusted service to meet new demand patterns and as a means to reduce crowding.

Please refer to APTA's [Heroes Moving Heroes](#) web page for stories and examples honoring public transit workers' work during COVID-19.



“They [transit operators] are heroes, moving heroes. We're moving the essential workers who are fighting this crisis.”

Sarah Feinberg,
Interim MTA New York
City Transit President

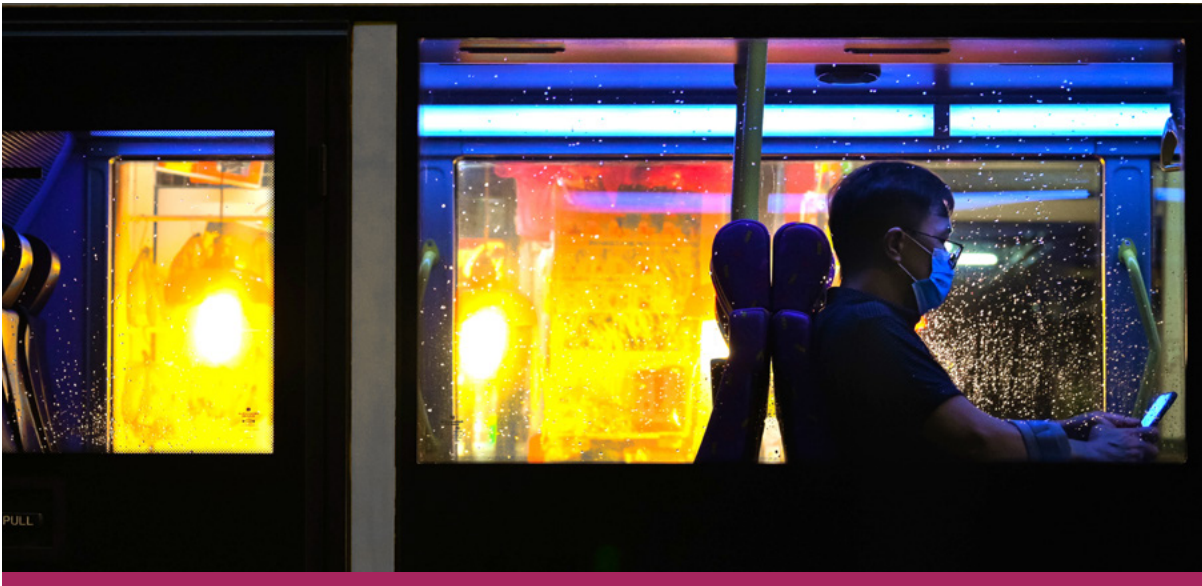


As outbreaks in various parts of the world have been brought under control and restrictions relaxed, populations have begun local travel again. However, the recovery of transit is lagging as vehicle traffic is returning to pre-pandemic levels in some places. A large portion of travelers' fear of riding transit is based on unsubstantiated perceptions regarding the safety of transit vehicles and risk of infection. Whether or not these fears are warranted was the impetus for this report, which critically and objectively examines the risks associated with transit and how agencies have responded.

This document compiles the latest scientific understanding of COVID-19 transmission and, specifically, the correlation between transmission and transit, as well as the salutary and often innovative response of transit agencies around the world. To inform our work, extensive research was conducted on the most recent and comprehensive information coming from scientific publications, articles, and governmental institutions. To further examine the link between transit and COVID-19 rates, we analyzed data from several domestic cities and compared the change in case rates to the change in transit ridership over several months.

An extensive review of both successful virus mitigation strategies and transit agency actions allowed us to identify a set of global best practices, highlighting those methods that seem to be most effective at protecting the health of both riders and operators. Finally, extensive interviews with leading public health experts added further insight into how transit agencies can best utilize their resources to mitigate virus risks.

Several global cities have maintained or increased ridership while keeping transmission rates low. To date, no known outbreaks have been traced to public transit. This document serves as a reference guide for transit operators on measures that could be implemented to achieve similar success.



Part I: Transit Usage and COVID-19 Infection Rates

- COVID-19 Transmission
- No Clear Link between Transmission and Transit
- Analysis of Transit Ridership and Infection Rates

COVID-19 Transmission

KEY TAKEAWAYS:

- ➔ Knowledge surrounding COVID-19 is an evolving science. At the time of this publication, transmission is thought to occur primarily through person-to-person spread via respiratory droplets (>5 µm in diameter). Surface-to-person transmission, once thought to be a main source of infection, is now considered less likely although proper disinfection and handwashing procedures should still be followed.
- ➔ Increasing evidence indicates the virus may also be spread via aerosol transmission, in which smaller microdroplets (<5 µm in diameter) become airborne and travel for longer distances than heavier respiratory droplets. This adds additional emphasis on the importance of all transit riders wearing face coverings to block transmission of disease.
- ➔ Different mitigation strategies can be employed to reduce the risk of spreading and contracting COVID-19. These include wearing of face coverings, physical distancing, enhanced ventilation and filtration, surface cleaning, and personal handwashing procedures.

Although the scientific knowledge around COVID-19 is limited due to the novel nature of the virus, it is helpful to understand the basics of transmission so that transit providers and riders can best protect themselves. As of August 2020, we know that transmission of the virus that causes COVID-19 (SARS-CoV-2) occurs via person-to-person transmission through *respiratory droplets* and surface-to-person through *fomites*. New evidence is emerging indicating that the virus can also be transmitted person-to-person via *aerosols*.

Duration of exposure

Limiting prolonged exposure to infected individuals is considered an important step in preventing virus transmission. While data are currently insufficient to determine what duration increases the risk of droplet and aerosol transmission, the CDC considers 15 minutes of close exposure to be the operational definition of prolonged exposure whether the individual is masked or unmasked.¹²

Increasing evidence indicates that duration of exposure increases the risk of disease transmission. One study found that despite having significant interactions with workers on other floors, infection occurring at a call center in South Korea was limited to the floor where the infected individual sat and was concentrated on immediate and nearby tables.¹³ Dr. Erin Bromage, Associate Professor of Biology at University of Massachusetts Dartmouth, emphasizes the importance of duration of exposure time in a now often cited article: “remember the formula: Successful Infection = Exposure to Virus x Time.”¹⁴





Successful Infection = Exposure to Virus x Time

MITIGATING TRANSMISSION

How can transmission be reduced in a public transit setting?

While all public activities carry some associated risk, risks can be lowered by following public health guidelines.¹⁵ Measures taken by transit agencies are likely contributing to low infection rates on public transit, at least in part.¹⁶ These include mandating face coverings, modifying service, monitoring capacity, improving sanitation and ventilation protocols, and increasing communication of regulations to passengers. It has been understood since the onset of the pandemic that physical distancing and sanitation efforts could help mitigate transmission risks. There is increasing consensus that fomites, or particles on surfaces, are not a main source of transmission, although cleaning and disinfecting protocol do reduce risk. In an interview with Scientific American, Dr. Melissa Perry, a leading epidemiologist and chair of the Department of Environmental and Occupational Health at George Washington University's Milken Institute School of Public Health, emphasized that mask wearing and physical distancing take precedent over disinfecting surfaces.¹⁷ In the section below, we briefly cover all mitigation tactics but explore two critical interventions, face masks and ventilation, in most detail.

For an expanded section on transmission and mitigating risk, please see [Appendix A](#).

Transmission Type	Mitigation Strategies
<div>COMMUNITY SPREAD</div> <div></div>	<div>Lowering overall infection rate in an area via elimination methods such as:</div> <div><ul style="list-style-type: none">Robust testing and contact tracingIsolation protocolsMobility restrictionsRestricted entry (thermal scanning, COVID-19 screening, etc.)</div>
<div>RESPIRATORY DROPLETS</div> <div></div>	<div>Reducing risk of contact with and spread of respiratory droplets via methods such as:</div> <div><ul style="list-style-type: none">Covering of nose and mouth with a face mask or shieldPhysical distancingVentilation, filtration, and air flow controls</div>
<div>AEROSOL (DROPLET NUCLEI)</div> <div></div>	<div>Reducing risk of contact with and spread of aerosols via methods such as:</div> <div><ul style="list-style-type: none">Covering of nose and mouth with a face mask or, if available, respirators such as N95/KN95 masksPhysical distancingVentilation, filtration, and air flow controlsHumidity controls</div>
<div>SURFACE (FOMITES)</div> <div></div>	<div>Reducing the risk of contact with and spread of fomites via:</div> <div><ul style="list-style-type: none">Covering of nose and mouth with a face mask or shieldCleaning and disinfection of surfacesHand washing/sterilization</div>

COMMUNITY SPREAD

Reduce community infection rate to lessen all forms of transmission

The United States Centers for Disease Control and Prevention (CDC) recommends several elements for transit agencies looking to accommodate current and returning riders.¹⁸ The foremost consideration is the level of community spread; this can be quantified in numerous ways, with many state agencies and institutions opting to measure the pandemic's impact by the growth rate of positive cases, hospitalizations, and deaths. Transit agencies should coordinate with local public health authorities to assess the community risk.

PHYSICAL DISTANCING

To reduce person-to-person transmission

To lower the risk via droplet transmission, the CDC recommends that individuals maintain a physical distance of at least six feet—although it should be noted that this metric was determined prior to the encouragement or mandate for mask wearing.¹⁹ The World Health Organization (WHO) recommends a one meter, or about three feet, distance; similarly, a study on the effects of physical distancing on COVID-19 transmission found the transmission was lower with distances of three feet or more.^{20, 21} Physical distancing may be less important in situations where individuals are masked, not talking, together for a brief period of time, and there is efficient ventilation, such as public transit. In these cases, less than six feet of physical distancing can be considered low risk.²²

FACE COVERINGS

To reduce person-to-person transmission via aerosols and droplets

The CDC recommends public transit riders wash hands or disinfect them with hand sanitizer before entering and when exiting transit, avoid touching surfaces and their nose, eyes, and mouth, practice physical distancing, and wear face coverings.²³ If made and worn properly, face coverings can serve as a barrier to droplets and aerosols expelled from the wearer into the air and environment.²⁴















WHY ARE MASKS IMPORTANT?

Masks have been shown, both in past studies of infectious diseases and in the current COVID-19 pandemic, to be effective in preventing disease spread. All face coverings are effective at source control, helping keep others safe by blocking infectious particles from being exhaled, coughed, or sneezed into an environment. Mask wearing compliance is increasingly important with the growing evidence of asymptomatic carriers. In addition, some masks are also protective to the wearer, blocking infectious particles from being inhaled. Increasing evidence is pointing to the importance of face coverings in preventing both droplet and aerosol transmission, even in indoor settings like public transit.

- Masks reduce the number of respiratory droplets emitted by blocking them.²⁵ This is considered source control: stopping the transmission of disease by blocking its source. Researchers have long known that masks can prevent people from spreading airborne germs, via both respiratory droplets and aerosols, to others.²⁶ In addition, “masks also decrease the risk that you’ll auto-inoculate [infect yourself by touching your mouth or nose],” states. Dr. Larry J. Anderson, Professor and Marcus Chair of Infectious Diseases at Emory University.²⁷
- Some masks protect the wearer. Varieties of respirator masks known as N95/KN95 and N99 masks, named after their 95% and 99% efficiency, filter aerosols so they are not inhaled.
- Increasing evidence suggests that even non-respirator masks (such as cotton face coverings) may also provide protection from the virus, either by lessening the severity of symptoms or completely preventing transmission.^{28, 29}
- Increasing evidence suggests that individuals can spread the virus while either asymptomatic or pre-symptomatic, indicating the importance of mask mandates in public settings.³⁰
- Leading scientists emphasize that mask wearing may be the most important way to reduce the transmission of COVID-19. Dr. Larry J. Anderson emphasizes that wearing a mask may be the “one thing that can actually make a difference” in reducing virus spread.³¹

PERSON WITH COVID-19	HEALTHY PERSON	LIKELIHOOD OF TRANSMISSION
 Neither person wearing face mask, less than 6 feet apart		Very High
 Only healthy person wearing face mask, less than 6 feet apart		High
 Only person with COVID-19 wearing face mask, less than 6 feet apart		Medium
 Both wearing face mask, less than 6 feet apart		Low
 Both wearing face mask, and at least 6 feet apart		Very Low
 Staying Home		Virtually None

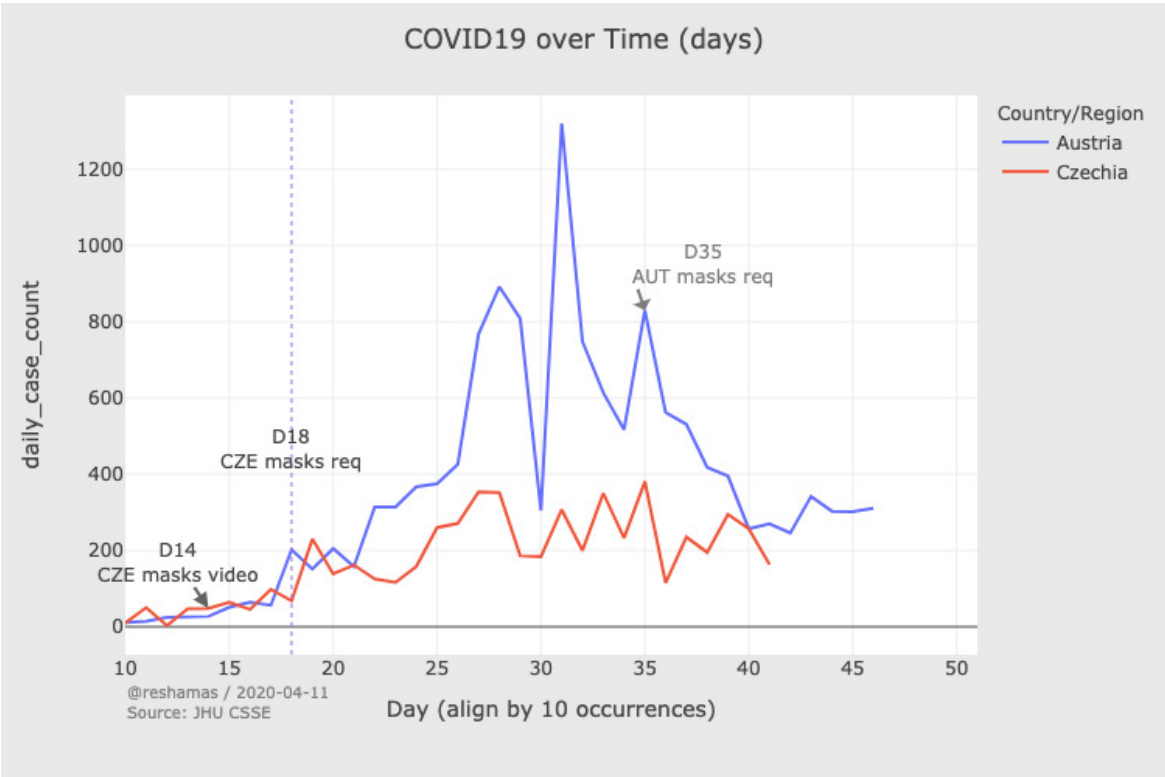
Source: Based on infographic prepared by Washington State Department of Health

Examples where masks may have limited COVID-19 transmission:

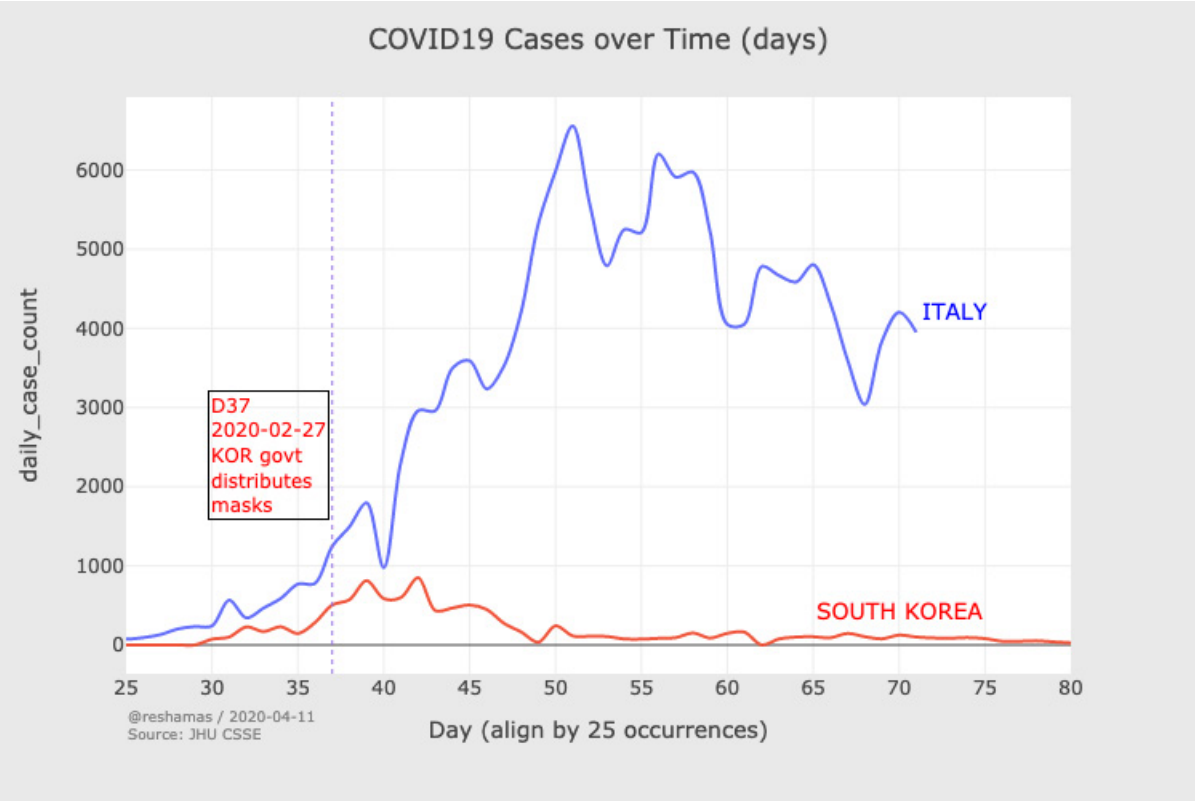
Although research on the COVID-19 is an emergent science, several case studies are highlighted here that illustrate how masks are preventing the virus spread.

- A study by doctors at the University of Oxford found that in every country that encouraged or mandated mask compliance, case and death rates have fallen.³² For example, both Austria and Czechia (geographical neighbors) had similar case rates at the onset of the pandemic. Czechia was first to initiate a mask mandate, and first to see cases flatten. Austria experienced a large spike, which only began to decline after their own mask requirements. Similarly, South Korea and Italy had comparable case growth early in the pandemic; South Korea's rate stabilized shortly after mask distribution by the government, while Italy's rate shot upwards.

Comparison of COVID-19 case counts over time in Czechia (with early mask mandates) and Austria (with later mask mandates). Source: Reshama Shaikh via <https://www.fast.ai/2020/04/13/masks-summary/>



Comparison of COVID-19 case counts over time in South Korea (with large-scale mask distribution) and Italy (without large-scale mask distribution). Source: Reshama Shaikh via <https://www.fast.ai/2020/04/13/masks-summary/>



- In one case study involving transportation (intercity bus), a symptomatic passenger rode a bus with 39 others for two hours without a mask, and infected five people; the passenger put on a face mask before boarding his second bus, a 50-minute ride on a minibus with 14 other passengers, and infected no one.³³
- In another case study, two infected hair stylists saw 139 clients over the course of a week. However, both the stylists and the customers were required to wear masks, and no subsequent spreading was reported.³⁴
- A study of secondary transmission in an indoor household space found face masks were 79% effective in preventing transmission, if used by all household members prior to onset of symptoms.³⁵
- An analysis of 196 countries found that by May 9, 2020, places where masks weren't recommended saw a 62.1% weekly increase in coronavirus deaths per capita, compared with a 15.8% growth in countries with cultures or guidelines supporting mask-wearing.³⁶ Another study found that mask mandates in 15 American states and Washington, DC led to a slowdown in the daily COVID-19 growth rate.³⁷ Mask use is higher in the Northeast and parts of the West, and lower in the Plains and the South—areas that are, at the time of publication, experiencing higher case rates.³⁸

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VENTILATION, FILTRATION, AND AIR FLOW

To reduce person-to-person transmission via aerosols

Ventilation and clean air are key interventions in creating a safer environment. Both the CDC and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the world’s leading authority on indoor environment control and ventilation, recommend increasing outdoor air ventilation, increasing humidity, assessing the air circulation, and increasing filtration to prevent the risk of COVID-19 airborne transmission.³⁹ Air circulating through subway cars and buses is typically replaced with fresh air close to 18-times an hour, more frequently than the 6-8 times recommended for restaurants, the 5-6 times recommended for classrooms, and the 12 times recommended for airborne isolation rooms in medical facilities.⁴⁰

Please refer to ASHRAE’s document [*Ventilation for Acceptable Indoor Air Quality*](#) for more information.



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CLEANING

To reduce surface-to-person transmission

Cleaning and disinfecting of surfaces and hands were rapidly adopted both by transit agencies and individuals. Although there is increasing consensus that person-to-person spread, rather than surface-to-person transmission, is the main source of transmission, cleaning and disinfecting are important actions for public transit agencies for both safety and restoring public confidence.⁴¹ Clinical Professor of Epidemiology at New York University School of Global Public Health, Dr. Robyn Gershon states, “frequent cleaning helps increase confidence in the system.”⁴² While studies revealed the virus’s ability to survive on surfaces for up to nine days, these experiments may have been misleading due to unnaturally high viral load utilized in the lab setting, and lack of clarity on how much infection virus remained (for example, 0.1% of the virus was found to exist on surfaces at the end of these time periods).^{43, 44}

Please refer to APTA’s [*Guide for Safeguarding Riders and Employees*](#) for up-to-date recommendations on protecting riders and employees on transit, including recommendations for physical distancing, face covering, ventilation, and filtration.

Please refer to APTA’s white paper titled [*Cleaning and Disinfecting Guidance During a Contagious Virus Pandemic*](#) for recommendations on cleaning and disinfecting transit vehicles.

Please refer to [*Appendix A: COVID-19 Transmission \(Expanded\)*](#) for additional details on transmission and mitigation.

No Clear Link between Transmission and Transit

KEY TAKEAWAYS:

- While research on the COVID-19 transmission on public transit is limited due to both the recentness of the outbreak and lack of rigorous contact tracing in many parts of the world, our research as of mid-August 2020 found no outbreaks of COVID-19 cases clearly linked to intracity public transit such as city buses and subways.
- Of the cases traced to transportation, the main sources have been tour buses, planes, and cruise ships—modes where passengers sit for extended periods of time with the same cohort of fellow passengers. These modes do not closely resemble either the operational or behavioral patterns of public transit options.
- Even in large cities where transit usage has begun to recover closer to pre-pandemic levels, no outbreaks have been traced to the increased ridership. In those areas, mask use is customary, mandatory, or widespread.
- Indoor dining, bar settings, poorly ventilated office spaces, and gyms are proving to be more risky environments for disease transmission than public transit.

Researchers and media, without much evidence, were quick to point to transit as a major cause of the virus’ spread. Later research shows otherwise. Within a month of the outbreak in the United States some researchers and the media were proclaiming that transit, specifically the New York City subway, was the cause. At that time the American COVID-19 outbreak was largely concentrated in transit-rich New York City. Since then, the disease has spread to nearly every corner of the country and is widespread in many communities where transit ridership is low or service non-existent.

Public transit has some characteristics associated with higher COVID-19 transmission risk, including the potential for crowding in enclosed environments on trains, buses and indoor stations. While public health and transit officials need to work together to manage that risk, available evidence indicates that transit is not as inherently risky as some people believe. According to Dr. Thomas Matte, Senior Science Advisor for Environmental Health at Vital Strategies, a global public health organization, “the public perceptions and press coverage of COVID-19 transmission risk in transit has created more fear than is warranted by the evidence.”⁴⁵ Growing consensus is that this may be due to several factors: less crowding than pre-pandemic times, face mask compliance, the high refresh rate of airflow on buses and train cars, and hygiene efforts of both riders and transit agencies.^{46, 47, 48, 49} A systematic review of available literature and news articles on transmission by epidemiologists at the London School of Hygiene found only one case linking transmission to transport, which occurred on a longer, intercity bus ride.⁵⁰ The results of this study have been compiled in a frequently updated and publicly accessible database. At the time of this publication, no cases of virus transmission events have been traced to public transit services such as commuter buses, trains, and subways. According to a survey of transportation agencies conducted by The New York Times in early August, there have been no notable super spreader events linked to public transit.⁵¹

“The public perceptions and press coverage of COVID-19 transmission risk in transit has created more fear than is warranted by the evidence.”

Dr. Thomas Matte, Vital Strategies

While trains and buses are enclosed, ventilation occurs either by air filtration, open windows, or opening and closing of doors at stations. For example, transit officials in New York City state that filtered air circulating through subway cars is replaced with fresh air close to 18-times an hour, more frequently than the rate recommended for restaurants and many other public indoor settings.⁵² Additionally, the brevity of exposure may help reduce risk as riders tend to not stay on transit for as long as passengers of planes and cruises.⁵³

Stay-at-home orders, work-from-home mandates, and limitation of travel have drastically affected public transit usage in many American cities. Some places, such as New York City, which typically has an average of 5.5 million daily subway riders, experienced ridership rates as low as 92% below normal in March (by August, ridership remained about 75% below pre-pandemic levels).⁵⁴ The early response of some global cities has been well-documented, and success attributed to quick and aggressive intervention measures such as physical distancing and isolation.⁵⁵ More recently, with the increased understanding of how the virus is transmitted, success may be in part related to mask compliance.⁵⁶ In places such as Seoul, Tokyo, and Hong Kong, cases have not been traced to public transit, ridership has fallen less drastically, and service levels remained high. Dr. Gurumurthy Ramachandran, Director of the Johns Hopkins Education and Research Center for Occupational Safety and Health at Johns Hopkins Bloomberg School of Public Health, agrees that “from what has been seen in East Asia, mask wearing on transit, even without what we consider adequate physical distancing, has been effective in reducing the spread of COVID-19.”⁵⁷ In other places that experienced large initial outbreaks, such as Milan, Vienna, and New York City, city-wide measures curtailed the spread of the virus and an increase of riders to transit systems has not led to subsequent case spikes.

Large outbreaks have been traced to settings other than public transit. Settings that seem to have high transmission rates tend to be indoors, with poor ventilation, and high rates of talking or singing. These environments can be very unlike successful transportation systems, which have good ventilation, little to no talking, anti-crowding measures, and mask mandates. Dr. Thomas Matte added that “prior to COVID-19, modeling studies to look at community influenza transmission suggested that transit accounted for a non-trivial but relatively small share of transmission.”⁵⁸ Instead, “spreading is from interactions where people are close together, talking or singing, and are unmasked.” Dr. William N. Rom, a research professor at New York University Grossman School of Medicine, echoed this sentiment: “this question of transmission on the subways came up during the TB and multi-drug resistant TB epidemic in the 1990s. We found that transmission was person-to-person with someone living with the infected case patient. We were always worried about our TB patients on the subway, but we didn’t document any cases.”⁵⁹ Additionally, it seems what individuals do at their trip ends has more impact. Many people who have traveled by car or transit over the past few months are essential workers, and both groups had higher case rates than those who did not travel.^{60 61}

“We were always worried about our TB patients on the subway, but we didn’t document any cases.”

Dr. William N. Rom, NYU Grossman School of Medicine

Please refer to [Appendix B: Studies looking for Links Between Transit and Transmission](#) for further information on studies examining transmission and transit.

Analysis of Transit Ridership and Infection Rates

As of August 2020, no outbreaks have been traced to public transit in the United States. Based on our data review of case rates and transit usage in domestic cities, the correlation between infection rates and transit usage is weak or non-existent. Rather, COVID-19 rates appear to be independent of ridership: in Northeast cities such as Hartford, Connecticut and New York, New York where the pandemic has been largely controlled, ridership has grown since peak pandemic low points, but case rates have been significantly reduced. Meanwhile, in Southern, Southwestern, and Midwestern cities, ridership has remained consistent while cases have skyrocketed. These areas are experiencing serious community outbreaks primarily attributed by public health experts to the reopening of bars and restaurants, large gatherings, nursing homes, prisons, and community fatigue of physical distancing practices.⁶² In fact, of the fifteen metro areas with the highest cumulative case rates as of August 2020, not one had a typical commuter transit share more than 5%, and most have minimal transit services with very light usage.⁶³

United States metro areas with highest COVID-19 case rates through August 2020—nearly all have typical commuter transit shares below 1%.

RANK	METRO OR MICRO AREA	METRO AREA POPULATION	TOTAL CASES	CASES PER 1,000 (AS OF 8/24/20)	METRO AREA TRANSIT SHARE
1	Gallup, NM	71,367	4,157	58.2	0.8%
2	El Centro, CA	181,215	10,393	57.4	0.8%
3	Yuma, AZ	213,787	12,072	56.5	1.9%
4	Eagle Pass, TX	58,722	3,117	53.1	0.0%
5	Show Low, AZ	110,924	5,496	49.5	0.9%
6	Rio Grande City, TX	64,633	2,973	46.0	0.4%
7	Marion, OH	65,093	2,978	45.7	0.8%
8	Yakima, WA	250,873	11,476	45.7	0.5%
9	Brownsville-Harlingen, TX	423,163	19,225	45.4	0.6%
10	Lake City, FL	71,686	3,226	45.0	0.0%
11	Corpus Christi, TX	452,534	19,468	43.0	0.8%
12	Miami, FL	6,198,782	262,738	42.6	3.5%
13	Palestine, TX	57,735	2,425	42.0	0.2%
14	Sioux City, IA	169,878	6,823	40.2	0.4%
15	Huntsville, TX	87,622	3,489	39.8	0.6%

Source: The New York Times, <https://www.nytimes.com/interactive/2020/04/23/upshot/five-ways-to-monitor-coronavirus-outbreak-us.html>

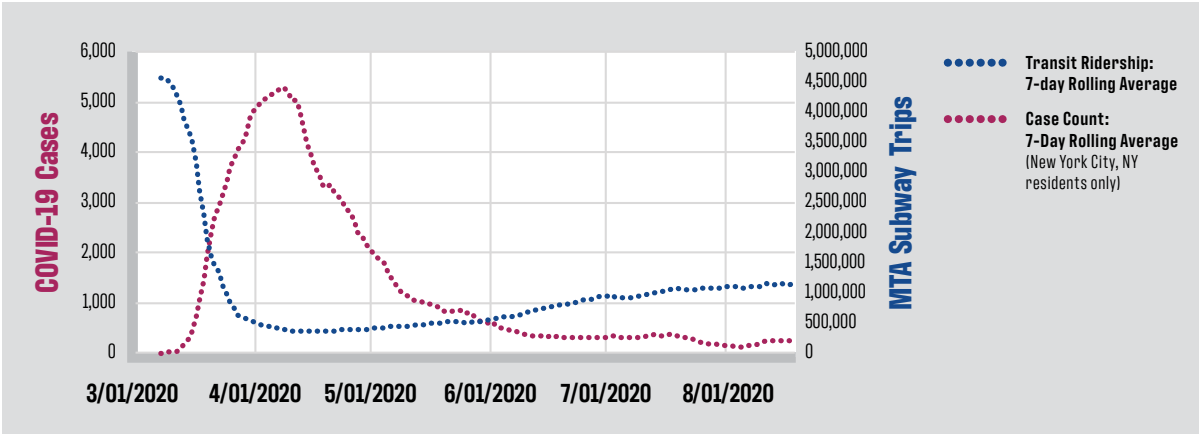
US Census Bureau, ACS 5-Year Estimate 2012-2018: Table B0141

New York, New York:

Approximately 55% of the New York City population relies on public transit for commuting to work.⁶⁴ Early claims linking the New York City subway system, operated by the Metropolitan Transportation Authority (MTA), to coronavirus infections were largely discredited.^{65, 66, 67} In early June 2020, the average case rate per capita for the top ten transit usage zones (omitting Manhattan, where many residents departed the city according to a New York Times analysis of cell phone data and mail forwarding addresses) was found to be 32% lower than the rate among the ten lowest.^{68, 69} A survey in early May of 1,300 patients admitted into New York City hospitals for the virus showed just 4% had recently used transit. In addition, the suburbs around New York City, with lower transit usage, have experienced higher case rates than New York City.⁷⁰

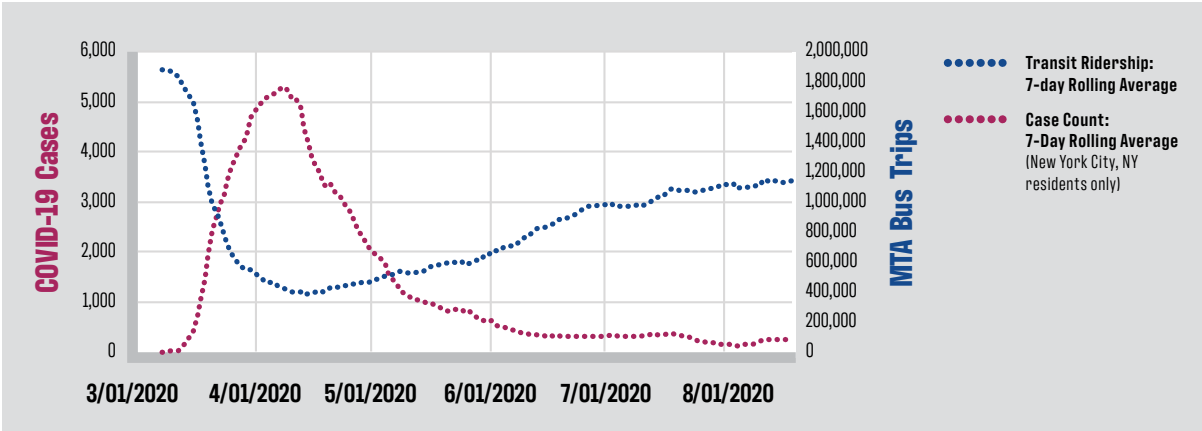
Ridership on both the subways and buses took major hits in March and April as case counts skyrocketed and public transit use was discouraged. However, in the time since, cases have fallen dramatically but ridership has begun a slow recovery. In April, ridership on subways was 8% of normal levels; in the first half of August, ridership hovered near 23%. Buses fared slightly better, growing from April’s nadir of 16% to over 55% in mid-August. As of this writing in August 2020, approximately 2.5 million rides are taken daily on the city’s buses and subways. Between the beginning of the phased reopening in early June and mid-August, the MTA subways served over 76 million riders and buses served close to 79 million riders. During that same period (June 1 to August 18) the number of daily cases in New York City dropped from an average of over 600 to approximately 250; meanwhile, the test positivity rate dropped from 3.3% to 1.0%. Hospitalizations per day also declined, down to 35 on August 18 from the peak of over 1,700 in spring.⁷¹ In New York City, case counts and public transit usage are seen to be inversely related.

New York City, NY: Comparison of COVID-19 case counts with MTA subway ridership



Data source: MTA, NYC Department of Health

New York City, NY: Comparison of COVID-19 case counts with MTA bus ridership



Data source: MTA, NYC Department of Health

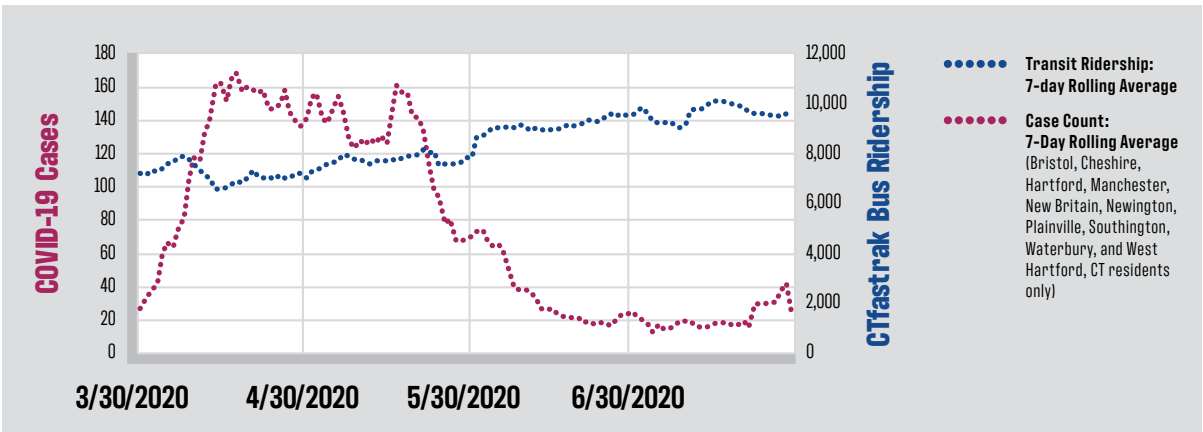
Strategies employed by local transit agencies:

- Maintained regular weekday schedule of subways and buses, with some increase in service (Staten Island Railway), to avoid crowding
- Nightly closures of subways from 1 AM to 5 AM for sanitization; enhanced bus service during these hours
- Frequent disinfecting of high touch surfaces
- Daily sanitization of all railcars and buses
- Piloting of UV light disinfectant technology
- Face covering mandate; free masks and hand sanitizer supplied in select stations
- Personal Protective Equipment (PPE) supplied to transit workers
- Physical distancing and wayfinding markers on platforms
- Safety Ambassadors employed in stations
- Expedited rollout of contactless payment options

Greater Hartford Area, Connecticut:

The CTfastrak bus rapid transit (BRT) system partially utilizes a bus-only roadway and serves riders in the Greater Hartford Area: Waterbury, Cheshire, Southington, Bristol, Plainville, New Britain, Newington, West Hartford, Hartford and Manchester. Approximately 4% of Hartford County residents rely on public transit for commuting to work.⁷² Since March, transit ridership has remained consistent although has begun to recover with the reopening. Connecticut began its phased reopening on May 20, 2020 and has continued to slowly reopen in the subsequent weeks, although is temporarily postponing its third phase of reopening.^{73, 74} Meanwhile, COVID-19 cases have dropped. On August 6, Connecticut reported its third consecutive date without a coronavirus-related death, and a record low daily positive rate of 0.2%.⁷⁵

Greater Hartford Area, CT: Comparison of COVID-19 case counts with CTfastrak ridership



Data Sources: CTfastrak, CT Department of Public Health COVID-19 data for Waterbury, Cheshire, Southington, Bristol, Plainville, New Britain, Newington, West Hartford, Hartford and Manchester

Strategies employed by local transit agencies:

- Rear door entry only on buses
- Barrier partitions between drivers and passengers
- Daily sanitization of buses and frequent sanitization of high touch surfaces
- Face covering mandate, distribution of free masks to riders

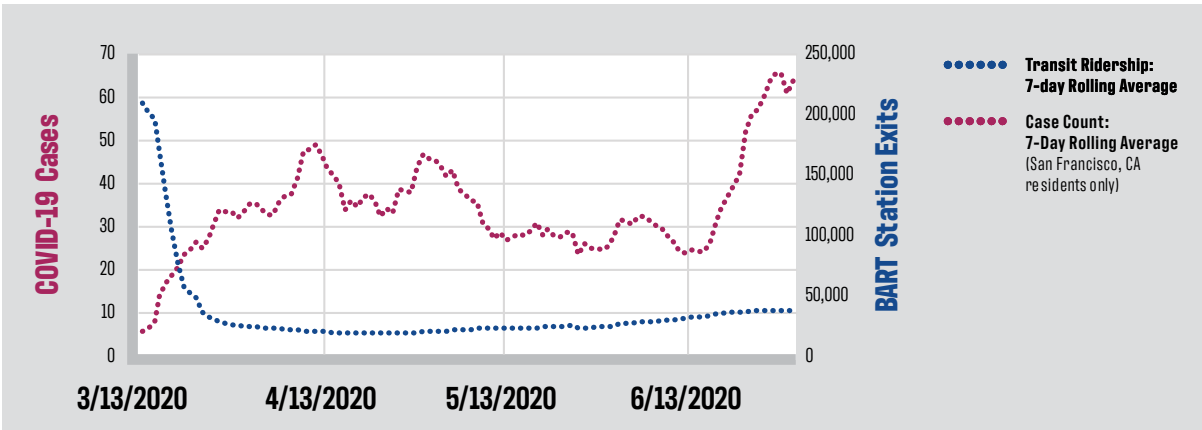
Bay Area, California:

The Bay Area’s Bay Area Rapid Transit (BART) connects San Francisco with Berkeley, Oakland, Fremont, Walnut Creek, Dublin/Pleasanton and other cities in the East Bay. Approximately 34% of San Francisco county residents rely on public transit for commuting to work.⁷⁶ BART began reducing service on March 19, 2020 and operating with limited hours beginning March 23.⁷⁷ Service in some areas was increased from peak pandemic lows beginning June 8.

Despite initial success in stemming the spread of COVID-19 in the early phases of the pandemic, attributed in part to the early and aggressive stay-at-home response by the city’s mayor, San Francisco and the Bay Area experienced a surge of cases beginning in June. Transit ridership remained consistent after an initial drop in March, showing no correlation to the outbreak.

Large portions of the outbreak are occurring in nursing homes and prisons; Governor Gavin Newsom has attributed many of the clusters to large family gatherings and holiday parties.^{78, 79}

Bay Area, CA: Comparison of COVID-19 case counts with BART ridership



Data sources: Bay Area Rapid Transit, San Francisco Department of Public Health COVID-19 data for City of San Francisco

Strategies employed by local transit agencies:

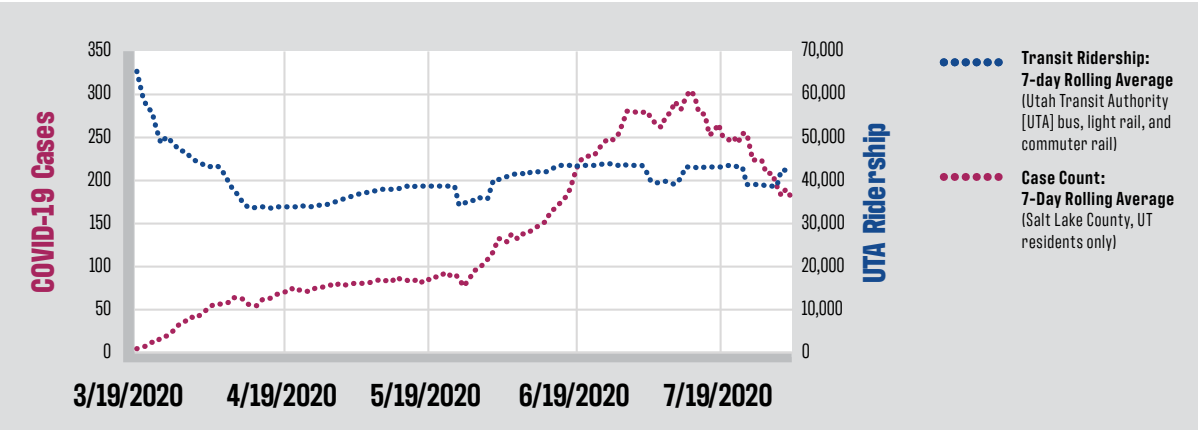
- Daily disinfection of railcars, wiping down of high-touch points, and fumigation
- Running of longer trains to allow more distancing
- Increased train frequency
- Piloting new seat configuration to allow more distancing
- Face covering mandate
- Visual indicators for physical distancing and media campaign to inform riders of regulations
- Hand sanitizer at every station
- Personal hand straps supplied to all riders, to avoid touching potentially contaminated surfaces
- Piloting of UV light disinfection technology
- Testing of advanced filters
- Encouraging of staggered shifts to avoid crowding

Greater Salt Lake City, Utah

Utah Transit Authority’s (UTA) fleet of more than 400 buses provides riders with access to Box Elder, Weber, Davis, Tooele, Salt Lake, Summit, and Utah counties.⁸⁰ Additionally, UTA operates the Transit Express (TRAX) light rail system.⁸¹ Approximately 3% of residents in the counties served by UTA rely on public transit for commuting to work.⁸² UTA temporarily reduced service on April 5, 2020 in response to low ridership numbers, temporally suspending, increasing headways, and cutting operational hours on certain lines.⁸³

While the Salt Lake area initially had low case counts along with most of the West, transit ridership declined in the early phases of the pandemic and has remained at a relatively steady, lower rate; however, cases surged since May, and through June and July. Some outbreaks are being traced to overcrowded meatpacking plants.⁸⁴ The state has not limited indoor dining and gatherings can be as many as 20 people, as of this publication.⁸⁵ Additionally, the state only recently granted local governments the power to issue mask mandates, after delaying a state-wide measure and despite the urging of science authorities.⁸⁶

Greater Salt Lake City, UT: Comparison of COVID-19 case counts with UTA ridership



Data Sources: Utah Transit Authority, Salt Lake County Health Department COVID-19 data for Salt Lake County

Strategies employed by local transit agencies:

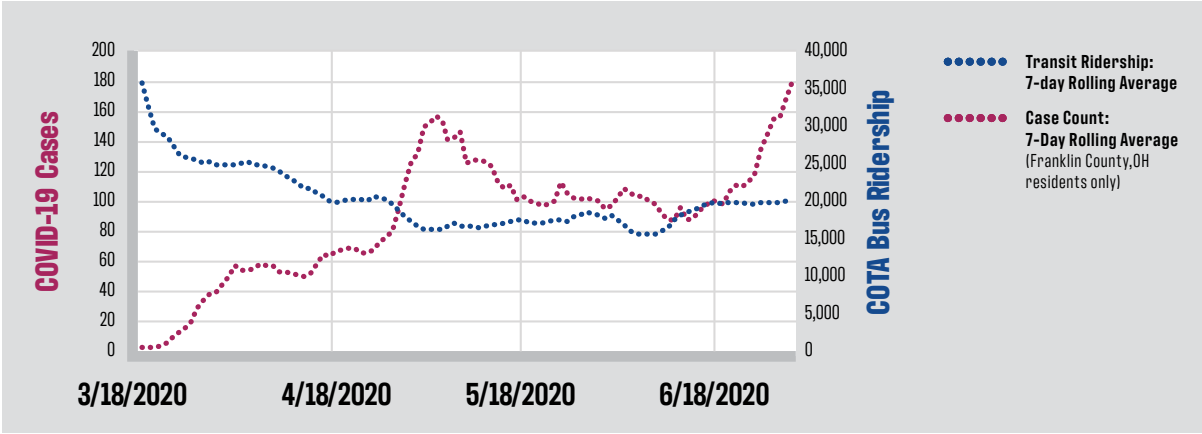
- Face covering mandate
- Daily sanitization of all vehicles and high-touch surfaces
- Complimentary face masks to those who request them
- Rear entry boarding; visual inspection of entry passes only
- Plexiglass barriers between operators and passengers employed on some buses
- Adjusted service to meet changes in demand and reduce crowding

Columbus, Ohio

The Central Ohio Transit Authority (COTA) services the Columbus metro-area. It operates fixed-route buses, BRT, micro transit, and paratransit services, and typically serves 19 million passengers annually.⁸⁷ Approximately 2% of Franklin County residents rely on public transit for commuting to work.⁸⁸ COTA reduced its service in mid-April 2020, reducing the number of bus routes and consolidating service in some areas.⁸⁹

Columbus has recently seen a surge in cases beginning in early June. Meanwhile, ridership remained relatively constant from late April through June. In late July, Ohio saw its largest number of hospitalizations since the pandemic began.⁹⁰ Many of the cases outbreaks have occurred among prisons, meatpacking plants, and residents between the ages of 20 and 40.^{91, 92, 93} Residents have been able to eat inside restaurants since May 21.⁹⁴

Columbus, OH: Comparison of COVID-19 case counts with COTA ridership



Data sources: Central Ohio Transit Authority, City of Columbus Public Health data for Columbus City and Franklin County

Strategies employed by local transit agencies:

- Adjusted services to meet changes in demand and to protect essential workers
- Rear entry boarding and suspension of fare collection
- Distribution of masks to all COTA operators
- Face covering mandate
- Daily sanitization and cleaning of vehicles and high-touch surfaces

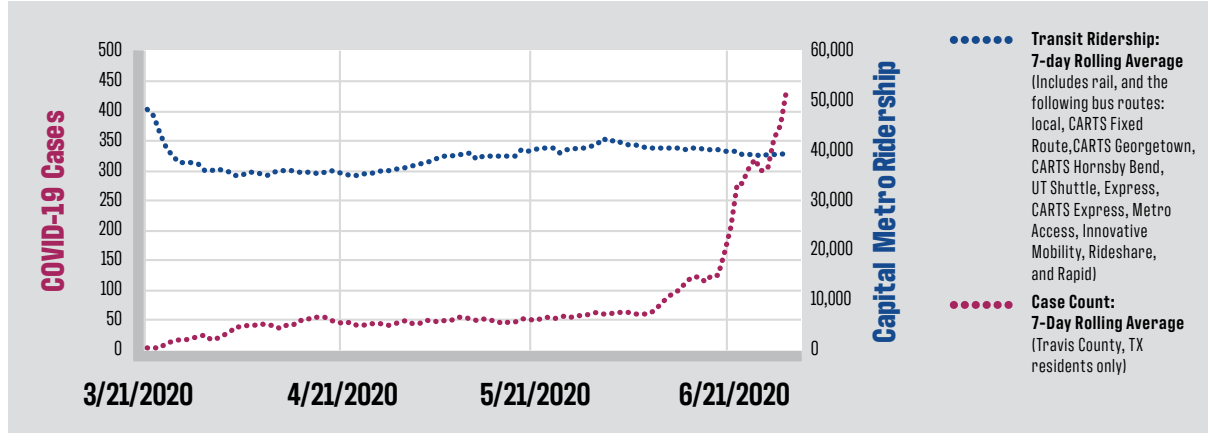
Austin, Texas

The Capital Metropolitan Transportation Authority (Capital Metro) operates bus, paratransit services, and a commuter rail system in Austin and several suburbs, within Travis County, Texas. Approximately 4% of and Travis County residents rely on public transit for commuting to work.⁹⁵ In response to reduced ridership, and to accommodate physical distancing recommendations, Capital Metro implemented temporary changes to its services.⁹⁶ Service was reduced on weekdays to a Sunday schedule for many lines, with the suspension of most express lines and fare collection. Service has since begun to increase on some lines to modified weekday schedules, and partial fare collection was reinstated beginning in June.

Despite initially having a low case rate, Austin experienced an outbreak in COVID-19 infections beginning in June, along with many other Southwestern cities.⁹⁷ In response, the City has recently prohibited gatherings larger than 10 people, restricted businesses to 50% capacity, and mandated face masks for most circumstances.⁹⁸ Restaurants are still able to offer dine-in service at 75% capacity, although they are being prompted to keep a ledger of all diners for contact tracing purposes.⁹⁹ Austin is having trouble tracing cases due to administrative limitations and rapidly growing cases and, on August 10, reported its highest positive test rate to date of 21%.^{100 101}

However, while cases began to skyrocket, transit ridership remained steady from early April through June— indicating that transit ridership has likely not been a contributing source of infection.

Austin, TX: Comparison of COVID-19 case counts with Capital Metro ridership



Data sources: Capital Metropolitan Transportation Authority, Texas Department of State Health Services, for Travis County

Strategies employed by local transit agencies:

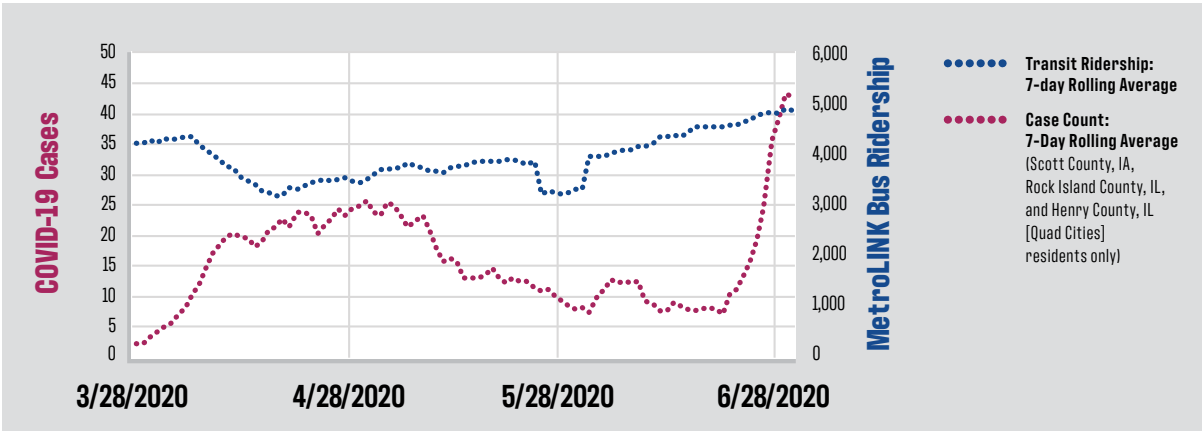
- Encouragement of physical distancing and mandating masks for riders (mandated by State order on July 2, 2020)
- Providing operators with face masks and gloves
- Signage encouraging adherence to hygiene protocol (hand washing, covering nose and mouth when sneezing or coughing) and regulations (physical distancing, face masks)
- Temporary suspension of fares and rear boarding only on buses; more recently installing plexiglass barriers and resuming fare collection

Quad Cities, Illinois

Rock Island County Metropolitan Mass Transit District (MetroLINK) serves the communities of Moline, Rock Island, East Moline, Silvis, Hampton, Carbon Cliff, Colona, and Milan in the Illinois Quad Cities (across the Mississippi River from Davenport, Iowa) with twelve fixed routes and sixty buses. Approximate 1% of residents in Rock Island and Henry counties in Illinois and the bordering Scott county in Iowa rely on public transit for commuting to work.¹⁰² MetroLINK suspended fare collection and front door boarding and suspended some routes in mid-March.¹⁰³ Some routes were restored in late June and fare collection resumed on July 6 as Illinois entered Phase 4 of its reopening. Effective August 10, 2020, Metro mandated face coverings on all buses.

Cases surged in the counties served by MetroLINK in June even though ridership remained mostly consistent, increasing only slightly. Additionally, the increasing number of cases reflect the broader trends of the state, which is experiencing even higher case rates in other areas – as of August 14, 2020, Rock Island and Henry counties did not fall within the top 14 counties with the highest case rates in Illinois; Scott County did not fall within the top 45 counties in Iowa.^{104, 105} As of early August the regions surrounding the Quad Cities are considered in stable condition, even though many other parts of the states are not.¹⁰⁶ The spike in infection has been attributed to a hasty reopening, large gatherings, and lack of mask and physical distancing compliance.¹⁰⁷

Quad Cities, IL: Comparison of COVID-19 case counts with MetroLINK ridership



Data sources: Quad Cities Metro; Illinois Department of Public Health data for Rock Island, and Henry counties, Iowa Department of Public Health data for Scott County; accessed via USAFacts.

Strategies employed:

- Rear door entry during the onset of the pandemic; temporary suspension of fare collection
- Reinstated fare collection in early July, with the installation of protective plexiglass panels for bus operators
- Frequent disinfection of terminals and high-touch points on buses; daily disinfection of buses using hospital grade disinfectant and electrostatic disinfectant sprayers

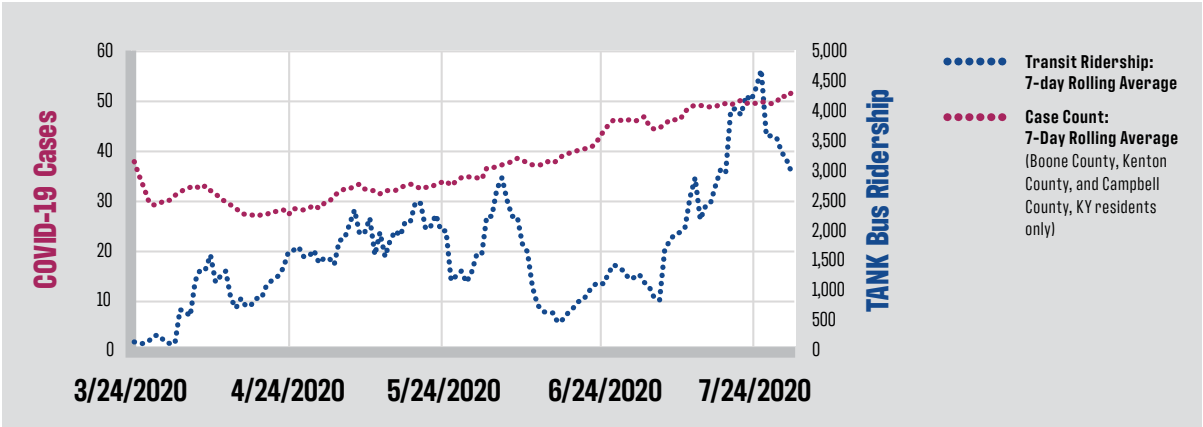
Northern Kentucky

The Transit Authority of Northern Kentucky (TANK) is the public transit system serving Northern Kentucky.¹⁰⁸ Today, TANK operates more than 130 buses for the residents of the suburbs of Cincinnati, Ohio located in Kenton County, Boone County, and Campbell County. Approximately 2% of residents rely on public transit for commuting to work.¹⁰⁹ TANK reduced service to a Sunday schedule due to low ridership resulting from the pandemic in late March, with the additional suspension of their shuttle service in early April.¹¹⁰ Beginning August 10, TANK resumed fare collection and front door boarding for all trips.¹¹¹

Despite low case rates earlier in the year, Kentucky experienced an outbreak of infections beginning in July. In this same period, TANK ridership recovered only slightly, indicating that the trend in cases may be reflective of the broader increase in cases statewide. As of August 24, the state had reached 43,899 total cases and a 4.77% positivity rate.¹¹² In this same period, TANK ridership recovered only slightly, indicating that the trend in cases may be reflective of the broader increase in cases statewide. Although case rates are surging throughout the state at the time of this publication, the counties served by TANK have relatively low case rates. As of August 25, Kenton ranked 33rd, Boone 37th, and Campbell 58th out of Kentucky’s 120 counties for cases per capita. All three have seen declining case counts compared to the previous two weeks.

The recent outbreak has been attributed in part to large gatherings, such as graduation parties, church services, and barbecues, and as of late August the state had 50 active cases within their K-12 school systems and 223 active cases at colleges and universities.^{113 114} Hasty reopening of high-risk settings may also be contributing to the recent spike in cases: while Kentucky took early action, shutting down non-essential businesses by mid-March, the state began its phased reopening in late April despite rising case numbers.¹¹⁵ Bars and restaurants were permitted to open, including indoor dining at a reduced capacity, on July 1, as were gatherings of up to 50 people. By the end of July, state Governor Andy Bershear had reduced the number of people allowed in restaurants and closed all bars for two weeks to stifle growing case numbers. State officials also recommended the delayed opening of schools until the end of September.

Northern Kentucky: Comparison of COVID-19 case counts with TANK ridership



Sources: Transit Authority of Northern Kentucky, Kentucky Department of Public Health case data for Boone, Kenton, and Campbell County; accessed via USAFacts.

Strategies employed:

- Rear door entry only and temporary fare suspension at the beginning of the pandemic¹¹⁶
- Installation of plexiglass dividers for bus operators upon restoration of front door entry and fare collection¹¹⁷
- Signage encouraging regulation adherence, including physical distancing and mask compliance
- Face mask requirement as of July 10, in concurrence with state mandate



Tokyo, Japan:

In late May 2020, none of the infection clusters in Japan were traced to the country's famously crowded rail systems. This success is attributed in part to mass testing, rigorous contact tracing, early shutdown of underlying sources of infection clusters such as gyms and nightclubs (schools and large events were closed in early March, earlier than most other countries), as well as traveler behavior: individuals commonly travel alone, wear masks, and do not commonly speak to other riders on transit.^{118, 119} Early on, Japan's government promoted avoiding "three C's": Closed off spaces with poor ventilation, Crowds, and Close-Contact Conversations. Hitoshi Oshitani, a virologist and public health expert at Tohoku University, attributes lack of transmission on trains to this behavior, stating "an infected individual can infect others in such an environment, but it must be rare."¹²⁰ While the country is, as of August 2020, experiencing an uptick in case rates, scientists and government officials are attributing the recent spread to the full reopening of bars, karaoke lounges, sporting events, and businesses.¹²¹ Ridership on the Tokyo Metro dropped by 60% in early April as the government initiated a lockdown prohibiting non-essential trips, but began a relatively quick rebound two weeks after the lockdown was lifted in mid-May as crowds returned to commuter lines.^{122, 123} Passenger numbers continued to rise through the summer months. By August, ridership was up to 63% of normal levels.¹²⁴



Hong Kong, China:

Despite being one of the world's densest cities, Hong Kong was able to keep infection rates low. By July 2020, the city of 7.5 million reported just 1,655 cases and 10 deaths.¹²⁵ Ridership dropped to 55% of normal in February 2020, and had recovered to 76% of normal by June.¹²⁶ Meanwhile, the city has not seen a large outbreak associated with public transit.¹²⁷ Hong Kong's success is attributed to almost universal adoption of masks early on, a quick shut down of bars and restaurants in March, rigorous contact tracing and strict quarantines, as well as sanitation efforts – including robotic cleaning of subway cars.¹²⁸ The sources of the recent uptick in virus cases are unknown at the time of this publication, but it is speculated to have come from foreign visitors to the county.¹²⁹



Seoul, South Korea:

Despite never entering a full lockdown like many other global cities, Seoul was able to curtail case rates and control disease spread without mandating severe mobility restrictions, despite having the second-most cases in the world until the beginning of March 2020. The city asked residents to take only essential trips in late February, when case rates were still low.¹³⁰ Large reductions in mobility did occur two weeks before the city's case peak, impacting subway ridership (decreasing 40%) more than private vehicle use (decreasing 15%).¹³¹ By May, ridership had recovered to 66% of normal.¹³² The city also imposed a mask mandate for bus and subway entry when train capacity exceeds 150% and during peak hours and thermal scanning at select stations.^{133, 134} The post-peak outbreak that the city is experiencing at the time of this publication, August 2020, has been attributed in large part to cluster infections from individuals visiting nightclubs, not transit.¹³⁵



Singapore:

As of August 2020, Singapore had traced no case clusters to public transit systems, in part with the assistance of a case tracking app "TraceTogether" made mandatory for certain populations.^{136, 137} Face masks are also mandatory for all riders. Ridership dropped to 20% of pre-pandemic levels by mid-April, but had recovered to 40% of pre-pandemic levels by early June.¹³⁸ While the city-state has, as of August 2020, experienced a recent uptick in case rates, the new clusters are mainly stemming from migrant worker dormitories and construction sites.¹³⁹ In April, Singapore's MRT saw a 75% reduction in demand for rail trips and a 71% reduction in bus ridership.¹⁴⁰



Paris, France:

In the month following lifting of restrictions, between May 9 and June 2, 2020, France had tracked 150 virus clusters; however, none were linked to public transit.¹⁴¹ Ridership on the city's metro system plummeted to just 5% of pre-pandemic rates by mid-April, but has recovered to 55% of pre-pandemic rates by late June.¹⁴² The city reported that while the systematic adoption of certain preventative measures (such as hand washing, physical distancing, etc.) had decreased overtime, mask wearing compliance was still high.¹⁴³ Masks were made mandatory, subject to a €130 fine, with some stations employing artificial intelligence to monitor mask usage.^{144, 145} At the time of this publication, five cases had been traced to transportation (boat, plane, or train) accounting for roughly 1% of the nation's 531 clusters, although the type of transport is not specified.¹⁴⁶ The increase in cases also corresponds with the reopening of the country, including the opening of schools, restaurants, shops, and international European travel.¹⁴⁷



Vienna, Austria:

By July 23, 2020, none of the 1,001 clusters identified in an epidemiological study in Austria were traced to riding public transit.¹⁴⁸ The city has required masks for all passengers, as well as deployed physical distancing ambassadors throughout stations to encourage distancing and to inform riders about the regulations.¹⁴⁹ Vienna has seen some of the strongest returns in public transit ridership: in March, ridership fell 80% but is now back to 65% of normal levels on weekdays and 75% on weekends.¹⁵⁰



Milan, Italy:

In late May 2020, despite the lifting of restrictions in the city and its transit systems, the most impacted region in Italy has not seen a subsequent spike in cases or deaths.¹⁵¹ Face masks are mandated for all passengers, with PPE vending machines in most subway stations, and vehicles are limited to 70-80% capacity in order to maintain physical distance of one meter (about three feet).¹⁵²



Denver, Colorado:

Denver's Regional Transportation District (RTD), which operates commuter rail, light rail, and bus systems, has identified no cases among its riders or operators.¹⁵³ Face masks are mandatory for both riders and operators, and capacity has been limited on both buses and rail cars. The city recently reinstated front door boarding and fare collection on its bus services, as well as began distributing free PPE to operators, including face coverings, face shields, and hand sanitizer.¹⁵⁴ Ridership rates are about 66% below normal.¹⁵⁵



Part II: Public Transit Response Measures

- Risk Mitigation for Health and Safety
- Service and Ridership Recovery Strategies
- Best Practices Summary and Recommendations

Transit agencies have taken steps since the onset of COVID-19 to help ensure the health and safety of riders and employees. These interventions vary across agencies, given differences in system size and mode(s), ridership, operating and human resources, geography, and jurisdiction. Two main categories of interventions are described here: Risk Mitigation for Health and Safety and Service and Ridership Recovery Strategies.

Risk Mitigation for Health and Safety

KEY TAKEAWAYS:

- ➔ Agencies are limiting on-board passenger capacities based on vehicle size and type, but enforcing these limits is at the discretion of operators.
- ➔ Many agencies are returning to front-door bus boarding and fare collection, but only after installing some form of physical separation for the operator, e.g. plexiglass shields.
- ➔ Face covering requirements for transit stem from state, county, or city executive orders, but agencies are rarely in a position to enforce these orders if and when a rider does not comply. Rather, they are encouraging compliance with messaging and free mask distribution.
- ➔ Cleaning, sanitizing, and disinfecting vehicles and facilities is a standard daily practice, prioritized for high-touch surfaces and high-activity locations.
- ➔ Agencies have not come to a coherent strategy on ventilation and filtration for buses and trains, but some are investing in UV irradiation.

VEHICLE CAPACITY AND RIDER PROXIMITY

Limiting capacity on board buses and paratransit vehicles is another COVID-19 intervention. This varies by vehicle size, with the intent of allowing riders to maintain distance from others while onboard. For some agencies this meant a no-standing policy, while others determined a maximum number of riders by vehicle type, set to a certain percentage or to allow a rider in every other seat (e.g. 16 to 20 riders maximum on a standard 40-foot bus). Enforcing capacity limits is at the discretion of the operator, as most agencies gave operators the instruction to skip stops and not pick up additional passengers once a bus is deemed full; however, this can be difficult in practice as operators need to balance it with letting current riders alight. Capacity limits have applied primarily to buses and paratransit vehicles rather than train cars. Corpus Christi Regional Transportation Authority (CCRTA) is monitoring ridership and year-over-year bus loads on a daily basis, issuing “Updated COVID-19 Service Levels” (span, frequency, route suspensions) accordingly and as needed via rider alerts.¹⁵⁶ New Jersey Transit (NJ Transit) lifted its executive order to operate at 50% capacity on July 15, 2020, transitioning to a less restrictive mandate to operate at seating capacity.¹⁵⁷ In Portland, Oregon, TriMet adjusted its mandate from 10-15 to 19-24 riders per bus and rider spacing from six feet to three feet on light rail starting July 26, 2020, citing the implementation and effectiveness of robust cleaning protocols.¹⁵⁸ Vancouver’s TransLink is monitoring load targets daily and modifies them based on the infection rate in the region.¹⁵⁹

Managing proximity between riders and between riders and operators is a related aspect of vehicle capacity. Some agencies, like Utah’s UTA and New York’s MTA, did not limit capacity and rather have focused on creating space between riders and operator at the front of the bus. The immediate response for most agencies was to implement rear door boarding only on buses, with exceptions for disabled riders needing to use the front door lift. This came with a suspension of fare payment for



A plexiglass shield separates a bus driver from passengers on a Humboldt Transit Authority vehicle. Source: The Times Standard

bus services with the farebox at the front door. Agencies scrambled to demarcate space for operators, using the equivalent of clear plastic shower curtains. Agencies are now transitioning from these immediate measures to resume front door boarding and fare collection. The installation of plastic shields for operators in the months since the pandemic hit has enabled this transition. For example, Dallas Area Rapid Transit (DART) began installing plexiglass shields throughout its bus fleet in mid-March, with goal of full installation (600 buses) by July 1, 2020.¹⁶⁰ Florida's Palm Tran installed operator doors on all its 159 buses by mid-July, to resume fare collection on August 16, 2020.¹⁶¹ Other agencies have resumed fare collection on buses but are no longer accepting cash to limit rider and operator interaction.¹⁶² This, however, may require the agency to perform a Fare Equity Analysis and take mitigation actions, to comply with Title VI of the federal Civil Rights Act of 1964.¹⁶³ Virginia's Greater Richmond Transit Company (GRTC) decided in late June 2020 to continue rear door boarding and free rides on buses indefinitely, both to help protect operators and to acknowledge the economic impact of COVID-19.¹⁶⁴

PPE AND HAND SANITIZER

PPE requirements for transit vehicles and facilities overwhelmingly stem from state, county, or city executive orders, rather than mandates from agencies themselves. The most common orders make face coverings mandatory where physical distancing is impossible, including transit. Agencies generally do not specify a type of face covering, other than it needing to cover both the nose and mouth. Individuals with medical conditions, religious prohibitions, and children are generally exempt. Timing of the orders varied from early April to as late as August, reflecting both political context and the severity of infection rates in the area (e.g. dense cities that experienced early outbreaks versus more sub-



PPE vending machine installed in one of New York's MTA subway stations Source: Mass Transit Magazine

urban areas where infections are rising in later outbreaks, etc.). Some agencies have amended their requirements. NJ Transit extended theirs to cover indoor facilities and outdoor areas, in addition to onboard transit vehicles.¹⁶⁵ The Milwaukee County Transit System (MCTS) initially only recommended masks but issued a requirement as of August 1, 2020.¹⁶⁶

Despite the crucial role face coverings play in helping to stop the spread, agencies are not in a position to enforce the orders if and when a rider does not comply. Toronto Transit Commission (TTC) makes it clear that it "will not be enforcing the use of masks or face coverings" despite its requirement.¹⁶⁷ UTA is relying on information and education, stating that "it is not our intention to refuse service."¹⁶⁸ Miami-Dade is atypical in that its face covering requirement can be backed by the County's "New Normal" guidelines, which allow civil citations and up to \$100 fines.¹⁶⁹ However, agencies are encouraging compliance with their orders with free mask distribution (onboard and at transit hubs), as well as by adding PPE vending machines in transit hubs and stations. For example, Washington, DC's Washington Metropolitan Area Transit Authority (WMATA) installed twelve PPE vending machines in ten different subway stations to complement its free mask distribution; Nevada's Regional Transportation Commission Washoe (RTC) installed free mask dispensers on buses as of mid-July; and Dallas's DART is in the process of fabricating mask dispensers for its vehicles as of August.^{170, 171} In New York City, MTA's "Operation Respect" campaign encourages compliance through celebrity public service announcements and volunteer "Mask Force" distributing free masks to bus, subway, and commuter rail riders.¹⁷²

Providing hand sanitizer in stations, at stops, and onboard is another measure that almost all agencies are taking. TTC installed dispensers at all subway entrances starting in April 2020, prioritized primary entrances and adding secondary entrances in May.¹⁷³ GRTC has dispensers at the rear door of all buses and on paratransit vans, as does UTA

and Northeast Illinois’ Metra on its train cars. In June, APTA assisted in the distribution of 100 million facial coverings supplied by the Federal Emergency Management Agency (FEMA) to public transit operators.¹⁷⁴

CLEANING, SANITIZING, AND DISINFECTING

Cleaning, sanitizing, and disinfecting vehicles and facilities has become a standard agency response. Daily protocols are the typical minimum, with CDC-recommended products and in some cases with electrostatic sprayers. High touch surfaces like handrails, straps, and door buttons may be cleaned multiple times per day, prioritized as resources allow on/at the busiest routes and stations; some agencies have hired additional cleaning staff as a result.¹⁷⁵ DART, for example, is cleaning its light rail trains at their terminal stations every 60-90 minutes, in addition to nightly and weekly disinfection.¹⁷⁶ NJ Transit commissioned a study (ongoing) by Rutgers University on the effectiveness of ultraviolet-c light (UVC) for disinfecting the agency’s bus fleet, as well as electronically mapping the interior of different bus models to determine the best placement for the UVC source.¹⁷⁷

VENTILATION AND FILTRATION

Airflow on buses and trains is another area of concern due to COVID-19. Metra, for example, is using hospital-grade filters to capture airborne particles on its commuter trains, as well as fresh air dampers to circulate the air.¹⁷⁸ Outside of Shanghai, the Songjiang tram system adjusted its air conditioning system to “wind mode” starting in January 2020, and equipped the units with UV tubes for sterilization.¹⁷⁹ However, some experts remain uncertain that UV light, which has not been tested in transit systems, is effective.¹⁸⁰ For buses, agencies have not come to a consistent strategy on ventilation and filtration. DART is notable for being one of the few agencies that had already invested in bus ventilation and filtration systems prior to COVID-19. After the 2014 Ebola crisis in Dallas, DART purchased buses with an air cleaning/disinfection system using UV germicidal irradiation in the bus air conditioning ducts; to date, over 70% of the bus fleet is equipped with the system.^{181, 182} However, Dr. Gurumurthy Ramachandran emphasizes that “from what I have seen of data available, rail cars have a fairly high air flow so the risk would be minimized assuming that the passengers are physically distanced. Air flow through a typical train car is quite a bit higher than a classroom, for example, with both being physically distanced, the risk would be much lower in a rail car.”¹⁸³



Hand sanitizer station installed on a SunLine Transit Agency bus. Source: News Channel 3

Service and Ridership Recovery Strategies

KEY TAKEAWAYS:

- ➔ Agencies are gradually restoring service to modified pre-COVID-19 levels, to meet demand while upholding limited passenger loads.
- ➔ On low-performing routes, some agencies are shifting to demand response service, operating weekend or modified schedules, or suspending service on some routes/lines until conditions warrant reopening.
- ➔ To address crowding, agencies are deploying standby vehicles and operators, per real-time or near real-time conditions.
- ➔ Some agencies are offering free and convenient COVID-19 testing for employees as well as distribution of PPE for transit operators.
- ➔ Agencies are developing guidance for reopening to help restore public confidence and boost ridership, in contrast to initial efforts to discourage non-essential trips.
- ➔ Physical distancing ambassadors have been deployed on several systems to remind riders of the importance of wearing face coverings and maintaining proper physical distancing.

SERVICE ADJUSTMENTS

Modifying service at the onset of COVID-19 in early Spring 2020 was an immediate response for almost all transit agencies. Initially, this typically resulted in a reduction in service, which was followed by shifts in resources based on demand. Many agencies, recognizing that individuals rely on public transit, maintained service in order to serve segments of the population without access to private vehicles. Transit equity is important for the 2.8 million essential workers in the United States who rely on public transit to get to their jobs.¹⁸⁴ Rather than documenting initial service reductions, this section focuses on the gradual steps that transit agencies have taken in reallocating resources and gradually returning to regular service.

As of August 2020, many transit agencies have restored normal service levels with minor modifications. Other agencies and service providers are planning to do so in August or September, aligned with the expected opening of the school year. However, agencies are also monitoring ridership and load levels, ready to adjust service per the changing demand patterns. Large agencies, such as New York City’s MTA, NJ Transit, Washington DC’s WMATA, and Philadelphia’s Southeastern Pennsylvania Transportation Authority (SEPTA), gradually restored bus service in the months of June and July, and currently operate at pre-COVID levels. In New York, MTA subway service was discontinued between 1 AM and 5 AM to allow for more extensive cleaning of the trains. To offset this reduction, overnight bus service was expanded and a new overnight-only bus route was established between Manhattan and both Brooklyn and the Bronx.¹⁸⁵ NJ Transit and SEPTA resumed most service – both buses and rail – by early July 2020 and WMATA is expected to do so throughout the month of August.^{186, 187, 188, 189, 190} Houston METRO has increased the number of trips to allow for more physical distancing on some of its local routes, or segments of them.¹⁹¹

VIA unveils 'Essential Service' schedule

New changes preserve transit service for essential workers amid COVID-19 crisis



VIA Bus (VIA Metropolitan Transit)

SAN ANTONIO – VIA Metropolitan Transit will begin operating what it calls an “Essential Service” schedule starting Monday.

San Antonio, Texas’ VIA maintains “Essential Service” to transport essential workers. Source: KSAT.com

Other agencies are still operating at lower capacity. San Antonio’s VIA Metropolitan Transit (VIA) has been operating on an “Essential Service” schedule since late April 2020. This maintains shorter headways on routes with continued high ridership and adjusts others based on changing conditions.¹⁹² Salt Lake City’s UTA is operating reduced service since early April 2020; it will return to 91% of the pre-COVID service levels in late August, while some lower-performing routes are suspended indefinitely. As part of the agency’s COVID-19 response, it surveys employees, patrons, and local companies to better understand the demand patterns.¹⁹³

In attempting to tailor service to demand and allow reallocation of resources to high-demand segments, service on lower-performing routes is being suspended or transitioned to demand response. Ozark Regional Transit (ORT) in Arkansas and Miami-Dade in Florida transitioned some of their low-performing fixed routes and overnight service to demand response services. Miami-Dade’s Go Nightly service, effective April 2020, partners with Uber and Lyft and supplements with its own paratransit service to more effectively serve customers on what had been eight fixed routes.¹⁹⁴ Pullman Transit (eastern Washington State), TANK (Northern Kentucky) and Palm Tran (eastern Florida) resumed their regular bus schedule, except for low-performing routes that are suspended.

Employing on-call or standby buses is a common practice to address routes or segments where reduced service may not always meet demand. Agencies in Miami, Boston, Washington DC, and many other cities are designating vehicles and operators on standby, to be dispatched per real-time feedback from operators about passengers who are left behind. This practice, used previously but now critical to COVID-19 operations, requires solid communication infrastructure and procedures, to ensure real-time response.

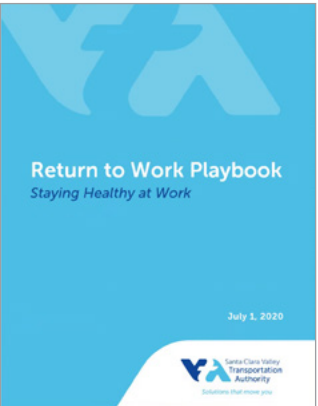
EMPLOYEE PRACTICES

Agencies have taken steps to promote the safety of operators and other employees, developing resources for reopening that help reduce risk within their organizations. Numerous public health experts emphasize the importance of supplying transit workers with adequate PPE, including N95 face masks and shields (where possible), as well as prioritizing their safety in both transit vehicles and employee breakrooms.¹⁹⁵ In San Jose, CA, the Santa Clara Valley Transportation Authority’s “Return to Work” employee playbook documents what the agency has done to help maintain a safe workplace, a flow chart of actions when an employee is exposed to COVID-19, frequently asked questions, and an appendix of memos and notices issued by the agency since the start of the pandemic.¹⁹⁶ Other resources agencies are providing for their employees include on-site free COVID-19 testing events; in Richmond, VA, GRTC has hosted five such events as of August 2020.¹⁹⁷ Miami-Dade began temperature checks at all garages and facilities, and purchased additional tables and rented tents for bus maintenance garages to enable physical distancing between employees.¹⁹⁸

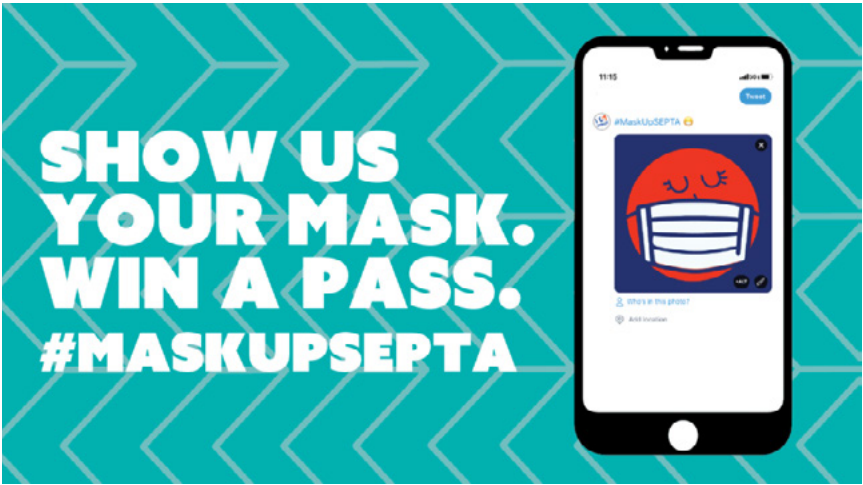
Workers have petitioned and protested for hazard pay, but few agencies have granted this as a result of COVID-19. The New Orleans Regional Transit Authority (RTA) is an exception, announcing in late July 2020 up to \$2,000 in hazard pay for employees working during the pandemic.¹⁹⁹ Philadelphia’s SEPTA set up a “Disaster Relief Memorial Fund” to help employees’ families, but noted it was not intended as a substitute for hazard pay.²⁰⁰ Given the financial struggles of many transit agencies, hazard pay may not be a feasible option without local and state government support.

RIDER COMMUNICATION

Rebuilding public confidence and communicating that transit is safe is part of agencies’ recovery and reopening efforts. For some, communication has been one of the most demanding aspects of the COVID-19 response.²⁰¹ Communication falls under three main categories: service changes, rider behavior, and agency efforts. Dedicated webpages, short videos, tweets, and other social media posts are strategies to communicate all three categories, for example, publicizing face covering requirements, encouraging riders to purchase fares via app rather than touching a ticket vending machine, and documenting agency



Source: Santa Clara Valley Transportation Authority



Philadelphia's SEPTA runs social media ads and contests to encourage riders to wear masks
Source: SEPTA

cleaning protocols. Transparency about COVID-19 conditions in agency communication varies; some medium and smaller sized agencies like GRTC have documented each case of an employee positive case on their website.²⁰² Physical distancing ambassadors have been deployed on a number of systems to remind riders of the importance of wearing face coverings and maintaining proper physical distancing.

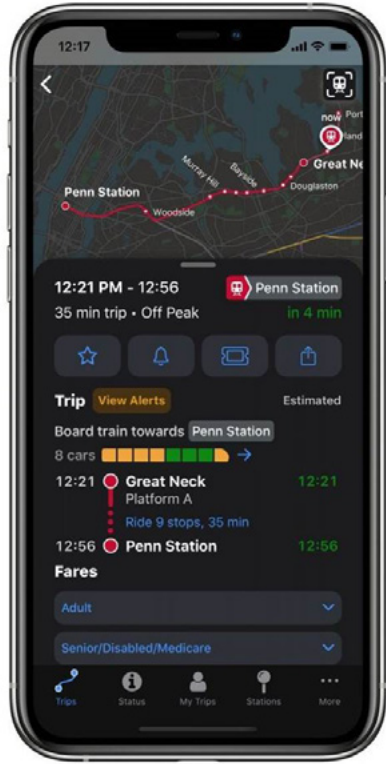
At the outset of the pandemic, many agencies changed their messaging to discourage ridership beyond essential trips. Flagstaff, Arizona's Northern Arizona Intergovernmental Public Transportation Authority (NAIPTA) reframed its mission from "Getting you Where You WANT to Go" to "Getting You Where You NEED to Go."²⁰³ That initial phase and corresponding messaging has now shifted to guidance for reopening. Dr. Gurumurthy Ramachandran emphasizes that agencies need to find impactful ways to "tell the general public that if you are infected, or think you are infected, do not take public transit."²⁰⁴ NJ Transit launched a campaign to encourage customers "to model ideal transit behaviors," as well as developing "Ride to Recovery" guidelines in mid-July 2020 that outline "what NJ Transit will do" and "what customers should do" by topic area.²⁰⁵ Similarly, Santa Clara Valley Transportation Authority (VTA) developed a "10 Point Plan to Strengthen Trust in Transit."²⁰⁶ UTA launched a "recovery storyboard" of real-time ridership, financial, and health/safety information; one metric displayed is the "Percent of UTA Buses with Shields Installed" (9% as of July 31, 2020).²⁰⁷

"Getting compliance of riders in wearing masks and respecting policies is important. Convincing people that it is in their own best interest (for their own health, the health of others, their jobs, their ability to watch and play sports, the very functioning of society) to comply," stated Dr. Larry J. Anderson on one of the biggest hurdles for public transit.²⁰⁸ To help achieve this SEPTA has tried to embrace the new normal, encouraging ridership and rider compliance with a social media contest. Riders who post a selfie wearing a mask on SEPTA are entered into a contest for a free monthly pass.²⁰⁹

DATA TECHNOLOGY

Agencies are employing data in new ways to help riders understand typical conditions during COVID-19. The most common response is sharing real-time or historical data on crowding, which is part of broader rider communications. For customers with flexible schedules and/or at high risk, this information can help them travel at less crowded times or on less crowded routes. In July 2020, New York's MTA updated two apps, one for the Long Island Rail Road (LIRR) commuter train and one for buses. The apps now let riders see real-time ridership data to know how many riders are onboard. The LIRR app shows available seats by car, while the bus app shows an estimated number of riders at each stop.²¹⁰ In Canada, the Société de Transport de Laval launched a comparable tool using automatic passenger count data for buses, as did MBTA in Boston. Other agencies are using recent historical passenger data (within the last two weeks) to provide similar information. The Chicago Transit Authority (CTA) introduced a bus crowding dashboard in June 2020 that shows crowding by hour by route.²¹¹ CTA is working on a similar crowding report for rail, as well as a real-time information version. BART and Metra also introduced train car loading information using historical data to help riders make travel decisions.²¹²

Internationally, agencies are experimenting with passenger flow monitors, weight sensors, and other technologies to capture crowding information.



The MTA's Long Island Rail Road TrainTime app now displays crowding conditions for each rail car.

Best Practices Summary and Recommendations

Summarized below are practices implemented by transit agencies across the United States and Canada. Beyond restoring service and reopening the systems, all practices focus on the need to provide a safe and clean environment throughout the transit system’s facilities and vehicles. As discussed, all practices come with challenges and typically require additional resources. Therefore, each agency may practice different procedures, based on the local conditions, available resources, and capabilities. We consider these practices to be the most actionable, likely impactful, and financially feasible for transit agencies.



SERVICE ADJUSTMENTS:

- Restoring service to modified pre-COVID levels, to meet increasing demand while allowing for limited passenger loads.
- On low-performing routes, shifting to demand response service or suspending service until conditions warrant reopening.
- Closely monitoring ridership patterns and continuously reallocating resources to address demand.
- Designating vehicles and operators on standby, to be dispatched per real-time feedback from the field about overcrowded vehicles and/or passengers who are left behind.



HEALTH PROCEDURES AND POLICIES:

- Mandating face coverings and encouraging frequent hand sanitizing, can be aided by making PPE available at transit stations and/or on-board transit vehicles.
- Limiting on-board passenger capacities, where possible, to allow physical distancing and maintain a safe environment for operators and riders. Enforcing capacity limits is at the discretion of operators, who are instructed to skip stops once the vehicle reaches its capacity limit.
- Managing proximity between riders and operators by shifting to rear door only boarding and/or installing physical separators around the operator. If rear door only boarding is implemented, it comes with the suspension of fare payment for bus services as the farebox is inaccessible.



EMPLOYEE PRACTICES:

- Engaging and educating employees in COVID-19 prevention through information and internal communications.
- Requiring daily health checks of employees prior to transit operations.
- Supplying operators with PPE, including face masks. If possible, transit workers should be provided with respirators (N95/KN95 masks) and/or face shields.
- Installing protective barriers for operators, such as plexiglass shields on buses.



RIDER COMMUNICATIONS:

- Communicating service changes, rider etiquette, and agency efforts regarding cleaning and prevention. This can be done through dedicated websites, press, tweets, and other social media posts.
- Encouraging riders to take responsibility for their own and others’ health by wearing face coverings, cleaning hands, minimizing conversation while aboard transit, and avoiding transit if they are or suspect they are infected.
- Restore rider confidence in the transit system by promoting the relative safety of transit and mitigation measures being instituted.
- Reach riders that have not yet returned to public transit via public service announcements.



DATA TECHNOLOGY:

- Use data and new technology for operators to track individual vehicle occupancy rates and adjust loading, as needed.
- Incorporating occupancy data into apps and websites to inform riders of real-time crowding conditions.

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Glossary

Respiratory Droplets: small, liquid particles consisting of saliva, mucus, and other matter (such as an infectious virus) derived from respiratory tract surfaces produced by exhalation, talking, sneezing, or coughing. Droplets range in size, but those classified as respiratory droplets are generally any droplet 5 to 10 micrometers in diameter. The larger the droplet, the more quickly they fall.

Aerosols: Aerosols, also known as droplet nuclei, are generally considered to be small particles less than 5 millimeters in diameter. In same way as respiratory droplets, aerosols are generated from the respiratory tract surfaces and produced by exhalation, talking, sneezing, or coughing. Aerosols can remain in the air for long periods of time and be transmitted to others over distances greater than 1 meter.

Fomites: a fomite is any inanimate object (such as surfaces like door handles and furniture) that, when contaminated with or exposed to infectious agents, can transfer disease to a new host. Fomites occur when droplets fall from the air onto a surface.

Viral Load: the amount of measurable virus in a sample. At the time of this publication, it is not yet known the amount of virus necessary for COVID-19 infection.

Source Control: a strategy for reducing disease transmission by blocking respiratory secretions produced through exhalation, speaking, coughing, or sneezing. Covering your mouth and nose while sneezing is a type of source control, as is wearing a face mask.

Respirator Masks: mouth and nose covering device designed to achieve a very close facial fit and very efficient filtration of airborne particles, including smaller particles. Edges of the respirator mask are designed to form a seal around the nose and mouth. N95, KN95, and N99 masks are examples of respirator masks.

Appendix A – COVID-19 Transmission (Expanded)

Basics of Transmission

Although the scientific knowledge around COVID-19 is limited due to the novel nature of the virus, it is helpful to understand the basics of transmission so that transit providers and riders can best protect themselves. As of August 2020, we know that transmission of the virus that causes COVID-19 (SARS-CoV-2) occurs via person-to-person transmission through *respiratory droplets* and surface-to-person through *fomites*. New evidence is emerging indicating that the virus can also be transmitted person-to-person via *aerosols*.

RESPIRATORY DROPLETS

According to the CDC, the virus that causes COVID-19 is spread primarily through person-to-person respiratory droplets from the mouth or nose that are emitted when a person coughs, sneezes, or speaks.²¹³ Recent evidence indicates that droplets may be emitted even by simple breathing, and speech droplets have been found to linger in the air for as long as 14 minutes.^{214, 215} Those within proximity of an infected individual can become infected themselves if respiratory droplets, which are generally classified as particles between 5 to 10 micrometers (µm) in diameter, penetrate the mucus membranes of the nose, mouth, or eyes.^{216, 217} Respiratory droplets are too heavy to remain airborne for long and thus fall onto nearby surfaces or people.²¹⁸ To avoid transmission via respiratory droplets, physical distancing is recommended. The CDC recommends that individuals maintain a physical distance of at least six feet, while the WHO recommends a one meter, or about three feet, distance.^{219, 220} Droplets may travel farther depending on the velocity of their expulsion or other environmental factors, such as lower humidity, which allows respiratory droplets to remain in the air for longer periods.

AEROSOLS

Aerosols, also known as droplet nuclei, are a smaller form of droplet. There is increasing evidence that transmission can be spread by these smaller (<5µm) particles. Aerosols are lighter than respiratory droplets, remain suspended in air for longer, and can travel in the air farther than one meter. However, at the time of this publication, the significance of aerosol transmission is undetermined. Scientists have not yet concluded if an infectious amount of virus material exists in aerosols.

In early June 2020, 239 scientists wrote to the WHO with growing evidence that COVID-19 is spread through aerosols. They urged that precautions be taken, including "avoid overcrowding, particularly in public transport and public buildings."²²¹ The WHO now recommends taking precautions to reduce airborne transmission, which includes the use of face coverings.²²²

Modeling of the highly contagious environment that occurred on the Diamond Princess cruise ship estimates that aerosols may have contributed approximately 59% of infections.²²³ A Wuhan hospital study examining airborne virus samples found airborne virus nuclei in a variety of settings, particularly in poorly ventilated spaces such as bathrooms. However, the study did not address if the amount of virus found in the air was enough to cause infection. While it is still unclear what viral load, or the amount of measurable virus in an individual, is necessary to cause COVID-19 infection, scientists have found that patients with high viral loads have higher mortality rates.²²⁴ One study suggested that virus nuclei remained viable in aerosols.²²⁵ However, the WHO states that this study utilized a high-powered machine in a laboratory setting, and other studies have found no evidence of airborne virus nuclei in non-hospital and hospital settings.²²⁶ At the time of this report, newly released research has found that viable virus, and not just non-infectious fragments of genetic material, does indeed exist in smaller aerosol particles and can be found as far as 16 feet from infected individuals.²²⁷

The mounting evidence behind aerosol transmission highlights the importance of ventilation, air flow, and face masks, particularly those with the ability to filter and block aerosols.

SURFACES

Surface-to-person transmission occurs when individuals touch a fomite, or a material or surface carrying an infection, and then touch their mouth, eyes, or nose. Fomites form when respiratory droplets fall from the air and onto surfaces. Fomites can be things such as door handles, counter tops, subway poles, fabric seat covers, or credit cards. It is unclear how long viruses remain viable on surfaces, and research indicates that the viability seems to vary by material. For example, the virus was found to remain on plastic surfaces for as long as 72-hours, on stainless steel for as long as 48-hours, and on cardboard and copper for as long as 8-hours.²²⁸ However, it is important to note that the small amounts of the virus remaining (0.1%) at the end of these durations may not be enough to cause infection. Hand washing and surface disinfection can be used to reduce the presence of fomites and risk of surface transmission.

Mitigating Transmission

COMMUNITY SPREAD

Reduce community infection rate to lessen all forms of transmission

The CDC recommends several checkpoints for transit agencies looking to accommodate current and returning riders.²²⁹ The foremost consideration for scaling up transit service is the level of community spread. This can be quantified in numerous ways, with many state agencies and institutions opting to measure the pandemics’ impact by the growth rate of positive cases, hospitalizations, and deaths. One tool, developed by the Harvard Global Health Institute, offers a risk rating for all US counties based on the daily new cases per 100,000.²³⁰ Other institutions, such as the Illinois Department of Public Health, are using a number of key indicators to track the risk in certain regions and develop milestones for reopening.²³¹ The state is tracking the 7 day rolling average for test positivity, hospital admissions, and hospital availability to assign regional risk. Transit agencies should defer to local governmental bodies to assess the community risk.

Studies indicate that low infection prevalence in the surrounding community prior to the substantial return of riders to transit is an important factor in preventing virus resurgence.²³² Controlling infection on a community level can be done via rigorous testing and contact tracing, isolation protocols, mobility restrictions, and other procedures that typically fall beyond the jurisdiction of transit authorities. Transit agencies can employ some tactics to keep infected individuals out of their systems, thus eliminating the risk to other passengers, such as the thermal scanning currently employed in some Asian countries.²³³

PHYSICAL DISTANCING

To reduce person-to-person transmission

While it is yet undetermined how many lives have been saved by physical distancing, epidemiological evidence indicates that the disease can be spread via respiratory droplets that are released into the air when an infected individual coughs, sneezes, talks, or breathes. To lower the risk via droplet transmission, the CDC recommends that individuals maintain a physical distance of at least six feet.²³⁴ The WHO recommends a one meter, or about three feet, distance; similarly, a study on the effects of physical distancing on COVID-19 transmission found the transmission was lower with distances of three feet or more.^{235, 236} The variability in these recommendations can be partially explained by the uncertainty of particle trajectory. The distance and duration particles travel before settling is impacted by the speed (for example, the velocity of a sneeze is greater than that of talking) as well as environmental conditions (temperature, humidity, airflow).²³⁷ The efficacy of physical distancing can be improved with the use of face coverings over the mouth and nose.

FACE COVERINGS

To reduce person-to-person transmission via aerosols and droplets

The CDC recommends public transit riders wash hands or disinfect them with hand sanitizer before entering and when exiting transit, avoid touching surfaces and their nose, eyes, and mouth, practice physical distancing, and wear face coverings.²³⁸ If made and worn properly, face coverings can serve as a barrier to droplets and aerosols expelled from the wearer into the air and environment.²³⁹

WHAT TYPES OF FACE COVERINGS ARE MOST EFFECTIVE?

Face coverings (cloth), surgical masks, and respirators are all effective at source control, protecting members of the community from an infected individual. Some masks are very effective at preventing infection for the wearer, such as respirators (N95/KN95 or N99, which are named after their 95% and 99% efficiency in filtering aerosols).

- Source control is only effective if face coverings successfully prevent respiratory droplets from traveling into the air and onto other people when the person wearing the mask coughs, sneezes, talks, or raises their voice. Face coverings should fit snugly around the mouth and nose to prevent leakage.
- While it is still not clear how high the risk of infection is from aerosols, the mask material impacts the level of protection for the wearer. Masks can reduce risk of airborne infection by up to 99%, depending on the specific mask material: in tests in highly contaminated environments for 20-minute exposures, N99 masks reduced a person's risk of infection by 94% to 99%, and N95/KN95 masks offered almost as much protection. On the other end of the spectrum, scarves were found to offer some but lower protection at 24%.²⁴⁰ Surgical grade masks, used in medical settings as source control, offer some respiratory protection from inhalation of infectious aerosols, but not as much as respirators (e.g., N95 masks).²⁴¹
- Scientists have demonstrated that certain homemade masks can be as effective as N95 masks. "hybrid" masks, which combine two layers of 600-thread-count cotton with another material like silk, chiffon, or flannel, filtered more than 80% of small particles and more than 90% of larger particles. They found that the combination of cotton and chiffon offered the most protection, followed by cotton and flannel, cotton and silk, and four layers of natural silk. The team also found that two layers of 600-thread-count cotton or two layers of chiffon might be better at filtering small particles than a surgical mask.²⁴²
- Another study found that three layers of either a silk or 100% cotton can be just as protective as a medical-grade surgical mask. Silk especially has electrostatic properties that can help trap smaller viral particles.²⁴³



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VENTILATION, FILTRATION, AND AIR FLOW

To reduce person-to-person transmission via aerosols

Ventilation and clean air are key interventions in creating a safer environment. A large amount of air supplied to a room ensures the dilution of airborne infection, making this mitigation tactic particularly helpful in reducing the risk of aerosol transmission.²⁴⁴ Both the CDC and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the world's leading authority on indoor environment control and ventilation, recommend increasing outdoor air ventilation, increasing humidity, assessing the air circulation, and increasing filtration to prevent the risk of COVID-19 airborne transmission.²⁴⁵ Air circulating through subway cars and buses is typically replaced with fresh air close to 18-times an hour, 50% more frequently than the 12-times recommended rate for air quality in indoor environments.^{246, 247}

Efficiency of filtration and ventilation on public transit systems is mixed, with room for improvement in some scenarios. It is generally understood that outdoor environments are lower risk than indoor environments, due in large part to the natural airflow.²⁴⁸ In one engineering study on bus airflow, researchers found that high quality filtration systems can have similar effects as 100% outdoor air supply.²⁴⁹ Airplanes, which utilize displacement ventilation with air entering at the floor and exiting at the ceiling, are most efficient at limiting airborne transmission risks since air is not passed among passengers. However, they note that most bus manufacturers do not employ the optimal ventilation systems to limit air-mixing, with air exhaust vents located in either the center or back of bus. With the onset of the pandemic, bus operators have acknowledged the limitations of bus airflow, which often operates in recirculation mode.²⁵⁰ Windows can also be opened to reduce risk.²⁵¹ Physical barriers in buses have been constructed on many buses to limit air-mixing between passengers and operators. A recent New York Times article details the ventilation system in a subway car, which “moves air within train cars more efficiently than restaurants, schools and other indoor settings, according to aerosol experts.” The article also visualizes the airflow scenario when a masked versus unmasked passenger sneezes—showing the importance of face masks in the subway car (<https://www.nytimes.com/interactive/2020/08/10/nyregion/nyc-subway-coronavirus.html?searchResultPosition=2>).

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Why are ventilation, filtration, and humidity important?

- Scientists and epidemiologists have proven that proper ventilation is helpful for reducing transmission risk of other highly contagious viruses such as measles and SARS.²⁵²
- Engineering controls, including effective ventilation, particle filtration and air disinfection, and avoidance of air recirculation and over-crowding can minimize COVID-19 transmission indoors.²⁵³
- Evidence indicates that more humid environments can reduce the infectivity of aerosolized virus.^{254, 255} Additionally, droplets evaporate less quickly, stay heavier, and thus travel less far in more humid environments. However, considerations must be made when increasing humidity within a space, including whether the structure's materials can withstand high humidity.
- One model of the aerosol spread of influenza estimated that bringing ventilation rates up to the recommended amount (12 times per hour) could have the same mitigating effects as the vaccination of 50% to 60% of the population.²⁵⁶
- Recent studies suggest that hybrid ventilation systems, with both mechanical and natural ventilation such as open windows, can maintain optimal air quality while reducing costs.²⁵⁷

Examples where ventilation and filtration have impacted transmission:

- Indoor settings are found to be far more risky than outdoor settings. In one study tracing outbreaks, indoor transmission was found to be 18.7 times more likely indoors.²⁵⁸ Another found all primary transmission outbreaks occurred indoors.²⁵⁹
- In a case from Guangzhou, China, poor ventilation is suspected to have contributed to the airborne transmission to diners in an indoor restaurant.²⁶⁰
- In another example, an infected passenger on a 50-minute bus ride in Zhejiang province, China transmitted the virus to 24 out of 67 passengers. Scientists speculate that having the air conditioning system on re-circulating mode contributed to the spread. Notably, no passengers sitting adjacent to an open window contracted the virus.²⁶¹
- Poor ventilation on buses has been shown to increase the risk of airborne transmission of disease, especially in crowded conditions.²⁶²
- Tests of the air quality in Wuhan hospitals with highly infected COVID-19 patients found low traces of aerosols in rooms with proper ventilation and filtration.²⁶³

Please refer to APTA's [*Guide for Safeguarding Riders and Employees*](#) for recommendations on filtration and ventilation.²⁶⁴

CLEANING

To reduce surface-to-person transmission

Cleaning and disinfecting of surfaces and hands was rapidly adopted both by transit agencies and individuals. However, there is increasing consensus that person-to-person spread, rather than surface-to-person transmission, is the main source of transmission.²⁶⁵ While studies revealed the virus’s ability to survive on surfaces for up to 9 days, these experiments may have been misleading due to unnaturally high viral load utilized in the lab setting, and lack of clarity on how much infection virus remained (for example, 0.1% of the virus was found to exist on surfaces at the end of these time periods).^{266, 267} In one article published in The Lancet, researchers state that “the chance of transmission through inanimate surfaces is very small, and only in instances where an infected person coughs or sneezes on the surface, and someone else touches that surface soon after the cough or sneeze (within 1–2 hours).”²⁶⁸

However, cleaning protocols have been proven to be effective at inactivating similar viruses and the virus causing COVID-19.^{269, 270} The CDC recommends routine sanitization of high-touch surfaces with either an EPA approved disinfectant, diluted household bleach, or solutions of at least 70% alcohol.^{271, 272} But riders should be aware that hand hygiene (using alcohol-based sanitizer or washing with soap and water) remains a critical additional layer of protection. “Hand hygiene for the passengers before and after transit trips is as or more important than cleaning and disinfection of vehicles.” according to Dr. Thomas Matte.²⁷³

Please refer to APTA’s white paper titled *Cleaning and Disinfecting Guidance During a Contagious Virus Pandemic* for the latest recommendations on cleaning and disinfecting transit vehicles.²⁷⁴

Appendix B – Additional Studies on Transit and Transmission

Studies Looking for Links between Transit and Transmission

In our research, we found no studies by public health experts linking public transit usage and COVID-19 outbreaks. However, there has been a rash of reports by economists drawing correlations between transit and infection rates. None of these reports established causation and now appear to be unfounded. These reports were done in the early months of the outbreak in the United States, when case rates were high among metropolitan areas with large populations of transit riders and before cases had skyrocketed in other parts of the country. Additionally, several of the analyses utilized United States Census Bureau data rather than actual ridership counts, which reflects an estimate of how populations normally commute but is not an actual ridership sample from a specific time period. That may explain the proclivity of some to pronounce transit as the villain.

In an analysis examining daily death rates nationwide on a county level between April and May 2020, researchers from Massachusetts Institute of Technology found commuting via public transit was correlated with higher death rates: a 20% increase in public transit use corresponded with an increase of 0.99 deaths per 1,000 residents, nearly ten times the average death rate across all counties, even when controlling for external factors such as race, income, age, and climate and excluding New York City.²⁷⁵ Researchers acknowledge that their model revealed that all forms of transportation except for biking are correlated with increased death rates— indicating that mobility itself, and the places people go, may be more of a risk than the mode.

Similarly, an analysis by Edward Glaeser, professor of economics at Harvard University on New York City found a link between COVID-19 prevalence and subway use in New York City in March and April (measured by turnstile data) to be positive and significant, but emphasized that this information could not be definitively used to tie public transit to transmission.²⁷⁶ Instead, high case rates may be attributed to the overall high levels of activity and infection in the city during the period of study.

Another economic study found that the higher mortality rate for African Americans and minority groups may in part be due to reliance on public transit: the racial discrepancy remained after controlling for such factors as income and insurance rates, but was less pronounced when controlling for public transit use.²⁷⁷ However, once more, the authors raised the possibility that other causes were leading to the higher case rates. For example, African Americans are more likely to work in essential occupations, which required employees to continue working during the pandemic. Additionally, differentials in levels of paid sick leave, coverage and quality of healthcare, and rates of preexisting conditions may also have an impact on the results of the analysis.

Thus, it appears that what you do at a trip end affects probability of contracting the virus as opposed to the mode of travel. Many people who have traveled by car or transit over the past few months are essential workers. Both groups had higher case rates than those who did not travel. Experts surmise it is probably because essential work as health-care providers, food and service workers increases the probability of contracting the virus. A more careful review of cases in transit-rich areas like New York City shows that even in the early days, where transit usage was still high, specific neighborhoods with typically high transit usage did not experience higher rates of infection than those with typically low transit usage. In fact, communities that depend mostly on private vehicles have fared worse. For example:

- Some of the New York City’s largest hotspots occurred in Staten Island, which has the lowest public transit usage and the highest car ownership rates than any other borough.²⁷⁸ High infection rates may instead due to a high percentage of first responders who live there.²⁷⁹
- As of August 2020, five suburban areas (Rockland, Westchester, Nassau, Suffolk, and Orange county) around New York City had higher case rates per capita than the city.²⁸⁰
- In early June 2020, the average case rate per capita for the top 10 transit usage zones (omitting Manhattan, where many residents departed the city) was found to be 32% lower than the rate among the 10 lowest.²⁸¹

While there is no clear evidence of an urban transit link to COVID-19, there are studies showing other travel modes may have played a role such as boats, tour buses, and airplanes: all places where passengers sit for extended periods of time with the same cohort of fellow passengers. These scenarios do not closely resemble either the operational or behavioral patterns of public transit options, which have better ventilation, doors that open frequently to allow passengers on and off, and riders taking shorter trips.

For example, in a study of 10 children in China who contracted the virus outside of Wuhan, one (10%) case was traced back to traveling; in this case, the child was on a bus traveling a long distance between cities with two symptomatic adults.²⁸² Most children contracted the virus in a household setting (70%). In another example, an infected passenger on a tour bus heading to a Buddhist worship ceremony in Zhejiang province, China transmitted the virus to 24 out of 67 passengers.²⁸³ However, that bus ride was 50 minutes each way (100 minutes total), the air conditioning system was on a re-circulating mode, and no masks were worn. Notably, no passengers sitting adjacent to an open window contracted the virus.

An analysis of 318 outbreaks in 120 cities in China between January and February identified 108 (34%) cases linked to transport; however, the researchers include train, private car, high-speed rail, bus, passenger plane, taxi, and cruise ship in their definition of “transport,” making it challenging to link the cases to typical public transit scenarios. In another instance in January 2020, 12 passengers aboard a 5-hour commercial flight between Singapore and Hangzhou, China contracted the virus from one infected individual.²⁸⁴ Most passengers aboard the 325-passenger aircraft took no precautionary measures, and the infected individual did not wear a mask. No cases were reported among the crew members, who wore face masks.

Our analysis of these studies and cases found no support for a correlation between transit and COVID-19 transmission. Where correlation between public transit and COVID-19 has been found, it has not been done via contact tracing; these correlations may be confounded with other factors, such as the destinations of public transit users. Some critical reviews of these studies found that all modes of travel, even private cars, have a correlation with COVID-19 suggesting that those who travel engage in riskier activities at the termini of their trips and perhaps are more likely to be essential workers. In some instances, transmission has been linked to travel modes such as airplanes and tour buses, but these are dissimilar from intercity public transit modes like subways and buses. Rather, personal behavior and hygiene, governmental policies (such as mask mandates and stay-at-home orders), and socioeconomics may be much greater factors in transmission risk.

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