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The Effect of COVID-19 on Mobility and Equity: A Case Study on Transit Users in Baltimore, Maryland

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Urban Mobility & Equity Center
Morgan State University, CBEIS 327
1700 E. Cold Spring Lane, Baltimore, MD 21251

Principal Investigators:

Samira Ahangari, Ph.D.
samira.ahangari@morgan.edu

Istiak Bhuyan
isbhu1@morgan.edu

Celeste Chavis, Ph.D., PE
(443) 885-5061
celeste.chavis@morgan.edu

Mansoureh Jeihani, Ph.D.
(443) 885-1873
mansoureh.jeihani@morgan.edu

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1 Introduction

The COVID-19 pandemic has drastically altered travel behavior worldwide. One of the sectors most affected by COVID-19 is public transport. North American cities' ridership decreased by 90% by the end of March 2020 as governments applied quarantine policies [1]. Such challenges required public transport agencies to restructure their services, reducing service frequency in some areas while boosting it in others, such as those serving hospitals and essential services.

Some 2.8 million U.S. essential workers rely on transit to get to their jobs [2]. However, as ridership dropped and additional expenses mounted, U.S. transit agencies were forced to scale back services that disproportionately affected lower-income and more vulnerable populations. Public transit plays an essential role during a pandemic; transit provides vital access to goods and services, especially for riders who do not have access to other modes.

Ridership declines varied across the country. The Maryland Transit Administration (MTA) saw maximum ridership declines of 64%, whereas neighboring the Washington Metropolitan Area Transit Authority (WMATA) saw declines as high as 90%. This paper analyzed the effect of COVID-19 on public transit ridership for the MTA and its nine peer transit agencies [3]. By using data from the National Transit Database[1] (NTD), the American Community Survey (ACS), and the Bureau of Labor Statistics (BLS), this report investigates ridership declines and service.

[1] https://www.transit.dot.gov/ntd/ntd-data

2 Literature Review

The COVID-19 pandemic has adversely impacted different aspects of people's lives and the economy. After first being identified in Wuhan, China in late December 2019, the novel coronavirus spread to almost nearly every country in the world. The virus spread quickly on international flights before airports were temporarily shut down [4]. By March 2020, community transmission had started in the affected countries, resulting in 150 million infections and more than one million deaths as of April 28, 2021 [5]. Almost all countries reacted by employing restrictions like complete and partial lockdowns of cities; closing businesses, offices, and educational institutions; restricting inter-city movements; border control; reducing public transport services; and asking people to wear masks and maintain a safe distance from each other. Almost all countries reacted by employing restrictions like complete and partial lockdowns of cities; closing businesses, offices, and educational institutions; restricting inter-city movements; border control; mask mandates; social distancing requirements; and the reduction of transportation services.

Transportation services have played an important role during the pandemic. Before the pandemic, transportation policy makers had begun to make significant strides in promoting equity and sustainable modes such as public transport, cycling, and walking.

Usually, the success of public transport is related to factors such as fare price, quality of service, fare of competing modes, people's income, and car ownership rate [6]. Due to the COVID-19 pandemic, forecasting modal choice has become a complicated phenomenon, and public transport has to withstand more challenges to ridership. According to the guidelines of the World Health Organization (WHO) and Centers for Disease Controls (CDC), personal safety measures to minimize the chance of being infected by COVID-19 include wearing a face mask, sanitizing hands, and keeping a distance of 6-8 feet from others [7] , all of which are difficult inside public transport vehicles [8, 9].

Also, limited research has shown that the chance of COVID-19 transmission is much higher in a crowded-closed space than in an open space [10]. Fear of personal safety might divert public transport users to other modes such as a personal car. It would be unfortunate if a portion of these trip-makers permanently switched to using private modes instead, and it's worth investigating the perspective of transit riders during a pandemic, especially in the context of other modes.

Several studies have investigated the effects of COVID-19 on travel behavior. Those studies mostly focused on the change in mode choice behavior during the early stage of the pandemic [1, 11–15]. This study focuses on changes in the use of public transit during the pandemic.

2.1 Public Transit and COVID-19

The COVID-19 pandemic affects inter-cities and intra-city trips. Generally, trips by all modes decreased in many countries and cities, especially in the USA. The need for mobility regressed as people started to work from home and students joined virtual classes, resulting in a decline in the demand for public transport by 40%-90% in American cities [16]. Among all urban transport modes, public transport suffered the most due to the pandemic [1, 15, 17, 18]. Many predicted that public transport ridership would decline as it would be difficult to maintain social distance onboard. Following the decline of public transport patronage in New York, service frequency dropped by 25% [19].

Deaths of transit operators from COVID-19 were reported in the USA and England [20, 21]. Twenty bus drivers in London died of COVID-19 by mid-April 2020. To protect drivers, London officials made bus travel free so that the drivers did not need to interact with the passengers to collect fares, and passengers were asked to use the back door instead of the front to get in and out of the buses. Unlike bus drivers, it is not easy to verify if a passenger has been infected while traveling on the bus as the passenger would likely have been engaged in other activities throughout the day.

The first case of infection by COVID-19 in the USA was detected on Jan 20, 2020 [22, 23]. Offices, educational institutions, and shopping centers were closed in March of 2020 as the country went under lockdown. After 2-3 months of closure, some businesses gradually reopened. Public transit services continued to operate under government recommendations and safety measures. Transit agencies needed to provide hand sanitizer. Everybody on board, including the staff and passengers, were required to wear face masks.

Initial indications during COVID-19 did not depict a positive picture for public transport. In a survey conducted in the UK, 40% of the respondents stated that they would not use public transport unless they were satisfied that it was safe enough, while 18% were ready to ride public transport when the service resumed [17]. Fear of maintaining adequate physical distance in the relatively confined spaces of buses and trains likely influenced these sentiments. Another study based on a survey of 1,203 people spread over 15 countries reported that 36% of the respondents were using public transport as their primary means of transportation before the pandemic [23]. This figure decreased to 13% during the early stage of the pandemic.

Walking and cycling have gained popularity during COVID-19 as they allow the trip-makers to maintain a safe social distance [19]. However, these two modes are limited by how far people can cycle or walk. Travel by cars and motorcycles increased during the pandemic as people perceived these modes as the safest. A recent study in Bangladesh showed that about 46% of the respondents expected to increase travel by motorcycle in the post-lockdown period compared to pre-COVID-19, and 31% of the

respondents planned to For many people, public transport is the only viable option when traveling to distant destinations.

During the pandemic, individuals have proven that they can make decisions and adopt different modes of transportation to prevent themselves and others around them from being infected with COVID-19. It is expected that individuals take responsibility for their travel-related activities, as they have with their personal protection, and consider the safety of other people in their vicinity.

Since the COVID-19 pandemic highlights the importance of public transit and the response of transportation agencies to ridership changes, it is essential to understand transit users' perceptions and behavior, how transit operators dealt with service changes, and how the agencies adjusted their services during the pandemic. This study provides some insight regarding these questions using various sources of data.

3 Data and Methodology

To better understand the impact of the COVID-19 pandemic on the Maryland Transit Administration (MTA) and its patrons, this study compared MTA ridership changes to the MTA's self-identified peer agencies. With the exception of neighboring WMATA, the peer agencies were selected from metropolitan areas of similar size and density [3]. Additionally, stop-level ridership data and GTFS service data was used to analyze MTA's response to declines in ridership. Lastly, a survey was deployed to better understand transit operator and rider response to the COVID pandemic.

3.1 MTA Peer Agency Analysis

3.1.1 National Transit Database Data

Monthly Module Adjusted Data[2] 2020 was downloaded from the National Transit Database (NTD) . The data contained the number of Unlinked Passenger Trips (UPT), Vehicle Revenue Miles (VRM), Vehicle Revenue Hours (VRH), and Vehicles Operated in Maximum Service (VOMS) by agency and mode. The data consisted of 20 modes [3] that were aggregated into two major modes – bus and rail – for this study analysis. The researchers selected MTA's self-identified nine-peer agencies: BSD (St. Louis), RTD (Denver), Metro Transit (Minneapolis), METRO (Houston), Port Authority (Pittsburgh), RTA (Cleveland), TriMet (Portland), UTA (Salt Lake City), WMATA (Washington, D.C.); see Table 1. Then, the authors analyzed the UPT, VRH, and VOMS of each agency based on mode (bus, rail). The VRM analysis is not presented since VRM and VRH are highly correlated. A regression analysis was conducted separately for each mode to find the relationship between UPT and other factors such as VRM, VRH, VOMS, and the unemployment rate.

[2] `https://www.transit.dot.gov/ntd/data-product/monthly-module-adjusted-data-release`

[3] **Bus modes:** Commuter Bus (CB), Bus (MB), Bus Rapid Transit (RB), Trolleybus (TB); **Rail Modes:** Commuter Rail (CR), Heavy Rail (HR), Inclined Plane (IP), Light Rail (LR), Monorail/Automated Guideway (MG), Streetcar (SR), Hybrid Rail (YR); **Demand Responsive modes:** Demand Responsive (DR), Demand Responsive Taxi (DT)

Table 1: Summary of Ten Selected Agencies

Agency/City	Service Area (Sq. Miles)	Service Area Population	Passenger Miles	Unlinked Passenger Trips	Operating Expenses	Start Date of Stay-at-Home Order (for state)	End Date of Stay-at-Home Order (for state)
BSD (St. Louis)	558	1,566,004	223,625,790	36,642,036	281,199,984	4/6/2020	5/3/2020
RTD (Denver)	2342	2,920,000	617,017,910	105,207,476	644,361,264	3/26/2020	4/26/2020
MTA (Baltimore)	2560	7,811,145	724,931,268	94,036,949	836,206,553	3/30/2020	5/15/2020
Metro Transit (Minneapolis)	653	1,837,223	338,221,652	77,927,237	426,019,463	3/27/2020	5/3/2020
METRO (Houston)	1309	3,757,692	581,575,901	89,951,217	574,298,124	4/2/2020	4/30/2020
Port Authority (Pittsburgh)	775	1,415,244	272,078,547	64,007,925	433,535,787	4/1/2020	5/8/2020
RTA (Cleveland)	458	1,412,140	149,778,197	32,171,825	300,662,840	3/23/2020	5/1/2020
TriMet (Portland)	383	1,565,010	420,317,515	96,633,005	519,559,059	3/23/2020	5/04/2020
UTA (Salt Lake City)	737	1,883,504	355,283,691	44,578,161	311,049,152	3/30/2020	4/13/2020
WMATA (Washington, D.C.)	950	3,719,567	1,705,447,703	354,656,249	2,019,388,171	4/1/2020	5/15/2020

3.1.2 Google Mobility Trend Data

The extremely contagious nature of COVID-19 led to the implementation of public policies to reduce the spread of the virus, often promoting social isolation as a result. The ubiquitous nature of cell phones has made it possible to quantify and measure the mobility patterns of large populations by acting as a new source of data of user behavior and location information. Google published data collated from those logs on its cell phone applications during the COVID-19 outbreak. These Google 'Community Mobility Reports' (CMR) illustrate variations in activity and mobility at different location types. The CMR follows a similar methodology as Google Maps in that it shows how crowded certain places are after aggregating and anonymizing the data. COVID-19 Community Mobility Reports provide insights into changes in mobility patterns as they provide the opportunity to study the relationship between social activity, mobility, and COVID-19 incidence. These mobility trends data are derived from Google location history, are dynamic, and reflect real-time changes in travel behavior. The data can be divided into six key categories:

- **Grocery & pharmacy** – Mobility trends for visits to places like grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies.
- **Parks** – Mobility trends for visits to places like local parks, national parks, public beaches, marinas, dog parks, plazas, and public gardens.
- **Transit stations** – Mobility trends for visits to places like public transport hubs such as subway, bus, and train stations.
- **Retail & recreation** – Mobility trends for visits to places like restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters.
- **Residential** – Mobility trends duration at places of residence.
- **Workplaces** – Mobility trends for visits to places of work.

The Google Community Mobility Report is developed based on the users' privacy settings on their android devices and anonymized, applying a differential privacy process. Unique user presence and time spent at specific locations are collated to indicate an activity. It compares the percentage change in activity and mobility from baseline data. The baseline for the report is the median value for the corresponding day of the week during the five (05) weeks between January 3, 2020, and February 6, 2020. Therefore, the values indicate the relative percentage changes compared to the baseline days rather than the absolute number of users. This study analyzed the CMR data for ten selected locations from February 15, 2020, until June 19, 2020.

3.2 MTA Maryland Service and Ridership Analysis

The General Transit Feed Specification (GTFS) was created in 2005 by Google and TriMet to standardize the transit schedule, trips, routes, and stops data from public transport agencies in an open-source format. The service providers share the GTFS data with researchers, developers, and users. For this study, the GTFS data of different months in 2019 and 2020 was downloaded from Open Mobility Data, formerly known as Transit Feeds[4]. The GTFS dataset consists of stops, routes, stopping times, and a calendar in plain text files formatted as Comma-Separated Values (CSV). Stops are the locations where buses pick up and drop off passengers. Routes are the sequence of two or more stops that are served by the same bus.

Stop level ridership data for three different months in 2020 (February, April, and October) were obtained from Maryland Transit Administration (MTA) to compare different stages of pandemic. The data were aggregated for monthly averages of the aforementioned months. The data table included the number of passengers boarding, alighting, and using the rear door. The stop-level ridership counts were not disaggregated by route.

3.3 Survey of Transit Riders and Operators

Researchers designed two survey questionnaires to investigate the behavior and experience of transit riders and operators before and during the pandemic, focusing on Maryland. One survey was designed for transit riders to find the changes in their use of public transit during and before the pandemic. The other survey was designed for transit operators to find their changes in operating public transit before and during the pandemic (Appendix A and B). The respondents' experience during COVID-19 related to their employment, transit ridership, activities, and health. Their attitude and likely behavior after the pandemic were also investigated.

Both surveys were distributed online via email and social media and in-person at bus stops from June to August 2021. We obtained 46 responses from transit operators and 130 responses from transit riders, mostly from Maryland. The survey collected riders' and operators' perceptions and travel activity before (Feb 2020) and during (April 2020) the peak of the pandemic.

[4] https://transitfeeds.com

4 MTA Peer Agency Analysis

4.1 National Transit Data

For each transit agency, we calculated the percentage change in ridership (UPTs) for each month from March (the start of COVID restrictions) to December 2020 and compared them to ridership in February 2020 (pre- COVID) to find the effect of the pandemic on ridership. As shown in Table 2, bus and rail ridership started decreasing in March and reached its lowest point in April for all cities except for St. Louis, Denver, and Minneapolis, which had the lowest bus ridership in June (48%), December (61%), and May (68%), respectively. The fewest rail passenger trips happened in April for all cities except for Minneapolis, which saw its lowest ridership in June. Washington, D.C. experienced the largest declines in bus and rail ridership overall. While Baltimore's rail ridership decline was similar to that of Washington, D.C., bus ridership only experienced a decline of 53% compared to Washington, D.C.'s 83%. Bus ridership in Washington, D.C. did recover to levels similar to other cities during the fall. St. Louis showed a steady and minimal decline in bus and rail UPTs throughout the study period. Considering that more captive riders take the bus [24], bus ridership declined less than rail for all agencies. Demand responsive services saw an initial decline of 67% on average in April. The decline in UPT's was the most varied among the three modes, ranging from a decline of 30% (Salt Lake City) to 83% (Portland). Demand responsive trips recovered similarly to bus modes; by April the decline in ridership compared to February 2020 was 52%.

The computed result for vehicle revenues hours (VRH) revealed the different responses of agencies regarding the decrease in passenger trips. As shown in Table 3, the peer agencies responded very differently to the fiscally constrained environment caused by COVID. Washington, D.C., initially had the steepest overall cuts and reduction in bus revenue hours. Cities like Cleveland and Portland, on the other hand, made minimal cuts in VRHs for buses. Baltimore had a large and sustained reduction in service. Starting in April, VRH for buses was reduced by about 20%-30% and rail was reduced by 50%-80%. By December of 2020, Baltimore maintained a 70% reduction in rail VRHs by December 2020 whereas peer agencies largely came within 20% of their pre-pandemic levels. Portland had a steep and sustained reduction in demand responsive revenue hours as well. Most agencies were able to restore demand responsive VRHs to about 30% of pre- pandemic levels. However, Baltimore and Denver were still around 45% below pre-pandemic service.

Generally, vehicle revenue miles (VRM) had similar patterns to VRHs; see Table 4. However, Salt Lake City had the steepest reduction in bus VRMs. While WMATA reduced VRHs by more than half for bus routes, VRMs were only reduced by a third. Denver had the largest reduction in VRMs of rail and WMATA the least. By September 2020, Baltimore had VRMs within 8% of pre-COVID VRMs.

Table 2: Percentage Change in Unlinked Passenger Trips (UPT) Compared to February 2020

All Modes	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-18.3%	**-50.3%**	-48.2%	-50.0%	-46.7%	-46.1%	-44.8%	-42.6%	-48.1%	-49.2%
RTD (Denver)	-27.7%	**-65.0%**	-62.5%	-56.4%	-58.8%	-58.0%	-58.4%	-56.9%	-62.9%	-63.0%
MTA (Baltimore)	-24.3%	**-64.0%**	-63.3%	-56.6%	-51.1%	-50.1%	-51.5%	-48.0%	-55.1%	-58.0%
Metro Transit (Minneapolis)	-29.9%	-67.5%	**-71.3%**	-69.8%	-60.4%	-60.7%	-61.3%	-59.2%	-62.5%	-63.5%
METRO (Houston)	-20.5%	**-56.8%**	-51.5%	-45.6%	-47.5%	-50.6%	-51.6%	-45.4%	-50.8%	-51.3%
Port Authority (Pittsburg)	-32.5%	**-72.1%**	-65.2%	-59.4%	-63.2%	-62.7%	-61.6%	-59.9%	-65.1%	-68.5%
RTA (Cleveland)	-24.7%	**-61.8%**	-57.0%	-51.8%	-49.1%	-49.4%	-48.0%	-45.9%	-53.0%	-54.6%
TriMet (Portland)	-29.8%	**-67.0%**	-65.5%	-61.2%	-57.1%	-53.6%	-59.1%	-55.1%	-60.5%	-59.7%
UTA (Salt Lake City)	-29.4%	**-67.6%**	-67.0%	-62.1%	-62.5%	-58.2%	-52.2%	-52.3%	-60.1%	-56.0%
WMATA (DC)	-41.5%	**-89.7%**	-88.9%	-82.6%	-81.5%	-79.9%	-74.3%	-72.6%	-75.1%	-75.1%
Average	*-27.9%*	***-66.2%***	*-64.0%*	*-59.6%*	*-57.8%*	*-56.9%*	*-56.3%*	*-53.8%*	*-59.3%*	*-59.9%*

Bus Modes	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-15.4%	-44.4%	-42.2%	**-47.9%**	-45.1%	-43.7%	-42.8%	-40.3%	-45.4%	-46.3%
RTD (Denver)	-22.2%	-60.8%	-59.6%	-52.0%	-56.1%	-55.7%	-56.9%	-55.6%	**-61.4%**	-61.4%
MTA (Baltimore)	-15.2%	**-53.2%**	-52.5%	-45.8%	-39.0%	-37.6%	-39.7%	-35.3%	-44.4%	-48.1%
Metro Transit (Minneapolis)	-28.7%	-65.9%	**-67.5%**	-65.0%	-55.8%	-56.9%	-58.9%	-58.0%	-61.8%	-62.9%
METRO (Houston)	-21.0%	**-54.0%**	-49.9%	-43.3%	-45.7%	-49.7%	-50.2%	-44.4%	-49.2%	-48.6%
Port Authority (Pittsburg)	-33.2%	**-69.8%**	-62.1%	-57.0%	-61.1%	-61.3%	-59.9%	-58.6%	-63.8%	-67.2%
RTA (Cleveland)	-24.4%	**-61.6%**	-56.6%	-50.6%	-45.7%	-47.2%	-46.4%	-44.9%	-50.9%	-53.5%
TriMet (Portland)	-29.2%	**-67.7%**	-66.1%	-62.0%	-57.2%	-52.2%	-58.2%	-53.3%	-59.4%	-58.7%
UTA (Salt Lake City)	-25.7%	**-66.4%**	-63.0%	-57.9%	-58.5%	-52.8%	-44.5%	-45.9%	-55.2%	-48.9%
WMATA (DC)	-31.7%	**-82.2%**	-80.8%	-68.0%	-67.4%	-66.0%	-54.3%	-51.3%	-55.1%	-53.3%
Average	*-24.7%*	***-62.6%***	*-60.0%*	*-54.9%*	*-53.2%*	*-52.3%*	*-51.2%*	*-48.8%*	*-54.7%*	*-54.9%*

Percentage Change in Unlinked Passenger Trips (UPT) Compared to February 2020 *(continued)*

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rail Modes										
BSD (St. Louis)	-23.7%	**-60.8%**	-59.0%	-54.5%	-50.8%	-51.8%	-49.8%	-48.4%	-54.4%	-55.9%
RTD (Denver)	-38.8%	**-73.1%**	-68.0%	-65.0%	-63.9%	-62.4%	-61.6%	-59.6%	-66.0%	-66.2%
MTA (Baltimore)	-49.5%	**-93.6%**	-93.1%	-86.8%	-85.1%	-84.8%	-84.9%	-83.9%	-85.9%	-86.7%
Metro Transit (Minneapolis)	-32.6%	-70.9%	-79.5%	**-80.2%**	-70.2%	-68.7%	-66.2%	-61.7%	-64.0%	-64.7%
METRO (Houston)	-16.5%	**-63.4%**	-54.3%	-50.6%	-50.3%	-50.5%	-54.3%	-46.1%	-53.5%	-58.6%
Port Authority (Pittsburg)	-27.3%	**-89.6%**	-87.7%	-78.5%	-81.1%	-75.7%	-77.7%	-73.6%	-77.7%	-80.7%
RTA (Cleveland)	-25.1%	**-61.6%**	-58.0%	-55.8%	-60.9%	-57.0%	-53.9%	-50.1%	-60.9%	-59.2%
TriMet (Portland)	-30.6%	**-65.5%**	-64.3%	-59.6%	-56.6%	-55.3%	-60.3%	-57.7%	-61.8%	-60.7%
UTA (Salt Lake City)	-34.2%	**-71.7%**	-71.5%	-65.8%	-67.0%	-63.8%	-59.7%	-58.7%	-65.1%	-63.5%
WMATA (DC)	-46.7%	**-93.7%**	-93.3%	-90.4%	-89.0%	-87.3%	-84.9%	-83.9%	-85.7%	-86.6%
Average	*-32.5%*	***-74.4%***	*-72.9%*	*-68.7%*	*-67.5%*	*-65.7%*	*-65.3%*	*-62.4%*	*-67.5%*	*-68.3%*
Demand Responsive Modes										
BSD (St. Louis)	-17.5%	**-52.4%**	-45.1%	-28.8%	-17.7%	-15.6%	-10.4%	-3.6%	-14.1%	-12.5%
RTD (Denver)	-36.4%	**-82.1%**	-78.6%	-69.8%	-66.6%	-62.9%	-60.2%	-58.5%	-64.3%	-63.7%
MTA (Baltimore)	-24.5%	**-65.9%**	-64.8%	-55.6%	-48.4%	-48.9%	-46.7%	-42.9%	-46.4%	-47.9%
Metro Transit (Minneapolis)										
METRO (Houston)	-30.8%	**-75.2%**	-66.4%	-62.2%	-65.2%	-65.8%	-64.0%	-60.2%	-64.7%	-62.9%
Port Authority (Pittsburg)	-31.9%	**-73.4%**	-69.3%	-57.7%	-51.7%	-50.7%	-46.5%	-43.5%	-50.9%	-57.6%
RTA (Cleveland)	-31.1%	**-68.8%**	-63.0%	-53.5%	-47.0%	-45.3%	-43.2%	-38.1%	-45.2%	-44.9%
TriMet (Portland)	-41.6%	**-83.4%**	-80.6%	-75.8%	-71.9%	-72.1%	-72.7%	-70.3%	-74.0%	-73.8%
UTA (Salt Lake City)	-15.6%	-30.0%	-61.1%	**-71.3%**	-57.5%	-57.7%	-57.5%	-55.3%	-59.4%	-52.9%
WMATA (DC)	-31.5%	**-70.7%**	-68.2%	-60.5%	-54.7%	-53.0%	-49.8%	-46.4%	-51.2%	-50.2%
Average	*-29.0%*	***-66.9%***	*-66.4%*	*-59.5%*	*-53.4%*	*-52.4%*	*-50.1%*	*-46.5%*	*-52.2%*	*-51.8%*

Table 3: Percentage Change in Vehicle Revenue Hours (VRH) Compared to February 2020

All Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-5.1%	**-31.8%**	-29.5%	-25.3%	-16.3%	-15.2%	-14.3%	-10.7%	-15.7%	-11.8%
RTD (Denver)	1.0%	-17.6%	-17.0%	**-31.8%**	-29.1%	-29.4%	-28.8%	-24.4%	-28.8%	-26.3%
MTA (Baltimore)	-12.2%	-45.1%	**-46.4%**	-39.5%	-37.9%	-39.5%	-37.9%	-34.0%	-39.6%	-37.8%
Metro Transit (Minneapolis)	-1.1%	-28.0%	**-29.3%**	-27.3%	-15.7%	-16.9%	-13.1%	-5.3%	-12.5%	-8.8%
METRO (Houston)	-2.4%	**-32.2%**	-26.7%	-17.2%	-11.5%	-14.6%	-18.3%	-13.5%	-22.3%	-19.2%
Port Authority (Pittsburg)	-5.9%	**-29.4%**	-24.1%	-14.4%	-2.4%	-1.8%	-2.4%	2.2%	-6.3%	-8.8%
RTA (Cleveland)	-0.7%	-17.5%	**-19.4%**	-17.8%	-12.7%	-11.0%	-11.3%	-7.2%	7.5%	12.3%
TriMet (Portland)	2.1%	**-18.9%**	-18.7%	-18.3%	-14.8%	-14.4%	-13.8%	-10.3%	-15.0%	-10.7%
UTA (Salt Lake City)	2.5%	-27.9%	**-33.6%**	-32.6%	-30.3%	-22.6%	-10.0%	-5.3%	-15.0%	-3.0%
WMATA (DC)	-21.4%	-54.3%	-56.1%	-56.3%	**-56.4%**	-43.1%	-16.6%	-16.5%	-22.0%	-16.7%
Average	*-4.3%*	***-30.3%***	*-30.1%*	*-28.0%*	*-22.7%*	*-20.9%*	*-16.7%*	*-12.5%*	*-17.0%*	*-13.1%*

Bus Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-4.7%	**-33.3%**	-31.5%	-29.0%	-20.4%	-19.5%	-18.5%	-15.4%	-19.4%	-15.7%
RTD (Denver)	7.6%	-9.7%	-9.9%	**-32.1%**	-29.7%	-30.8%	-30.9%	-25.2%	-28.8%	-26.0%
MTA (Baltimore)	-0.3%	-28.8%	-27.6%	-23.1%	-28.6%	**-32.0%**	-29.5%	-24.4%	-27.4%	-23.8%
Metro Transit (Minneapolis)	0.0%	**-25.7%**	-25.1%	-23.5%	-16.6%	-18.1%	-15.2%	-7.8%	-13.8%	-8.7%
METRO (Houston)	2.3%	**-21.8%**	-21.4%	-10.6%	-2.6%	-6.3%	-11.9%	-8.5%	-17.7%	-13.7%
Port Authority (Pittsburg)	1.7%	**-17.4%**	-12.1%	-3.3%	7.5%	6.9%	5.1%	9.5%	1.1%	2.2%
RTA (Cleveland)	7.7%	-3.2%	-7.8%	**-8.0%**	0.0%	-0.1%	-1.9%	1.8%	23.3%	29.9%
TriMet (Portland)	9.8%	-8.9%	-9.8%	**-10.1%**	-6.8%	-5.6%	-3.5%	0.4%	-4.9%	0.0%
UTA (Salt Lake City)	7.5%	-27.8%	**-34.6%**	-32.3%	-33.4%	-24.6%	-5.8%	-1.6%	-11.9%	3.0%
WMATA (DC)	-24.8%	-53.9%	-55.6%	-52.9%	**-56.8%**	-52.4%	-15.1%	-17.6%	-21.6%	-14.4%
Average	*0.7%*	*-23.0%*	***-23.5%***	*-22.5%*	*-18.7%*	*-18.3%*	*-12.7%*	*-8.9%*	*-12.1%*	*-6.7%*

Percentage Change in Vehicle Revenue Hours (VRH) Compared to February 2020 *(continued)*

Rail Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	1.4%	**-12.6%**	-8.8%	-7.1%	-0.5%	0.7%	-2.2%	1.2%	-3.9%	1.2%
RTD (Denver)	7.1%	-4.0%	-3.1%	-13.4%	-10.7%	-11.6%	-15.7%	-14.5%	**-17.3%**	-14.5%
MTA (Baltimore)	-36.7%	-77.0%	**-79.9%**	-67.3%	-55.0%	-51.8%	-54.1%	-52.5%	-70.2%	-69.7%
Metro Transit (Minneapolis)	-6.4%	-38.8%	**-49.2%**	-45.5%	-11.5%	-11.5%	-3.2%	6.5%	-6.2%	-9.3%
METRO (Houston)	0.6%	**-61.6%**	-6.5%	2.3%	6.2%	3.9%	-7.9%	-2.9%	-9.8%	-23.5%
Port Authority (Pittsburg)	-4.0%	**-36.7%**	-30.5%	-24.5%	9.9%	7.7%	5.5%	10.1%	3.0%	-20.6%
RTA (Cleveland)	3.7%	-7.9%	-6.6%	-12.2%	**-27.7%**	-13.7%	-10.8%	-7.3%	13.6%	17.8%
TriMet (Portland)	6.9%	-3.7%	-2.7%	-4.8%	-1.5%	-2.7%	-5.4%	-2.6%	**-5.7%**	-1.8%
UTA (Salt Lake City)	2.5%	-21.4%	-21.8%	**-22.5%**	-18.6%	-9.4%	-6.0%	1.6%	-8.8%	-0.5%
WMATA (DC)	-17.6%	-52.4%	-56.7%	**-64.7%**	-64.4%	-36.3%	-9.1%	-9.0%	-16.8%	-11.9%
Average	*-4.2%*	***-31.6%***	*-26.6%*	*-26.0%*	*-17.4%*	*-12.5%*	*-10.9%*	*-6.9%*	*-12.2%*	*-13.3%*

Demand Responsive Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-13.0%	**-42.9%**	-39.1%	-24.5%	-11.3%	-9.6%	-5.6%	0.3%	-8.7%	-5.5%
RTD (Denver)	-32.6%	**-67.2%**	-63.9%	-56.8%	-52.6%	-48.9%	-39.2%	-34.7%	-45.0%	-44.2%
MTA (Baltimore)	-20.1%	-56.5%	**-60.5%**	-52.4%	-44.8%	-45.5%	-43.9%	-40.7%	-46.2%	-46.3%
Metro Transit (Minneapolis)										
METRO (Houston)	-13.7%	**-50.0%**	-43.0%	-36.2%	-35.7%	-37.5%	-35.1%	-27.2%	-35.3%	-30.9%
Port Authority (Pittsburg)	-27.9%	**-60.6%**	-55.4%	-42.2%	-33.7%	-28.6%	-25.4%	-20.3%	-29.4%	-35.8%
RTA (Cleveland)	-26.1%	**-61.8%**	-57.3%	-47.4%	-40.6%	-39.8%	-37.4%	-32.0%	-39.0%	-38.7%
TriMet (Portland)	-34.2%	**-77.4%**	-73.7%	-67.4%	-62.7%	-63.9%	-65.1%	-62.2%	-66.4%	
UTA (Salt Lake City)	-16.6%	-37.9%	-47.6%	**-48.7%**	-35.8%	-34.9%	-32.5%	-29.7%	-36.1%	-30.0%
WMATA (DC)	-22.8%	**-58.7%**	-55.6%	-45.9%	-39.8%	-39.3%	-34.4%	-29.5%	-33.3%	-30.7%
Average	*-23.0%*	***-57.0%***	*-55.1%*	*-46.8%*	*-39.7%*	*-38.7%*	*-35.4%*	*-30.7%*	*-37.7%*	*-32.8%*

Table 4: Percentage Change in Vehicle Revenue Miles (VRM) Compared to February 2020

All Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-4.9%	**-30.4%**	-27.5%	-22.7%	-14.6%	-13.2%	-11.9%	-8.2%	-13.6%	-9.9%
RTD (Denver)	0.2%	-20.5%	**-34.2%**	-33.5%	-30.6%	-29.9%	-30.4%	-26.7%	-30.8%	-28.3%
MTA (Baltimore)	-17.8%	**-53.7%**	-44.5%	-41.8%	-39.7%	-39.7%	-39.4%	-35.5%	-43.6%	-42.5%
Metro Transit (Minneapolis)	-1.5%	**-31.4%**	-32.5%	-30.1%	-19.7%	-20.8%	-16.6%	-8.9%	-16.2%	-12.7%
METRO (Houston)	-7.9%	**-41.4%**	-34.0%	-24.7%	-19.9%	-23.1%	-26.1%	-21.5%	-29.4%	-27.3%
Port Authority (Pittsburg)	-7.0%	**-32.0%**	-26.8%	-17.3%	-5.7%	-5.1%	-5.1%	-3.5%	-11.1%	-12.6%
RTA (Cleveland)	-1.1%	-17.4%	**-18.6%**	-16.2%	-11.5%	-9.5%	-9.9%	-5.5%	-9.8%	-6.3%
TriMet (Portland)	0.7%	**-20.1%**	-19.4%	-18.6%	-15.0%	-12.7%	-15.9%	-12.3%	-16.9%	-12.7%
UTA (Salt Lake City)	3.2%	-27.4%	**-36.8%**	-32.0%	-30.5%	-25.0%	-14.7%	-9.8%	-18.5%	-7.7%
WMATA (DC)	-20.8%	-54.4%	-57.1%	**-60.2%**	-58.7%	-40.0%	-13.9%	-14.0%	-20.6%	-15.4%
Average	*-5.7%*	*-32.9%*	***-33.1%***	*-29.7%*	*-24.6%*	*-21.9%*	*-18.4%*	*-14.6%*	*-21.1%*	*-17.5%*

Bus Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	7.6%	-10.3%	-32.2%	**-33.8%**	-31.4%	-32.2%	-32.8%	-28.3%	-31.3%	-28.4%
RTD (Denver)	-6.1%	-34.6%	-33.4%	-25.9%	-31.1%	-34.6%	**-36.0%**	-31.4%	-34.2%	-31.3%
MTA (Baltimore)	-0.6%	**-28.0%**	-27.4%	-25.7%	-19.2%	-20.5%	-18.4%	-11.7%	-18.0%	-13.0%
Metro Transit (Minneapolis)	2.3%	**-25.2%**	-21.9%	-10.7%	-1.4%	-5.7%	-11.7%	-8.1%	-18.0%	-14.2%
METRO (Houston)	2.1%	**-16.3%**	-11.2%	-3.0%	7.4%	6.8%	5.0%	6.0%	-1.5%	2.3%
Port Authority (Pittsburg)	7.9%	-2.3%	**-7.5%**	-6.6%	1.8%	1.6%	-0.4%	3.3%	-0.6%	4.5%
RTA (Cleveland)	9.4%	-8.1%	-8.8%	**-9.0%**	-5.7%	-5.3%	-4.1%	-0.1%	-5.4%	-0.2%
TriMet (Portland)	7.1%	-29.7%	**-36.9%**	-34.6%	-35.7%	-27.6%	-11.1%	-7.5%	-16.7%	-0.4%
UTA (Salt Lake City)	-24.9%	-54.0%	**-55.7%**	-53.1%	-55.0%	-51.3%	-14.0%	-16.7%	-20.7%	-13.5%
WMATA (DC)	-4.0%	**-30.9%**	-29.4%	-27.2%	-18.9%	-17.9%	-16.2%	-13.0%	-17.2%	-13.7%
Average	*0.1%*	*-23.9%*	***-26.4%***	*-23.0%*	*-18.9%*	*-18.7%*	*-14.0%*	*-10.8%*	*-16.4%*	*-10.8%*

Percentage Change in Vehicle Revenue Miles (VRM) Compared to February 2020 *(continued)*

Rail Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	7.1%	-4.2%	-14.1%	-14.3%	-11.7%	-12.4%	-15.9%	-13.9%	**-16.7%**	-13.9%
RTD (Denver)	-32.0%	-71.2%	**-75.4%**	-62.4%	-46.0%	-41.8%	-44.9%	-43.0%	-65.9%	-64.4%
MTA (Baltimore)	-5.5%	-46.7%	**-54.8%**	-49.8%	-22.3%	-22.2%	-8.3%	3.5%	-8.1%	-11.3%
Metro Transit (Minneapolis)	1.7%	**-64.4%**	-6.7%	5.8%	9.7%	7.3%	-6.7%	-2.6%	-9.6%	-24.3%
METRO (Houston)	-4.9%	**-37.6%**	-32.4%	-26.9%	8.1%	5.7%	3.8%	8.3%	1.1%	-25.3%
Port Authority (Pittsburg)	5.2%	-6.1%	-4.5%	-9.9%	**-22.6%**	-11.0%	-9.0%	-5.1%	-7.7%	-3.6%
RTA (Cleveland)	7.0%	-6.1%	-5.3%	-7.4%	-4.2%	6.2%	-8.0%	-5.6%	**-8.3%**	-4.5%
TriMet (Portland)	3.5%	-29.5%	**-33.8%**	-32.1%	-26.2%	-20.8%	-10.7%	-3.6%	-13.7%	-4.9%
UTA (Salt Lake City)	-17.5%	-52.3%	-56.8%	**-64.6%**	-64.3%	-36.3%	-9.8%	-9.8%	-17.7%	-12.5%
WMATA (DC)	0.6%	**-14.8%**	-10.8%	-9.0%	-2.4%	-0.7%	-3.6%	-0.2%	-5.6%	-0.2%
Average	*-3.5%*	***-33.3%***	*-29.5%*	*-27.1%*	*-18.2%*	*-12.6%*	*-11.3%*	*-7.2%*	*-15.2%*	*-16.5%*

Demand Responsive Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	-14.9%	**-48.2%**	-41.4%	-22.9%	-13.8%	-11.2%	-6.4%	-0.5%	-10.3%	-7.9%
RTD (Denver)	-36.2%	**-83.2%**	-76.9%	-66.8%	-62.2%	-53.6%	-48.3%	-44.3%	-54.1%	-53.4%
MTA (Baltimore)	-23.4%	**-66.5%**	-38.3%	-48.5%	-46.5%	-45.1%	-40.1%	-35.9%	-40.8%	-42.3%
Metro Transit (Minneapolis)										
METRO (Houston)	-25.2%	**-64.1%**	-56.4%	-50.5%	-52.9%	-54.3%	-51.1%	-45.0%	-49.9%	-48.3%
Port Authority (Pittsburg)	-29.4%	**-68.5%**	-62.8%	-49.2%	-40.7%	-36.2%	-31.4%	-29.1%	-37.3%	-45.1%
RTA (Cleveland)	-31.6%	**-69.4%**	-61.3%	-48.5%	-41.4%	-40.3%	-38.0%	-31.0%	-37.7%	-39.2%
TriMet (Portland)	-35.2%	**-77.1%**	-71.8%	-63.9%	-58.9%	-61.2%	-64.0%	-60.2%	-64.9%	-63.4%
UTA (Salt Lake City)	-4.9%	-20.1%	**-40.4%**	-26.9%	-25.6%	-25.3%	-26.8%	-22.4%	-28.3%	-25.5%
WMATA (DC)	-28.6%	**-65.1%**	-61.4%	-53.0%	-39.3%	-36.7%	-32.7%	-28.5%	-34.2%	-32.3%
Average	*-25.5%*	***-62.5%***	*-56.8%*	*-47.8%*	*-42.4%*	*-40.4%*	*-37.6%*	*-33.0%*	*-39.7%*	*-39.7%*

Table 5: Percentage Change in Vehicles Operated in Maximum Service (VOMS) Compared to February 2020

All Modes	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	4.9%	**-23.4%**	**-23.4%**	-9.6%	-6.2%	-6.2%	-6.2%	-6.2%	-6.2%	-6.2%
RTD (Denver)	-11.7%	**-46.2%**	**-46.2%**	-39.4%	-39.4%	-39.4%	-38.9%	-38.9%	-38.9%	-38.9%
MTA (Baltimore)	-0.6%	**-50.7%**	-50.1%	-46.6%	-30.9%	-30.5%	-28.0%	-27.8%	-30.6%	-30.5%
Metro Transit (Minneapolis)	**-43.7%**	-40.9%	-41.0%	-39.5%	-39.1%	-39.1%	-30.5%	-30.5%	-30.7%	-30.4%
METRO (Houston)	-0.4%	**-42.8%**	-41.1%	-39.4%	-35.7%	-39.6%	-39.5%	-40.7%	-41.5%	-42.2%
Port Authority (Pittsburg)	0.0%	**-33.6%**	-31.4%	-28.1%	-29.6%	-27.9%	-14.9%	-14.6%	-14.6%	-17.2%
RTA (Cleveland)	2.9%	-29.9%	**-30.1%**	-25.0%	-25.0%	-18.0%	-17.0%	-15.8%	-16.5%	-16.0%
TriMet (Portland)	0.7%	-34.2%	**-34.5%**	-32.3%	-31.3%	-27.7%	-25.2%	-25.5%	-25.6%	-25.5%
UTA (Salt Lake City)	-0.3%	-27.3%	**-30.4%**	-30.3%	-30.0%	-21.5%	-21.9%	-20.5%	-19.6%	-12.2%
WMATA (DC)	-1.3%	-40.6%	**-41.0%**	-38.7%	-37.6%	-23.2%	-21.8%	-22.0%	-22.3%	-22.1%
Average	*-4.9%*	***-37.0%***	*-36.9%*	*-32.9%*	*-30.5%*	*-27.3%*	*-24.4%*	*-24.2%*	*-24.6%*	*-24.1%*

Bus Modes	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	7.2%	**-23.9%**	**-23.9%**	-11.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%
RTD (Denver)	0.0%	**-51.1%**	**-51.1%**	-39.3%	-39.3%	-39.3%	-39.3%	-39.3%	-39.3%	-39.3%
MTA (Baltimore)	0.0%	**-54.4%**	**-54.4%**	-53.1%	-30.4%	-30.0%	-26.4%	-26.2%	-27.7%	-27.7%
Metro Transit (Minneapolis)	**-49.4%**	-46.2%	-46.4%	-44.7%	-44.2%	-44.2%	-34.5%	-34.5%	-34.7%	-34.4%
METRO (Houston)	0.0%	**-43.4%**	-42.9%	-42.9%	-31.2%	-38.4%	-38.4%	-38.4%	-40.6%	-40.6%
Port Authority (Pittsburg)	-0.2%	**-24.8%**	**-24.8%**	**-24.8%**	**-24.8%**	**-24.8%**	-7.0%	-7.0%	-7.0%	-8.8%
RTA (Cleveland)	0.0%	**-26.9%**	**-26.9%**	-22.3%	-22.3%	-13.6%	-13.6%	-13.6%	-13.6%	-13.6%
TriMet (Portland)	0.9%	-20.9%	-22.9%	**-23.1%**	-22.9%	-18.0%	-12.5%	-12.5%	-12.3%	-12.7%
UTA (Salt Lake City)	0.0%	**-44.2%**	**-44.2%**	**-44.2%**	**-44.2%**	-24.8%	-24.8%	-24.8%	-24.8%	-12.5%
WMATA (DC)	0.0%	-59.4%	-59.4%	-59.4%	**-60.1%**	-23.9%	-23.9%	-23.9%	-23.9%	-23.9%
Average	*-4.1%*	*-39.5%*	***-39.7%***	*-36.5%*	*-32.6%*	*-26.3%*	*-22.7%*	*-22.7%*	*-23.0%*	*-22.0%*

Percentage Change in Vehicles Operated in Maximum Service (VOMS) Compared to February 2020 *(continued)*

Rail Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	0.0%	**-68.0%**	**-68.0%**	-16.0%	-16.0%	-16.0%	-16.0%	-16.0%	-16.0%	-16.0%
RTD (Denver)	0.0%	**-35.0%**	**-35.0%**	**-35.0%**	**-35.0%**	-35.0%	-31.0%	-31.0%	-31.0%	-31.0%
MTA (Baltimore)	0.0%	**-59.8%**	**-59.8%**	-41.9%	-15.4%	-14.5%	-14.5%	-13.7%	-26.1%	-26.6%
Metro Transit (Minneapolis)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
METRO (Houston)	0.0%	**-19.2%**	7.7%	7.7%	7.7%	7.7%	-3.8%	-3.8%	-3.8%	-30.8%
Port Authority (Pittsburg)	0.0%	**-60.0%**	**-60.0%**	-48.3%	-56.7%	-56.7%	-56.7%	-56.7%	-56.7%	-56.7%
RTA (Cleveland)	0.0%	0.0%	0.0%	0.0%	**-18.2%**	0.0%	0.0%	0.0%	0.0%	0.0%
TriMet (Portland)	0.0%	**-20.0%**	**-20.0%**	**-20.0%**	-19.2%	-11.7%	-18.3%	-19.2%	-19.2%	-19.2%
UTA (Salt Lake City)	0.0%	-14.4%	**-36.7%**	**-36.7%**	**-36.7%**	-21.6%	-21.6%	-9.4%	-9.4%	-9.4%
WMATA (DC)	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	*0.0%*	***-27.6%***	*-27.2%*	*-19.0%*	*-18.9%*	*-14.8%*	*-16.2%*	*-15.0%*	*-16.2%*	*-19.0%*

Demand Responsive Modes

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BSD (St. Louis)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RTD (Denver)	-40.6%	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**	**-41.8%**
MTA (Baltimore)	-1.6%	**-42.9%**	**-41.2%**	-39.9%	-36.9%	-36.6%	-34.8%	-34.8%	-35.8%	-35.5%
Metro Transit (Minneapolis)										
METRO (Houston)	-0.8%	-43.4%	-41.7%	-38.2%	-42.1%	-43.1%	-42.3%	**-44.8%**	-44.3%	-44.3%
Port Authority (Pittsburg)	0.4%	**-48.6%**	-40.6%	-31.5%	-34.7%	-28.7%	-23.9%	-22.7%	-22.7%	-27.9%
RTA (Cleveland)	9.5%	**-41.3%**	-42.1%	-34.9%	-31.7%	-30.2%	-27.0%	-23.0%	-25.4%	-23.8%
TriMet (Portland)	0.8%	**-70.9%**	-67.4%	-58.9%	-55.8%	-57.0%	-57.0%	-57.8%	-58.5%	-57.4%
UTA (Salt Lake City)	-0.6%	-17.6%	-18.1%	-18.0%	-17.2%	-18.9%	-19.7%	**-20.0%**	-18.3%	-12.7%
WMATA (DC)	-4.3%	-57.7%	**-59.0%**	-51.3%	-46.8%	-45.9%	-41.3%	-42.0%	-42.8%	-42.3%
Average	*-4.1%*	***-40.5%***	*-39.1%*	*-34.9%*	*-34.1%*	*-33.6%*	*-32.0%*	*-31.9%*	*-32.2%*	*-31.7%*

As shown by the vehicles operated in maximum service (VOMS) table (Table 5), service was reduced in the peak period as well. Overall, Baltimore had the largest reduction in VOMS. In addition to Baltimore, transit agencies in Denver, Minneapolis, and Houston maintained a reduction in VOMS of 30-40% through December 2020. Comparing rail and bus reductions in VOMS, agencies again took very different approaches. Washington, D.C., made large cuts to buses during the peak early on, but began to restore service in September. Minneapolis, Cleveland, and Washington, D.C. did not change the number of rail vehicles operating during peak periods. Conversely, Pittsburgh greatly reduced the rail VOMS. Demand responsive strategies varied. St. Louis maintained pre-pandemic VOMS; Denver, Houston, and Portland sustained reductions in VOMS. Baltimore had a percentage change in VMT of -41% in April and -36% in December of 2020.

The results of the study highlight the nuanced decisions that transit agencies face. While service adjustments impact bus ridership less, it is a more critical service to provide. Some agencies such as Baltimore recognized this and made more significant cuts to rail, whereas others such as St. Louis focused the VRH reductions on bus modes. For many of the agencies, rail service is limited. Thus, the most noteworthy financial gains will be made by reducing bus service.

4.2 Ridership Regression

To find the factors affecting transit ridership, several regression analyses were performed on the number of UPTs for bus, rail, demand responsive modes, and comparison among all modes; see Table 6. We also considered the unemployment rate and median income. The unemployment rate for February through December (see Figure 1) was obtained from the Bureau of Labor Statistics (BLS) by metropolitan statistical area (MSA); see Figure 1 for the monthly unemployment rate in each of the peer regions. In addition, the Metropolitan Statistical Area (MSA) median income was obtained from the U.S. Census.

As further supporting evidence of the difference between different modes' riders, demand responsive ridership was not dependent on VRHs. Rail and bus ridership were significantly correlated to the service metrics of VRH, while rail was not correlated to VOMS. While the unemployment rate was significant in all three modes, the unemployment rate had a greater impact on ridership in the rail mode than the other modes. Except for the bus mode, for which we could not find a significant relationship between ridership and employment, a significant relationship exists between employment in all industries and ridership for rail and demand responsive transit.

Table 6: Regression Analysis

Bus					
	Unstd. Coeffs.		Std. Coeffs.		
Variable	B	Std. Error	Beta	t	Sig.
Intercept	13.96	0.074		189.008	0
VRM_Bus	0	0	-0.186	-1.884	0.061
VRH_Bus	0	0	0.506	3.733	0
VOMS_Bus	0.001	0	0.484	6.498	0
Unemployment Rate	-0.05	0.007	-0.245	-7.54	0
All industries	0	0	-0.015	-0.28	0.78
Dependent Variable: UPT-Bus					
Adjusted R Square= 0. 805					
Rail					
	Unstd. Coeffs.		Std. Coeffs.		
Variable	B	Std. Error	Beta	t	Sig.
Intercept	14.01	0.089		156.77	0
VRM_Rail	0	0	-1.97	-5.352	0
VRH_Rail	0	0	2.558	7.549	0
VOMS_Rail	0	0	0.012	0.12	0.904
Unemployment Rate	-0.157	0.01	-0.467	-16.011	0
All industries	0	0	0.077	1.745	0.082
Dependent Variable: UPT-Rail					
Adjusted R Square= 0. 809					
Demand Responsive					
	Unstd. Coeffs.		Std. Coeffs.		
Variable	B	Std. Error	Beta	t	Sig.
Intercept	10.693	0.059		180.268	0
VRM_DR	0	0	0.654	8.176	0
VRH_DR	0	0	0.015	0.217	0.828
VOMS_DR	0.001	0	0.261	3.671	0
Unemployment Rate	-0.049	0.007	-0.205	-7.195	0
All Industries	0	0	-0.117	-2.363	0.019
Dependent Variable: UPT-Demand Responsive					
Adjusted R Square= 0. 867					
All Modes					
	Unstd. Coeffs.		Std. Coeffs.		
Variable	B	Std. Error	Beta	t	Sig.
Intercept	14.517	0.084		172.552	0
VRM_All Modes	0	0	-2.464	-8.299	0
VRH_All Modes	0	0	2.848	10.429	0
VOMS_All Modes	0.001	0	0.471	3.829	0
Unemployment Rate	-0.08	0.009	-0.292	-8.75	0
All Industries	0	0	-0.178	-2.97	0.003
Dependent Variable: UPT-All Modes					
Adjusted R Square= 0. 772					

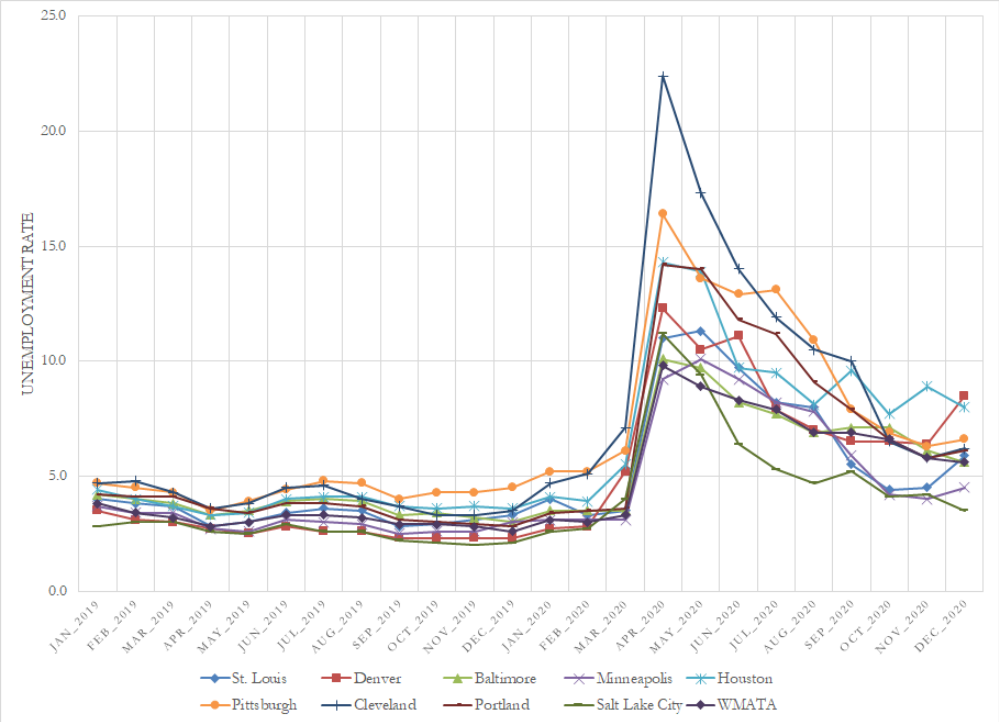


Figure 1: 2019-2020 Monthly Unemployment Rate by Metropolitan Statistical Area

4.3 Google Mobility Trend Data

The Google Community Mobility Report (CMR) was used to investigate the mobility trends in Baltimore and its peer cities from February 15, 2020 to June 19, 2020 for the following trip destinations: grocery stores & pharmacies, parks, transit stations, retail & recreational spaces, residential homes, and workplaces. Figure 2 shows the change in the use of public transportation for the selected locations. The dramatic drop in transit began in the week of March 9, 2020, and hit the lowest mark by the end of the month. Transit use in Baltimore, Maryland dropped 47% by March 25, 2020, whereas Denver, Colorado, and Washington, D.C., dropped by 85% and 81%, respectively, by that day. The numbers started rising after April 2020, and by June 2020, there was only an 8% drop from pre-pandemic levels in Baltimore, Maryland and Cleveland, Ohio. The numbers started going down as the second wave of COVID-19 cases began to surge, and by December 25, 2020, Baltimore ridership had dropped 73%, and by 89% in Washington, D.C. Transit ridership began to increase in 2021 but still has not returned to pre-pandemic levels for all the locations.

During the pandemic, remote work or telework become more popular as many employees were reluctant to commute to their work locations for fear of contracting COVID-19. Google mobility data illustrates the downward trend in work location presence across all ten (10) locations; see Figure 3. At the beginning of April, the decline in workplace travel was more than 50% for all the locations; in Washington,

D.C. the decline was 70%, and in Baltimore 55%. Minneapolis and Cleveland experienced the lowest drop in workplace attendance, with less than a 10% decline in each of these locations. Workplace attendance steadily increased as vaccination rates improved, but did not return to pre-pandemic levels until August 2021. Time spent at retail and grocery/pharmacy locations declined noticeably. Figure 4 shows the drastic drop in April 2020 followed by a steady increase the following summer. There is a decline during the fall and winter with peaks during the holiday seasons. Washington, DC experienced the greatest reduction in retail trips.

Whereas people limited their retail shopping, grocery shopping saw the least reduction in travel. As shown in Figure 5, there was a huge spike in grocery shopping trips as it became evident that COVID would require restrictions in travel. This pattern suggests fewer trips to these locations and less time spent there. Parks and outdoor spaces were a refuge during COVID. In summer 2020, park trips increased for most cities; see Figure 6. There was variability in park visits; however, primarily due to variation in weather. Time spent at residential locations, on the other hand, increased greatly. Figure 7 depicts that the residential mobility is inversely associated with mobility in other public places. While the lockdowns and travel restrictions clearly affected mobility, it largely coincided with the self-protective measures of the individuals of any given region. These readily available data can help investigate the social and economic issues responsible for some of the differences in adherence to social distancing measures.

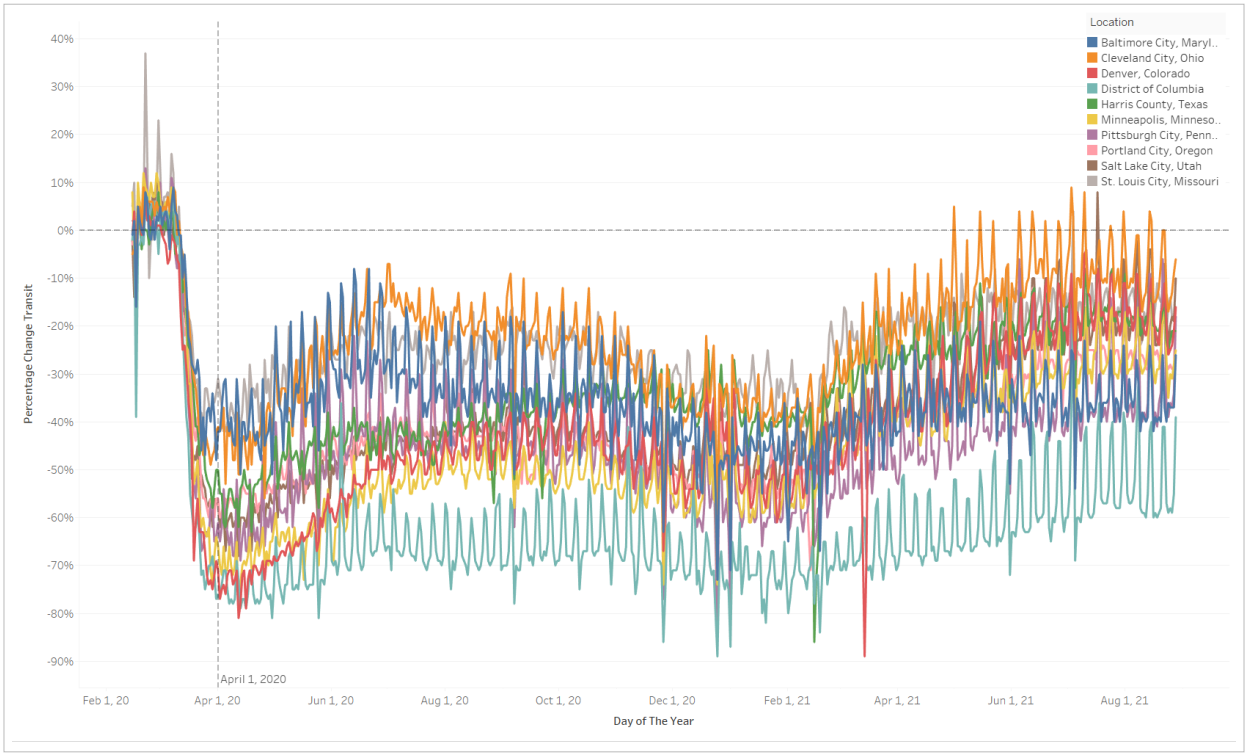


Figure 2: Changes in the Mobility Patterns on Transit (Source: Google Mobility Report)

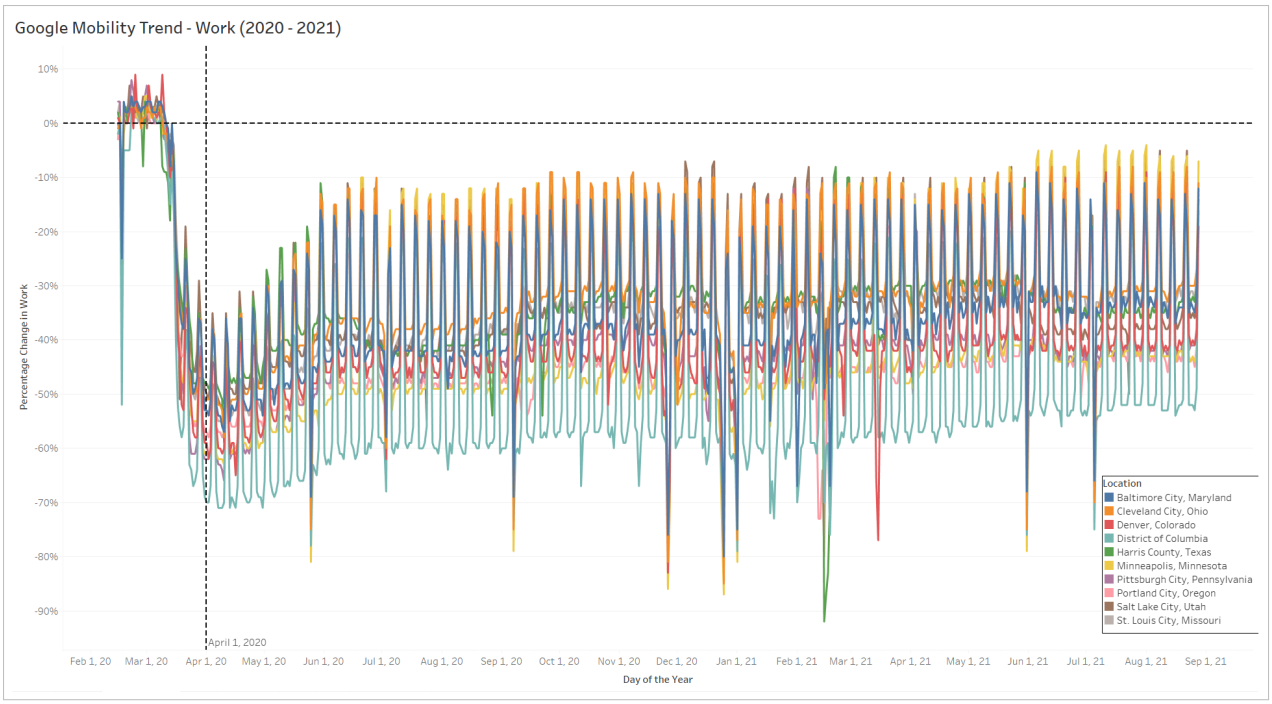


Figure 3: Changes in the Mobility Patterns on Work (Source: Google Mobility Report)

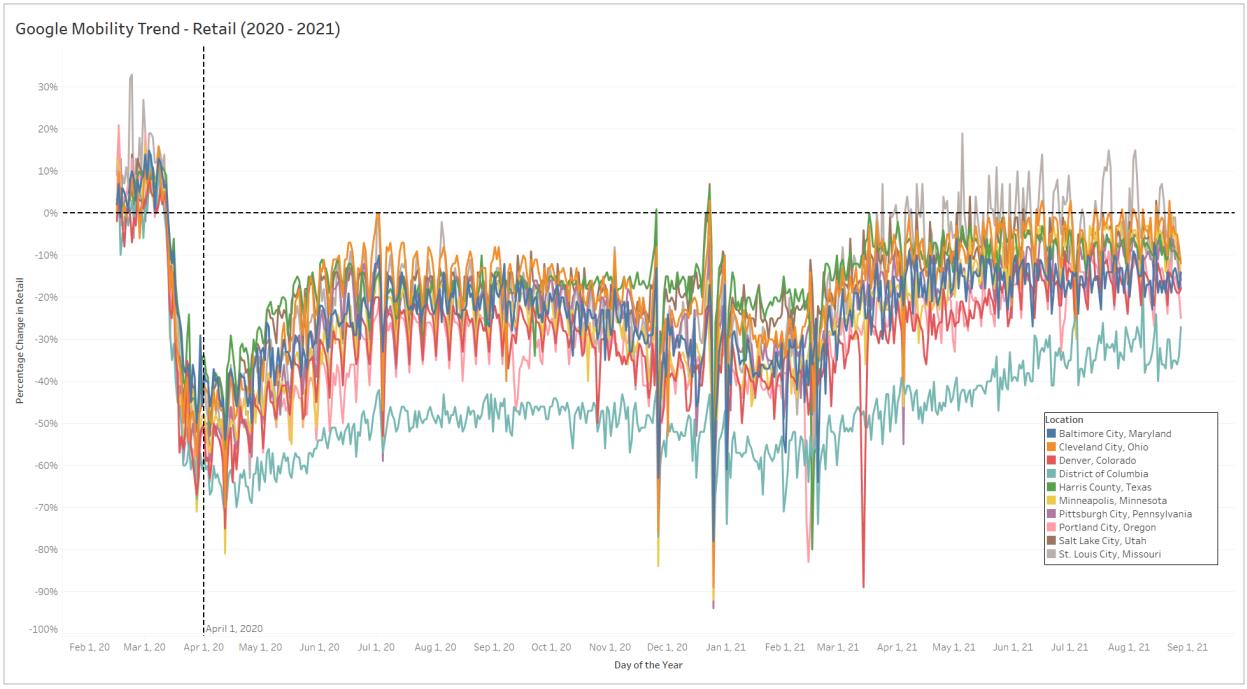


Figure 4: Changes in the Mobility Patterns on Retail (Source: Google Mobility Report)

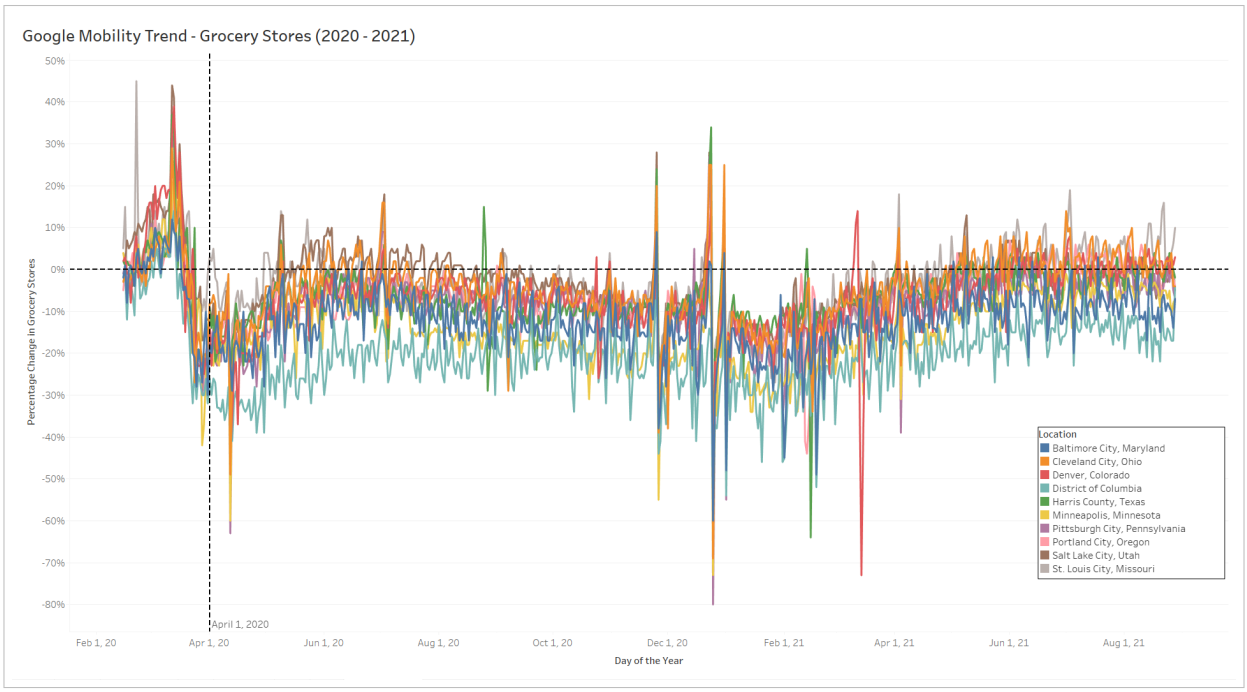


Figure 5: Changes in the Mobility Patterns on Grocery (Source: Google Mobility Report)

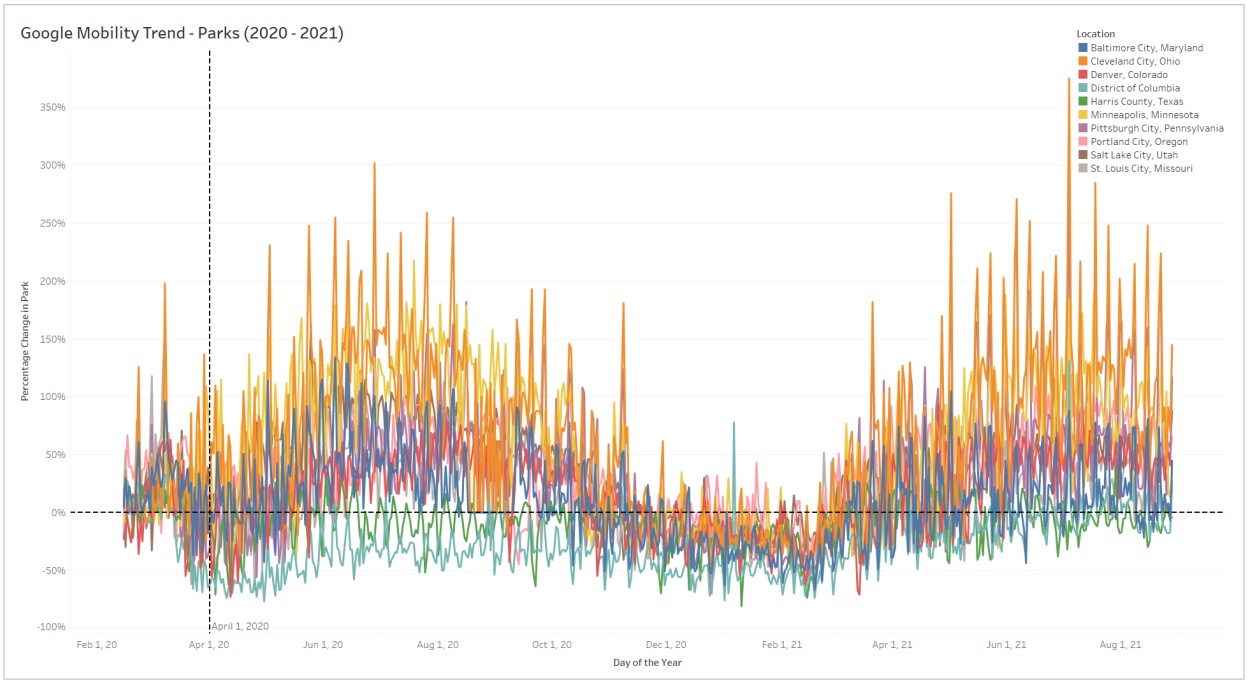


Figure 6: Changes in the Mobility Patterns on Parks (Source: Google Mobility Report)

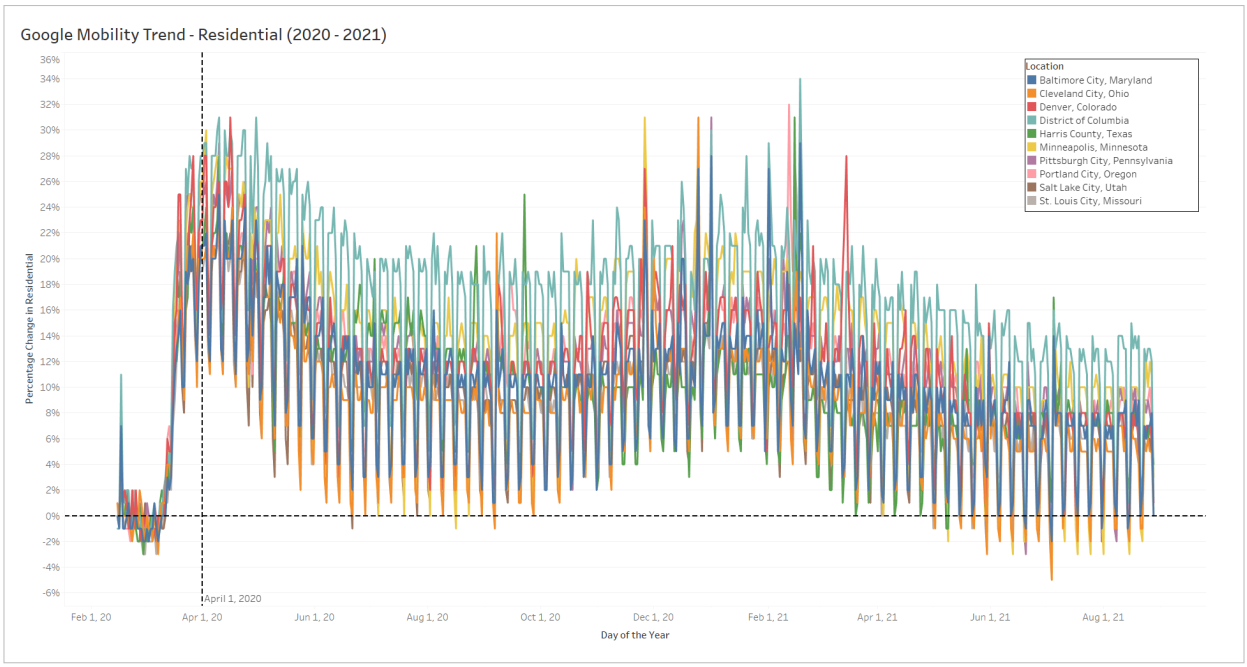
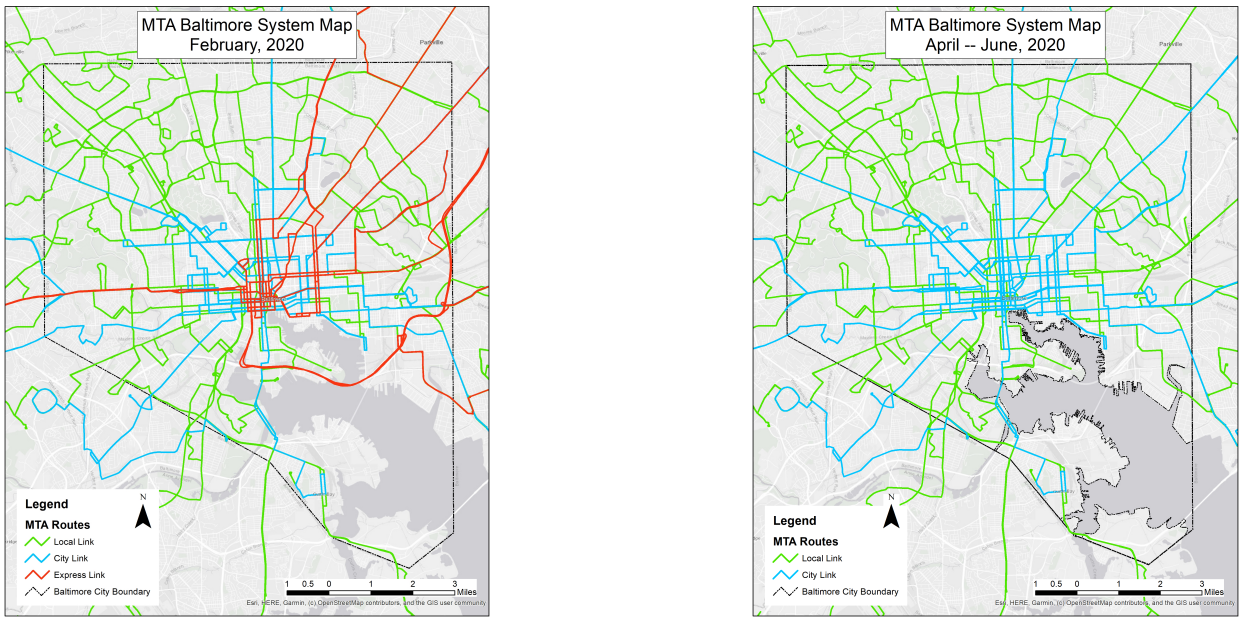


Figure 7: Changes in the Mobility Patterns on Residential (Source: Google Mobility Report)

5 MTA Ridership Analysis

5.1 MTA Response to the COVID-19 Pandemic

The Maryland Transit Administration (MTA) adjusted its transit services throughout the COVID-19 pandemic in response to ridership declines. By the end of March 2020, MTA saw an overall 55% decline in ridership, and ridership on peak hour Express Link buses had dropped by 82%. By April 2020, MTA transit ridership was down 70%, with MARC down 97%, Commuter Bus down 95%, and Core Local Bus down 61% compared to the previous year (2019). Due to the reduced ridership, the MTA implemented several service reductions on all vehicle modes; see Table 7. Figure 8 illustrates the MTA system map (a) before COVID-19 (February 2020) and (b) during the COVID-19 system changes (April to June 2020). The green lines represent the LocalLinks, blue lines represent the CityLinks, and red lines represent the ExpressLinks. As part of the measures taken during the COVID-19 shutdowns, the MTA suspended the ExpressLinks.



(a) Pre-COVID (February 2020) **(b) COVID (April-June 2020)**

Figure 8: MTA System Map

Table 7: Timeline of MTA Service Adjustments due to COVID-19

Date (2020)	Mode	Actions Taken by MTA
18-Mar	Citylink, Local Link, and Express Bus Link	No change.
	Light Rail	On a Saturday schedule.
	Metro Subway	On a Saturday schedule.
	Commuter Bus	On "S" schedule only.
	MARC Train	On "R" schedule for all three lines.
25-Mar	CityLink, LocalLink, and Express BusLink	The following routes were impacted due to an operator testing positive for COVID-19: · CityLink Navy, Orange, Blue, Pink, Lime and Gold · LocalLink 21, 22, 28,36, 56, 59, 62, 63, and 65 · Express BusLink 105, 120, and 160.
	Light Rail	On a Saturday schedule.
	Metro Subway	On a Saturday schedule.
	Commuter Bus	On "S" schedule only.
	MARC Train	On "R" schedule for all three lines.
6-Apr-20	CityLink, LocalLink, and Express BusLink	All nine Express BusLink routes (103, 104, 105, 115, 120, 150, 154, 160, 164) and LocalLink 38 and 92, which primarily serve schools, were temporarily suspended.
	Light Rail	On a Saturday schedule.
	Metro Subway	On a Saturday schedule.
	Commuter Bus	On "S" schedule only.
	MARC Train	On "R" schedule for all three lines.
10-Apr-20	CityLink, LocalLink, and Express BusLink	Service reductions on the following routes: · Route 201, 220, 240, 260, 305, 310, 315, 335, 345, 515, 610, 620, 630, 640, 705, 715, 735, 810, 820, 830, 840, and 850.
	Light Rail	On a Saturday schedule.
	Metro Subway	On a Saturday schedule.
	Commuter Bus	On "S" schedule only.
	MARC Train	MARC's run on new "R" schedule that includes eliminated select trains on all lines – Penn, Camden and Brunswick.
12-Jul	CityLink, LocalLink, and Express BusLink	Regular summer weekday/weekend schedule. Express Bus service and LocalLinks 38 and 92 remain suspended.
	Light Rail	Regular weekday/weekend schedules.
	Metro Subway	Regular weekday/weekend schedules.
	Commuter Bus	Enhanced "S" schedule service; regular service.
	MARC Train	Penn, Camden and Brunswick lines operate on regular scheduled service.

5.2 Stop-level Ridership Analysis

Researchers obtained the stop-level transit ridership data from the MTA for the months of February (pre-COVID), April (peak of COVID), and October (recovery). For this study, February was considered the base month to compare the changes in ridership during and after the pandemic. The values represent total boarding and alighting at each stop for all routes served by the stop. The MTA ridership data contained three key attributes, i) boarding, ii) alighting, and iii) total count for weekday average for the months of February, April, and October. The ridership count of boarding in one direction is almost equal to the alighting in the other direction.

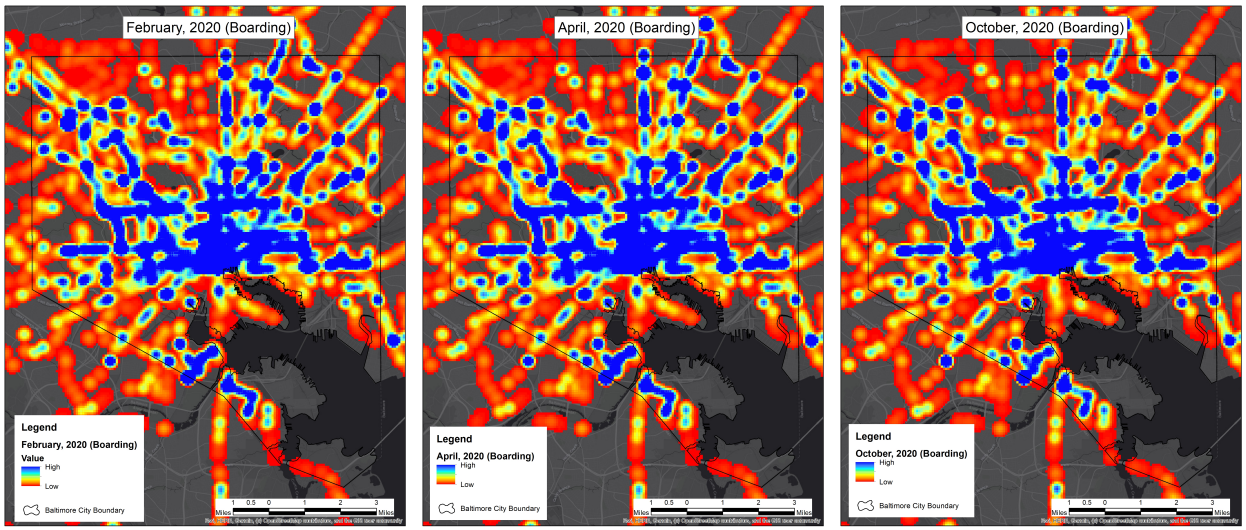
To understand the regional nature of transit ridership, a non-parametric statistical method, "Kernel Density," was performed. The kernel density function uses a quadratic formula to calculate the intensity of an attribute within a specified neighborhood around each output cell. It shows the spatial decay of the attribute rather than a sharp distance cutoff. If there are n number of stops within the given search radius h (bandwidth), then the parameter is denoted by x_i, $1 \leq i \leq n$, and the kernel density function $f_n(x)$ can be calculated using following equation:

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \quad (1)$$

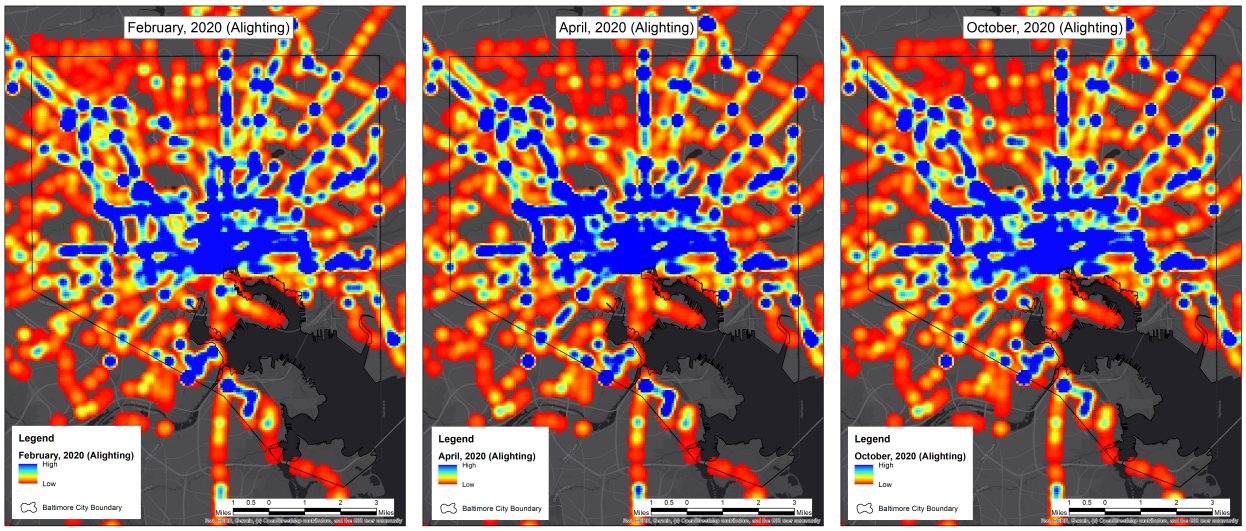
In this study, the bandwidth (search radius) parameter h is considered as 402.33 m or a quarter-mile radius, considered the walkable distance to reach a transit stop. The cell size is set to 100 m to capture traffic in both directions in a road segment. The nearby transit stops are considered in the same cell, and the higher the ridership at those stops, the higher the kernel density score the cell acquires.

The monthly boarding and alighting are illustrated in Figure 9.The overall ridership spatial pattern did not show any significant change from the base month (February) to peak-Covid (April) and recovering (October). The average weekday ridership for February 2020 was 411,292. It was 271,578 in April 2020, which is a 34% drop from February and down 61% from the previous year. During October 2020, the ridership was 229,629, a 44% drop from February 2020 and a 15% drop from April 2020. The MTA reported that for the third week of August, compared to the same week a year ago, transportation volumes were ramping back up with local bus ridership down at only 47%.

To evaluate riders' movements throughout the city during these months, the Kernel Density Estimation (KDE) was performed on the percentage change from the base month (February 2020). It revealed some regions where people were boarding or alighting more than the rest of the city. During April 2020 the ridership activity increased around elementary/middle schools, religious or community organizations, and grocery stores. This is likely because Baltimore City started various COVID relief

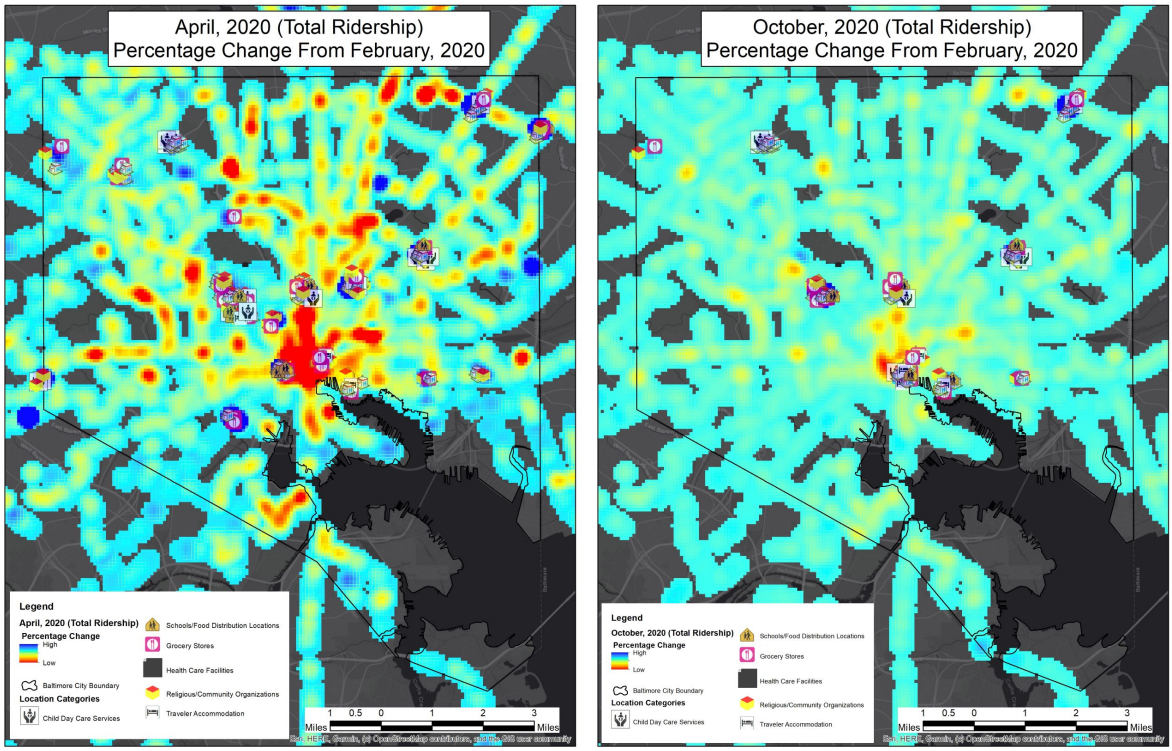


(a) Boardings - February (b) Boardings - April (c) Boardings - October



(d) Alighting - February (e) Alighting - April (f) Alighting - October

Figure 9: Boarding and Alighting for the Months of February, April, and October 2020



(a) Total - April **(b) Total - October**

Figure 10: Percentage Change in Total Ridership for the Months of April and October

and support programs, including food distribution from the schools and community organizations. Ridership to health care facilities, employment centers, and travelers' accommodations (i.e., hotels, motels, etc.) started to rise again in October. As COVID became more entrenched and the recovery process began, people started to travel more, which explains the increase in hospitality locations.

6 Survey Analysis

6.1 Transit Riders Survey

Some 130 people responded to the travel survey; 95% resided in the DC-Maryland-Virginia (DMV) area. Table 8 shows the sociodemographic characteristics of the participants. Some 55% of participants were female and 45% were male; the largest age group was 25 to 34 accounting for 25% of participants. Some 46% of participants were white and 33% were Black or African American. Participants differed in education levels with 43% at the post-graduate level and 27% with a bachelor's degree. The household size of the participants shows that most of the participants, 48%, have a household size of two, and only 4% have a household size of five or more while 35% have an annual household income of $100,000 or more and 18% earn less than $20,000. Some 32% of participants do not have vehicle, and 32% have one vehicle.

The results of questions regarding the impact of the pandemic are shown in Figure 11. Only 3% of participants are not worried about COVID-19, while 13% are slightly worried, 45% are moderately worried, 35% are very worried, and 4% are extremely worried. As shown in Figure 12, the majority used face masks and hand sanitizer. However, only 30% used gloves and 10% used face shields when in public.

The pandemic changed our lives, and while some changes are temporary, others might be long-term or permanent. We asked the participants how their activities would change when COVID-19 is no longer a threat compared to before COVID-19. They stated that they would shop online about the same as pre-COVID (48%) or even more (30%), have or attend fewer social gatherings (44%) or about the same (33%), visit movie theaters less (52%) or about the same (33%), travel less (40%) or about the same (35%), telework more (44%) or about the same (28%), and have more online meetings (49%). As shown in Figure 13, the largest predicted shifts were for more online meetings and teleworking and less visits to the cinema.

Figure 14 shows that the percentage of workers who commute daily dropped from 74% before the pandemic to 23% during the pandemic. There was no change in partial commute/telework (19%), and a drastic increase in daily teleworking from 4% before the pandemic to 51% during it. We also investigated the short-run effect of COVID-19 on mode of commute (Figure 15). Though this survey was restricted to transit riders, only 65% used transit for commuting purposes prior to the pandemic. This percentage dropped to 17% during the height of the pandemic. Overall, auto and walking percentages were relatively the same before and during though there were shifts to and from these modes. Biking/e-scooter dropped from 25% to 9% and ride-hailing from 15% to 3%. As expected, teleworking increased drastically from 8% of workers to 39%. As presented in Figure 16, 55% of the participants stayed home and thus had no commute. About 9% of people experienced a longer travel time work while another 9% had shorter commutes.

Table 8: Riders' Socio-Demographic Information

Variables	Categories	N	Percent
Gender	Female	72	55.4%
	Male	58	44.6%
Age	Less than 25	19	14.6%
	25 to 34	40	30.8%
	35 to 44	22	16.9%
	45 to 54	19	14.6%
	55 to 64	16	12.3%
	65 or older	14	10.8%
Race	Black or African American	43	33.1%
	White	60	46.2%
	Hispanic, Latino or Spanish origin	8	6.2%
	Asian	14	10.8%
	Multiple Race	4	3.1%
	Other Races	1	0.8%
Education	Less than high school graduate	7	5.4%
	High school graduate, GED or equivalent	16	12.3%
	Some college or Associate Degree (e.g., AA, AS)	11	8.5%
	Associate Degree (e.g., AA, AS)	5	3.8%
	Bachelor's Degree (e.g., BA, BS)	35	26.9%
	Graduate Degree (e.g., MA, MS, MED, Ph.D.)	52	40.0%
	Professional Degree (e.g., MD, DDS)	4	3.1%
Household Size	1	45	22.0%
	2	99	48.3%
	3	37	18.0%
	4	15	7.3%
	5 or more	9	4.4%
Household Income	Less than $20,000	23	17.7%
	$20,000 to $49,999	33	25.4%
	$50,000 to $79,999	24	18.5%
	$80,000 to $99,999	5	3.8%
	$100,000 and higher	45	34.6%
Number of Vehicles Owned	0	41	31.5%
	1	41	31.5%
	2	32	24.6%
	3	8	6.2%
	4	5	3.8%
	5 or more	3	2.3%

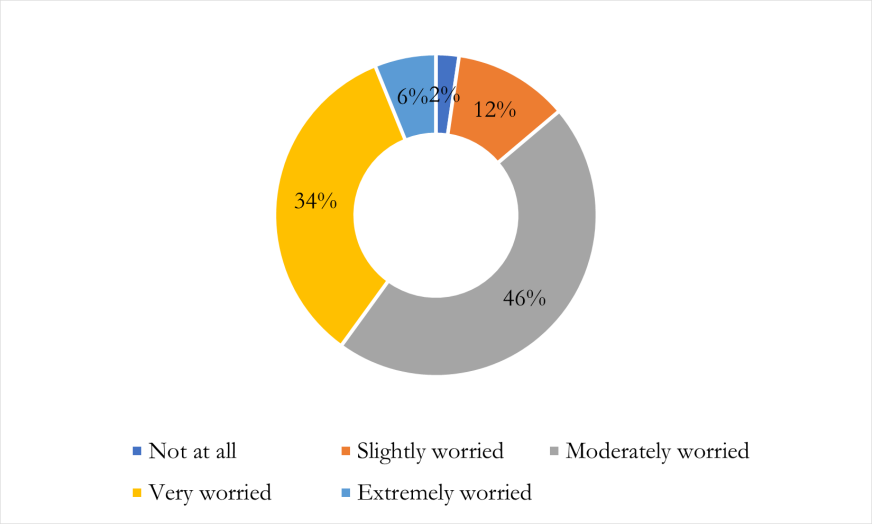


Figure 11: Level of Worry about the COVID-19

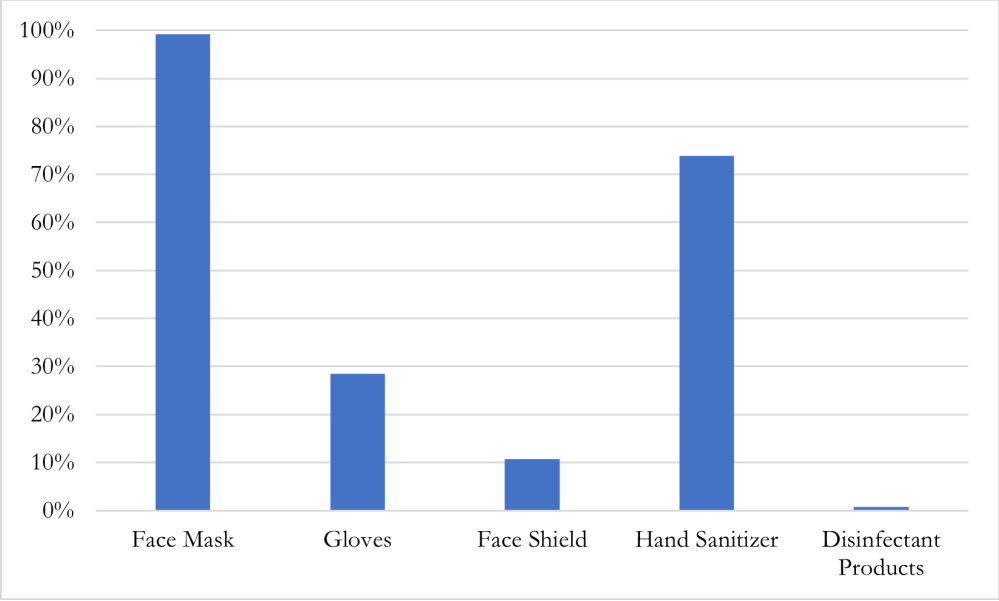


Figure 12: Types of Safety Precautions Used

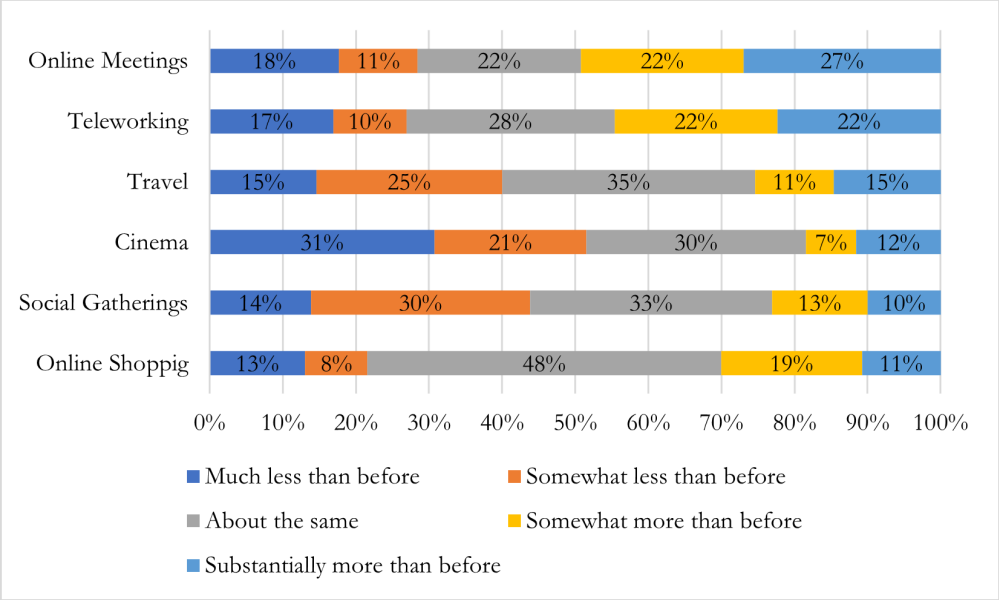


Figure 13: Predicted Long-term Changes in Activities by Type

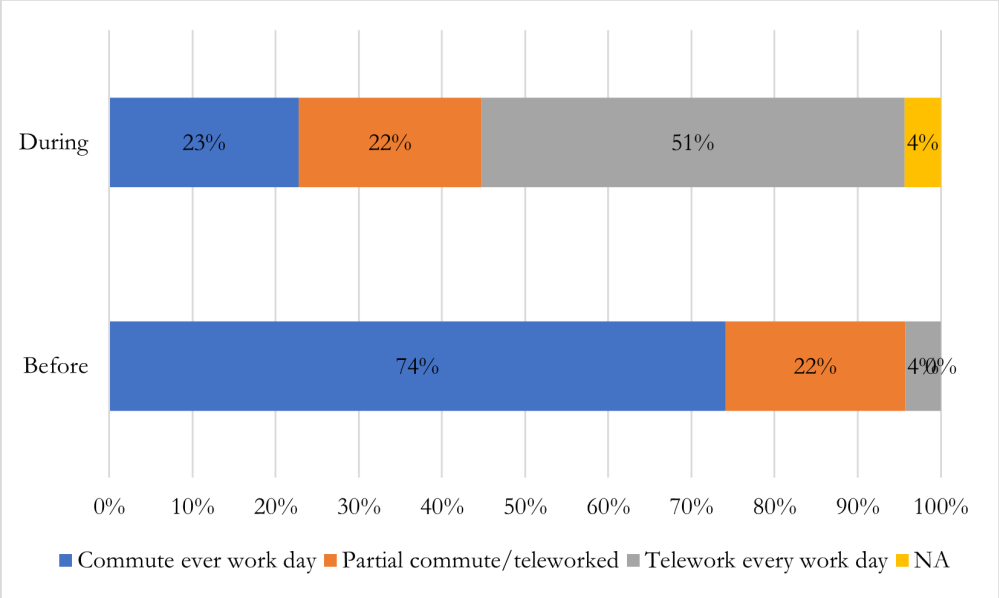


Figure 14: Commuting Frequency

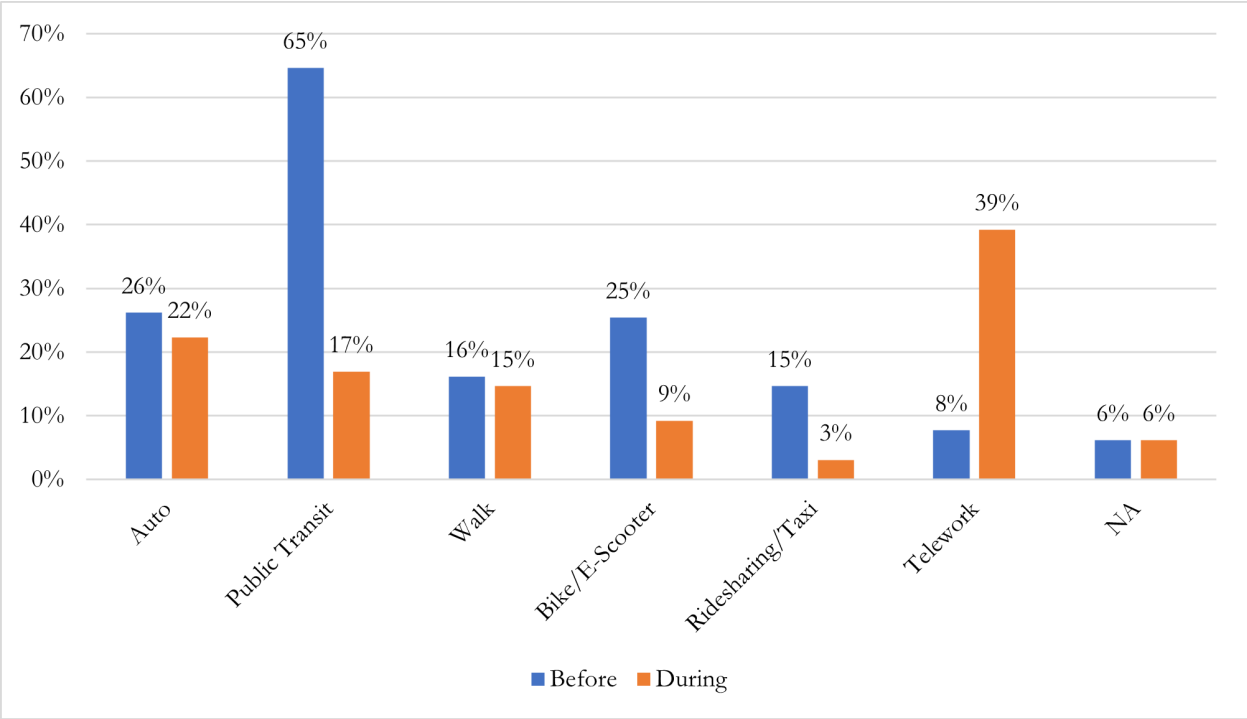


Figure 15: Primary Modes used for Commuting to Work

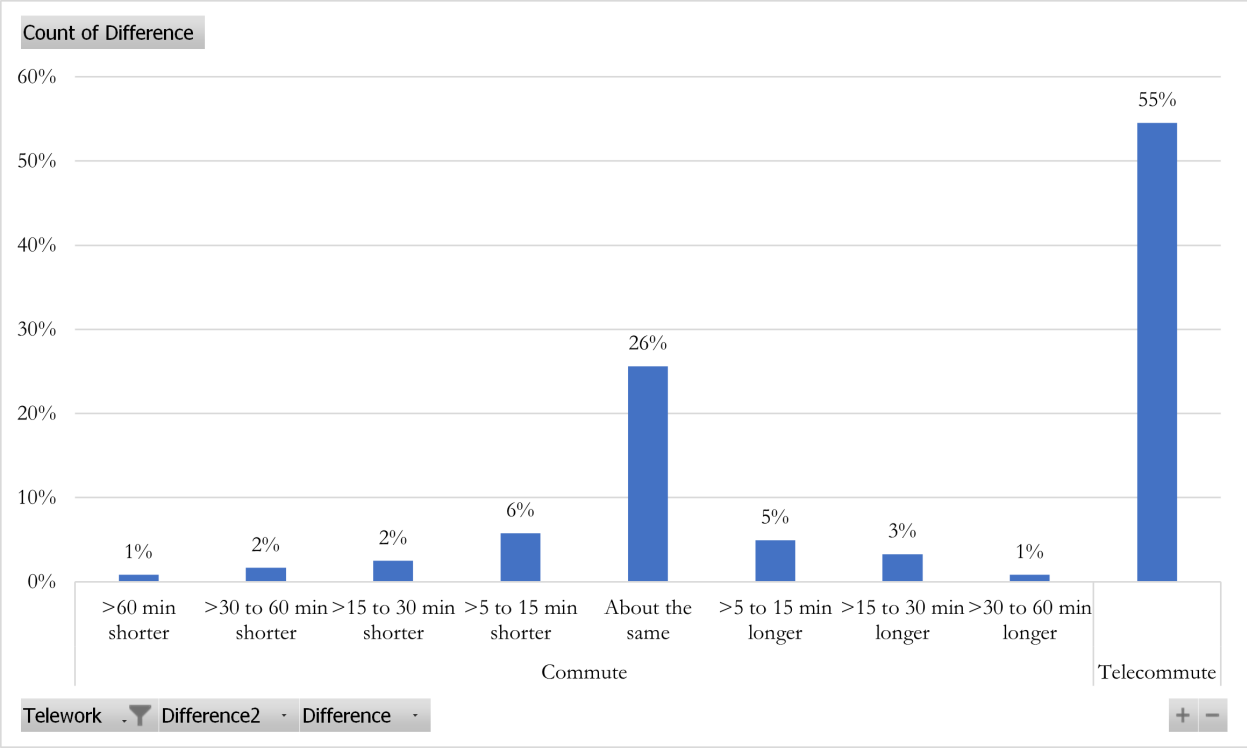


Figure 16: Length of Commute (in minutes)

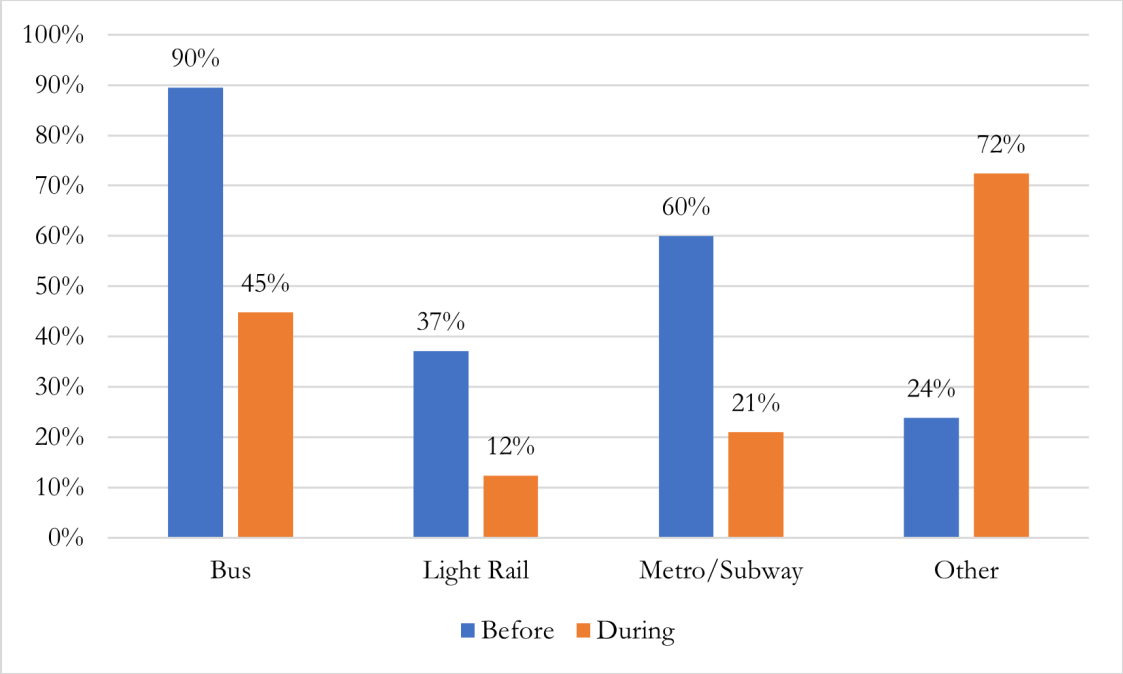


Figure 17: Type of Public Transit Used

We also asked the participants about the type of public transit they use. Some 90% used the bus pre-pandemic, which dropped to 45% during the pandemic; 37% took light rail, which dropped to 12%; 60% opted for metro/subway which dropped to 21%; but 24% chose other transit modes, which increased to 72% during the pandemic. See Figure 17. Unfortunately, it is not clear what the respondents meant by "other," whether they meant teleworking or other transit modes. Having teleworking as an available option could have clarified this.

Figure 18 shows that the primary purpose of taking public transit before and during the pandemic is commuting to work, which became far less relevant during the pandemic. Medical trips serve a critical need; the percentage who used transit for medical trips was 34% pre-pandemic and 21% during the pandemic. As shown in Figure 19, medical trips were the most frequent, with 36% of respondents saying they made medical trips at the same or higher frequency. Social activities saw the steepest drop in frequency of trips; 78% stated that they do fewer social trips on transit.

6.2 Operators Survey

A survey was distributed to local (largely MTA) operators to better understand their experiences during the height of the COVID-19 pandemic. Forty-six responses were received. Table 9 shows the socio-demographic information of the operators surveyed. Of the operators surveyed, 65% are males and 33%

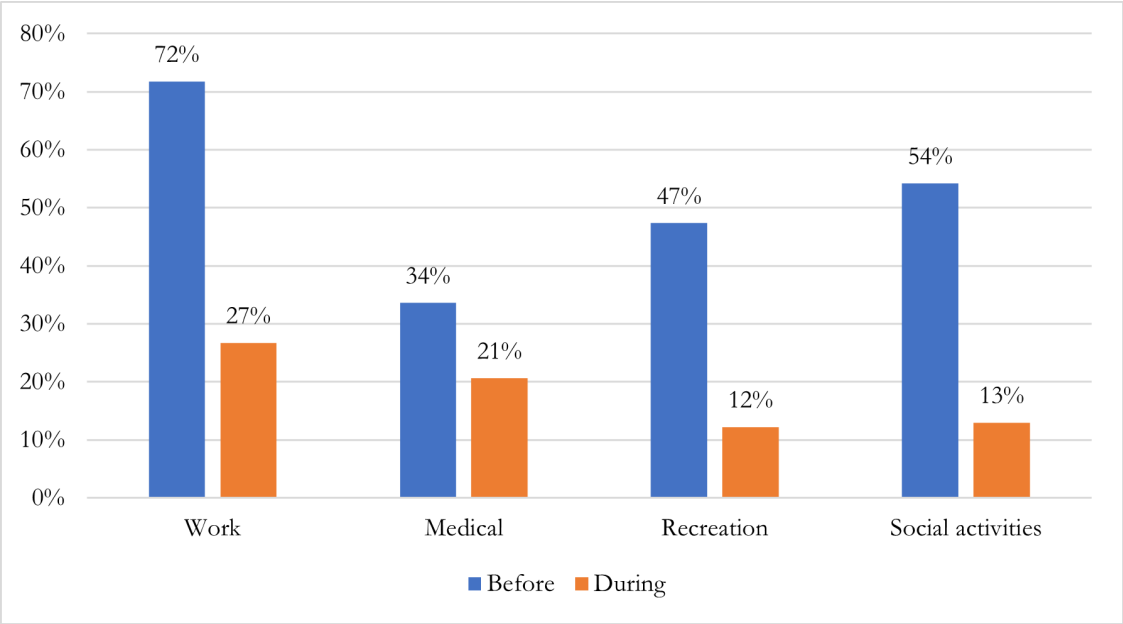


Figure 18: Purpose for Taking Public Transit

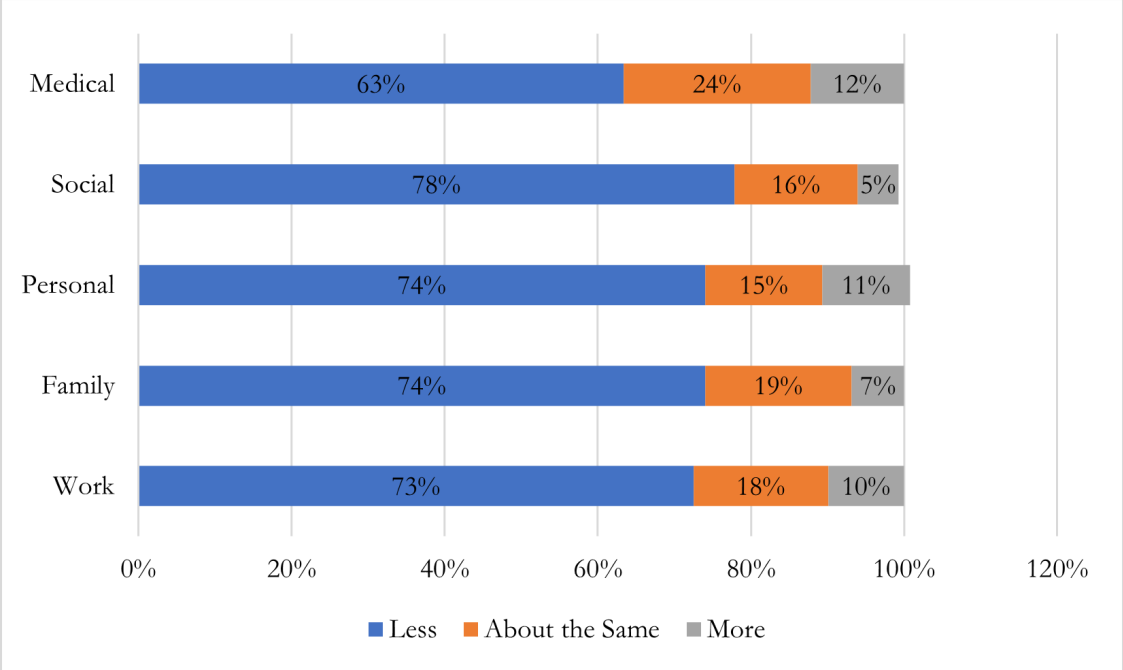


Figure 19: Frequency of Using Public Transit for Different Activities

are females; 37% of the respondents are in the age group 25 to 34; 87% are Black or African American; 70% have a high school degree; and 6% of the participants do not have a personal vehicle. The majority of the respondents (90%) operate a bus.

Table 9: Operators' Socio-Demographic Information

Variables	Category	Frequency	Percent
Gender	Female	15	32.6%
	Male	30	65.2%
	Decline to answer	1	2.2%
Age	25 to 34	17	37.0%
	35 to 44	9	19.6%
	45 to 54	14	30.4%
	55 to 64	5	10.9%
	65 or older	1	2.2%
Race	Black or African American	40	87.0%
	White	4	8.7%
	American Indian or Alaska Native	1	2.2%
	Asian	1	2.2%
Education	High school graduate, GED or equivalent	32	69.6%
	Associate Degree (e.g., AA, AS)	11	23.9%
	College Degree (e.g., B.S., B.A.)	0	0.0%
	Graduate Degree (e.g., MA, MS, MED, Ph.D.)	3	6.5%
Number of	0	3	6.5%
Vehicles	1	12	26.1%
Owned	2	15	32.6%
	3	7	15.2%
	4	5	10.9%
	5 or more	4	86.9%
Mode	Bus	41	89.6%
Operate	Light Rail	1	2.2%
	Demand Responsive	1	2.2%
	Metro or Subway	2	4.3%
	Other	1	2.2%

For increased operator safety, agencies introduced safety precautions such as social distancing and personal protective equipment (PPE). Figure 20 shows the frequency of crowding on the operator's transit vehicle before and during the pandemic. As previously described, respondents were asked to consider February 2020 as the before period and April 2020 as the during period. Social distancing occurred more often in the during period. Only 31% of operators noted that there was often or always 6 feet of distance, this increased to 59% during the pandemic. Fewer reported that people still had to sit next to others. However, there was still about the same percentage of those who noted standing room only often and always occurred on their route.

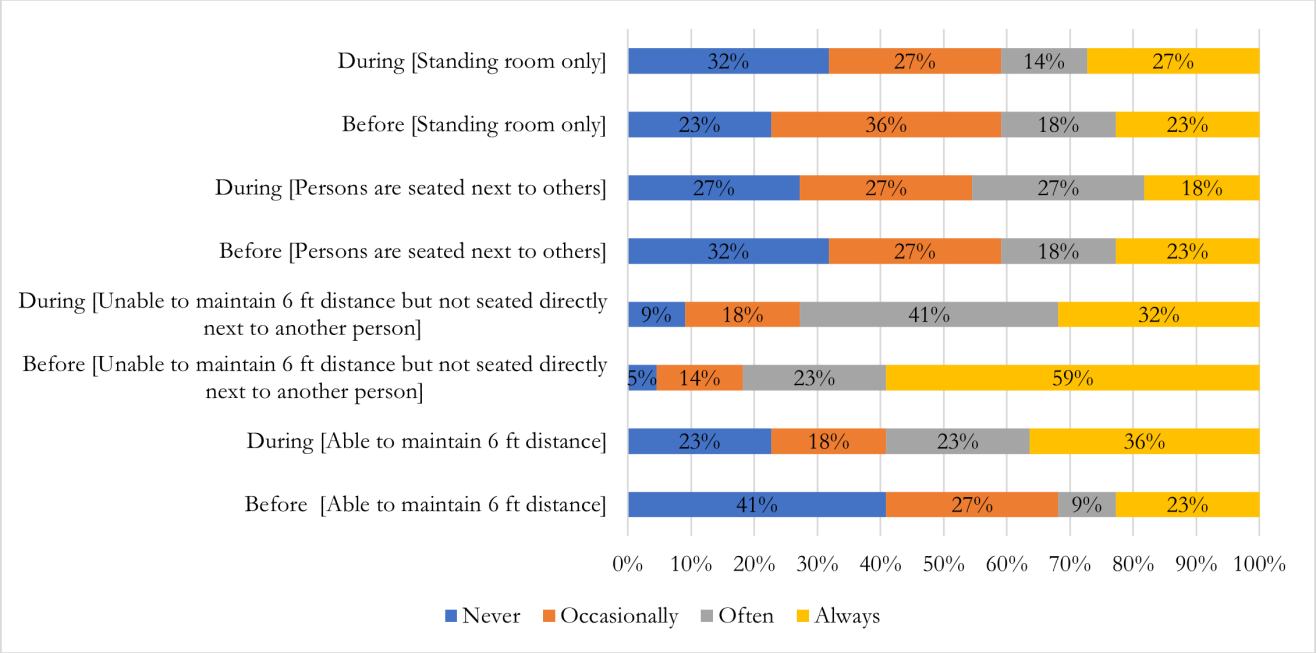


Figure 20: Frequency of Crowding on Public Transit Vehicle Operated

As shown in Figure 21, operators took precautions to avoid contracting COVID. Nearly all wore face masks and used hand sanitizer. There were increased disinfectant measures as well. Gloves were used by nearly half and face shields were used by about a third of the operators.

Figures 22 and 23 show the hours worked before and during the pandemic. The majority of operators worked 40 or more hours per week. However, 7 fewer reported working full-time, an 18% decline in the number of full-time operators in our survey. Two operators (5%) stopped working all together and 16% reported working fewer hours during the pandemic. Operator shortage was a concern for many agencies. In our sample, the dominant reason for calling out was having to quarantine due to COVID exposure, see Figure 24. Eleven operators reported that they called out because they felt unsafe due to COVID. Twelve (26%) reported calling out due to a COVID-related illness.

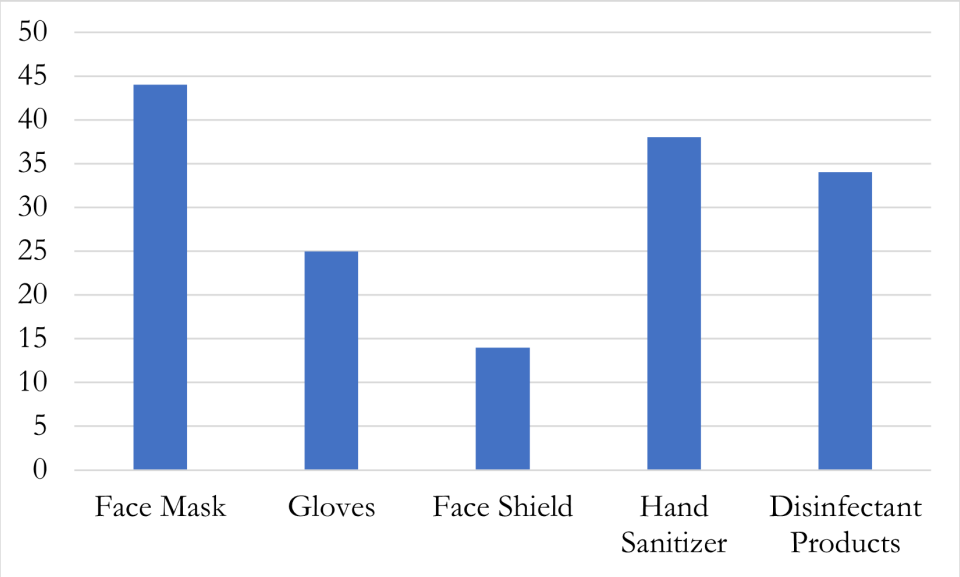


Figure 21: Safety Precautions Taken by Operators

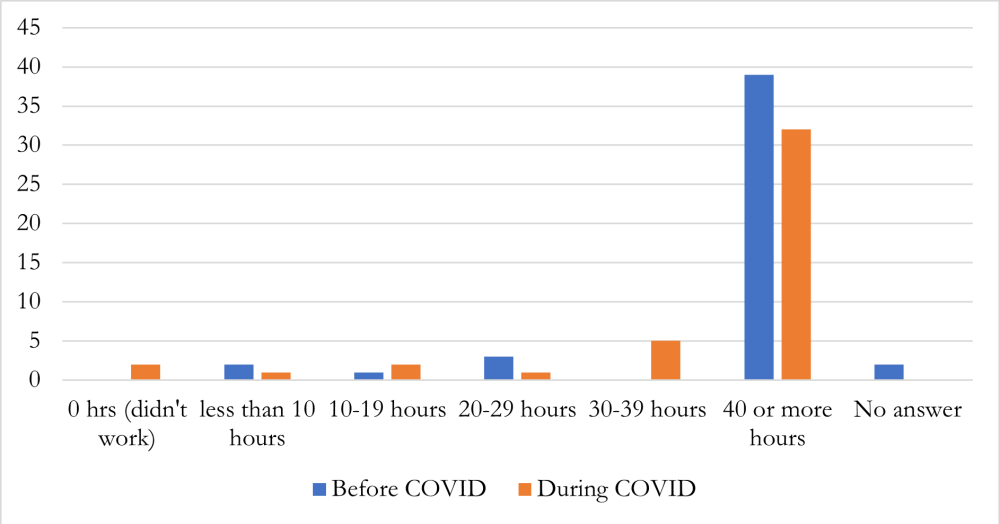


Figure 22: Hours Worked per Week

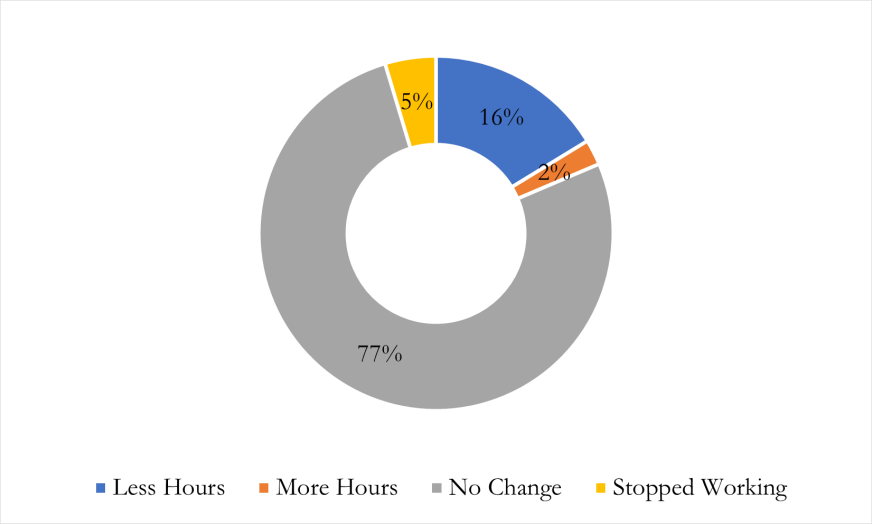


Figure 23: Change in Hours Worked (Before vs. During COVID)

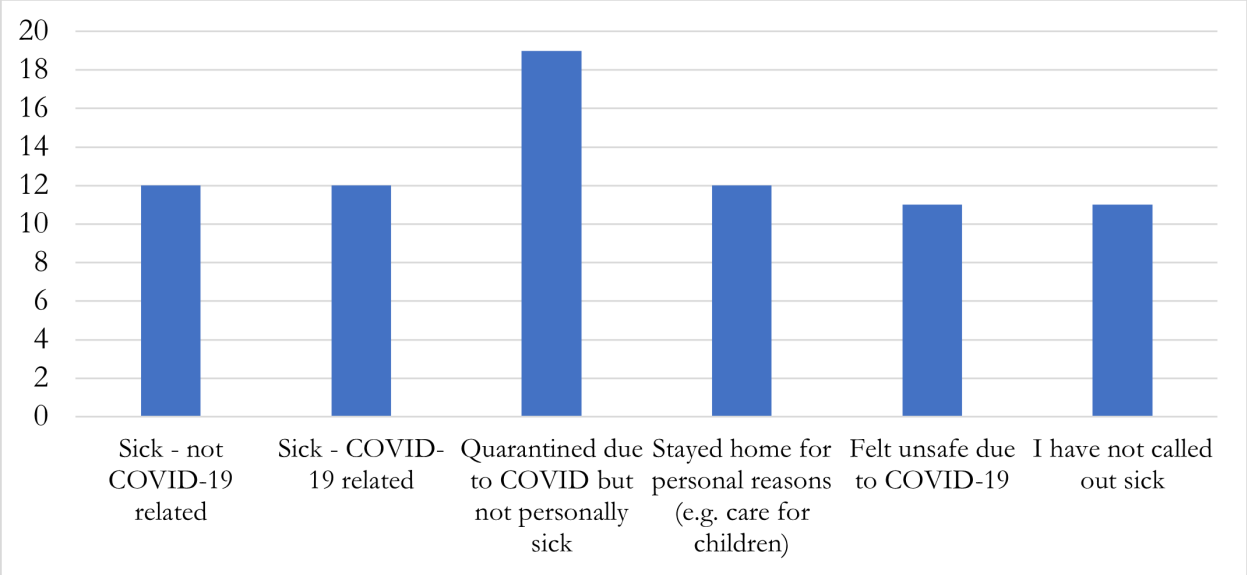


Figure 24: Reasons for Calling Out of Work During the Height of the Pandemic

7 Conclusions

This study investigated the effects of the COVID-19 pandemic on transit ridership and service adjustments using different databases such as the National Transit Database (NTD), MTA stop-level ridership counts, and survey questionnaires of transit riders and operators. The NTD database was used to compare key metrics such as unlinked passenger trips (UPT), vehicle revenue hours (VHR), vehicle revenue miles (VRM), and the vehicles operated during maximum service (VOMS) for MTA (Baltimore) and its nine self-identified peer agencies.

The NTD analysis of MTA's peer agencies showed that that while WMATA in Washington, DC is the nearest large agency, they are vastly different in the population served and in operation. WMATA experienced the largest overall drop in unlinked passenger trips whereas MTA in Baltimore, MD maintained more riders. In fact, only BSD in St. Louis maintained more of its bus ridership. The agencies' reactions to the ridership decrease differed. All reduced VRHs and VRMs. The reduction in service was not comparable across modes. For example, MTA cut rail service more substantially than bus. Future work is needed to understand how agencies made these decisions.

The Google Mobility Trend Data demonstrates that over the study period, Baltimore initially had one of the lower percentage changes in trips to transit stations; however, many peer cities recovered faster than Baltimore. Work travel declined substantially and did not pick back up to pre-pandemic levels while retail trips have recovered in many of the peer cities. Trips to the grocery store did not change as much as other purposes, and there was a strong reliance on parks and recreation space during the warm pandemic months. Future work is needed to understand if more recreational travel is sustained. The April 2020 MTA transit ridership data from Baltimore demonstrates that ridership activity increased around elementary/middle schools, religious or community organizations, and grocery stores.

The survey questionnaire results from 130 transit riders indicated that the pandemic affected riders' behavior in the short run. Transit ridership dropped significantly, and teleworking increased dramatically during the pandemic; many riders will continue teleworking even after the pandemic is over. Transit has been less crowded, and many riders have been able to partially practice social distancing while riding transit. The majority of the respondents mainly used transit for work. Using transit for medical needs and work, respectively, dropped the least during the pandemic, while the biggest drops were for social activities and recreation, respectively. This is in line with the NTD data; essential workers and captive riders had to use transit during the pandemic.

Some 46 transit operators, mostly bus drivers, responded to the survey, 26% of whom had contracted the virus, way above the riders and the state average.

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Appendix

COVID-19 Operators Field Survey

Start of Block: INFORMED CONSENT AGREEMENT The purpose of this survey is to collect data to inv

INFORMED CONSENT AGREEMENT

The purpose of this survey is to collect data to investigate the effect of COVID-19 (also known as Coronavirus) on mobility and equity. This study is conducted by Dr. Mansoureh Jeihani and Dr. Celeste Chavis at Morgan State University. Any information obtained in connection with this study that can identify you will remain confidential. Your decision whether or not to participate will not prejudice your future relations with Morgan State University. If you decide to participate, you are free to discontinue participation at any time without prejudice. If you have any questions, please do not hesitate to contact us at Mansoureh.Jeihani@morgan.edu or Celeste.Chavis@morgan.edu. Your participation is of great importance in this study.

Thank you in advance for your participation.

I have read the informed consent agreement and wish to continue with the survey.

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If I have read the informed consent agreement and wish to continue with the survey. = No

End of Block: INFORMED CONSENT AGREEMENT The purpose of this survey is to collect data to inv

Start of Block: What is your state of residence?

Q1 What is your state of residence?

- ○ Maryland (6)
- ○ DC (7)
- ○ Delaware (9)
- ○ Pennsylvania (8)
- ○ Other (10) _____

Q2 What is your city of residence?

_____

Q3 What is your zip code of residence?

_____

Q4 Which gender do you identify with?

- ○ Male (1)
- ○ Female (2)
- ○ Decline to answer (3)
- ○ Other (4) _____

Q5 What is your age?

- ○ 18 - 24 (2)
- ○ 25 - 34 (3)
- ○ 35 - 44 (4)
- ○ 45 - 54 (5)
- ○ 55 - 64 (6)
- ○ 65 - 74 (7)
- ○ 75 - 84 (8)
- ○ 85 or older (9)

Q6 What is your ethnicity or race?

- ☐ White (1)
- ☐ Black or African American (2)
- ☐ Hispanic, Latino or Spanish origin (3)
- ☐ Asian (4)
- ☐ American Indian or Alaska Native (5)
- ☐ Other (6) _____

Q8 What is the highest level of education you have completed? If you are currently enrolled in school, please indicate the highest degree you have.

- ○ Less than high school diploma (1)
- ○ High school graduate, GED or equivalent (2)
- ○ Associate Degree (e.g., AA, AS) (3)
- ○ Bachelor's Degree (e.g., BA, BS) (4)
- ○ Graduate Degree (e.g., MA, MS, MED, Ph.D.) (5)
- ○ Professional degree (e.g., MD, DDS) (6)
- ○ Other (7) _____

Q9 How many people are in your household including yourself?

- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 or more (5)

Q12 How many automobiles does your household own?

- ○ 0 (1)
- ○ 1 (2)
- ○ 2 (3)
- ○ 3 (4)
- ○ 4 (5)
- ○ 5 or more (6)

Q16 Have you or any other members of your household been confirmed to have the COVID-19?

- ○ Yes - One or more persons in my household had COVID-19 (1)
- ○ No - No one in my household had COVID-19 (2)
- ○ Unsure - One or more persons in my household demonstrated COVID-19 symptoms but was not tested (3)

Q17 AFTER the COVID-19 pandemic is no longer a threat, how might your participation in the activities below change relative to what you did pre-pandemic (e.g. Feb 2020)?

	Much less than before (1)	Somewhat less than before (2)	About the same (3)	Somewhat more than before (4)	Substantially more than before (5)
Online shopping (1)	○	○	○	○	○
Social gatherings (2)	○	○	○	○	○
Going to the cinema (3)	○	○	○	○	○
Travel (4)	○	○	○	○	○
Teleworking (5)	○	○	○	○	○
Online meetings (6)	○	○	○	○	○

End of Block: What is your state of residence?

Start of Block: Transit Operator Questions

Q19 What transit agency do you work for?

- ○ MTA Maryland (4)
- ○ WMATA (7)
- ○ Anne Arundel County (5)
- ○ Other (6) _____

Q46 How many years have you been a transit operator?

_____

Q45 How many hours per week did you work as an operator?

	0 hrs (didn't work) (1)	less than 10 hours (2)	10-19 hours (3)	20-29 hours (4)	30-39 hours (5)	40 or more hours (6)
Before COVID (e.g. Feb 2020) (1)	○	○	○	○	○	○
In the peak of COVID (e.g. April 2020) (2)	○	○	○	○	○	○
Today (e.g. March 2021) (3)	○	○	○	○	○	○

Q23 What time of day do you typically operate public transit?

	Early Morning: 12 AM to 5 AM (1)	Morning: 5 AM to 9 AM (2)	Late morning: 9 AM to 12 PM (3)	Afternoon: 12 PM to 4 PM (4)	Evening: 4 PM to 7 PM (5)	Night: 7 PM to 12 AM (6)
Before COVID (e.g. Feb 2020) (1)	☐	☐	☐	☐	☐	☐
In the peak of COVID (e.g. April 2020) (2)	☐	☐	☐	☐	☐	☐
Today (e.g. March 2021) (3)	☐	☐	☐	☐	☐	☐

Q22 What kind of public transit do you operate?

- ☐ Bus (1)
- ☐ Light Rail (2)
- ☐ Metro or Subway (3)
- ☐ Other (4) _____

Q26 Mark the frequency of crowding on the public transit vehicles you operate BEFORE the COVID-19 pandemic.

	BEFORE the COVID-19 pandemic (e.g. Feb 2020)				DURING the peak of COVID-19 pandemic (e.g. April 2020)				Today (e.g	
	Never (1)	Occasionally (2)	Often (3)	Always (4)	Never (1)	Occasionally (2)	Often (3)	Always (4)	Never (1)	Occasion (2)

Able to maintain 6 ft distance (1)	○	○	○	○	○	○	○	○	○	○
Unable to maintain 6 ft distance but not seated directly next to another person (2)	○	○	○	○	○	○	○	○	○	○
Persons are seated next to others (3)	○	○	○	○	○	○	○	○	○	○
Standing room only (4)	○	○	○	○	○	○	○	○	○	○

Q27 What type of safety precautions do you take at work DURING the peak of COVID-19 pandemic (e.g. April 2020)?

- ☐ Face Mask (1)
- ☐ Gloves (2)
- ☐ Face Shield (3)
- ☐ Hand Sanitizer (4)
- ☐ Disinfectant products or wipes (5)
- ☐ Other (6) _____

Q28 What type of safety precautions does the employer provide for you DURING the peak of COVID-19 pandemic (e.g. April 2020)?

- ☐ Face Mask (1)
- ☐ Gloves (2)
- ☐ Face Shield (3)
- ☐ Hand Sanitizer (4)
- ☐ More frequent cleaning (5)
- ☐ More thorough cleaning (6)
- ☐ Rear boarding (7)
- ☐ Reduced capacity on transit vehicle (8)
- ☐ Other (9) _____

Q29 How worried are you about contracting COVID-19 while operating public transit?

- ○ 0 (0)
- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (10)

Q30 DURING the COVID-19 pandemic, have you called out for any of the following reasons?

- [ ] Sick - not COVID-19 related (1)
- [ ] Sick - COVID-19 related (2)
- [ ] Quarantined due to COVID but not personally sick (3)
- [ ] Stayed home for personal reasons (e.g. care for children) (4)
- [ ] Felt unsafe due to COVID-19 (5)
- [ ] I have not called out sick (6)
- [ ] Other (7) _____

Q31 How many people at your transit agency contracted COVID-19?

- ○ 1-5 (1)
- ○ 6-10 (2)
- ○ 11-20 (3)
- ○ 21-30 (4)
- ○ 31-40 (5)
- ○ 41-5 (6)
- ○ More than 50 (7)
- ○ I don't know (8)

Q32 What recommendations or policies do you suggest for increasing safety on public transit during the COVID-19 pandemic?

_____

Q47 Have you taken the COVID vaccine yet?

- Yes (1)
- No, but I will take it (2)
- No, I will not take it (3)

End of Block: Transit Operator Questions

Start of Block: Contact Information for Gift Card Raffle

Q45 Name

_____

Q46 Email Address

_____

Q47 Phone Number

_____

End of Block: Contact Information for Gift Card Raffle

Distracted Driving and COVID-19

Start of Block: Block 1

Q0 Morgan State University researchers are seeking your input on the current COVID-19pandemic and distracted driving to find solutions to improve the traffic safety of Maryland's roadways. The purpose of this survey is to better understand the effect of COVID-19 on mobility and equity, as well as to find the demographics of distracted drivers and reasons for drivers' distraction. This study is conducted by Dr. Mansoureh Jeihani and Dr. Celeste Chavis at Morgan State University. Any information that is obtained in connection with this study and that can be identified with you will remain confidential. If you have any questions, please do not hesitate to contact us at Mansoureh.Jeihani@morgan.edu or Celeste.Chavis@morgan.edu.Please feel free to share this survey with others. Your participation is of great importance in this study. Thank you.

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q21 21. How much are you worried about the COVID-19?

- ○ Not at all (2)
- ○ Slightly (3)
- ○ Moderately (4)
- ○ Very (5)
- ○ Extremely (7)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q22 22. What type of safety precautions do you take when you are out DURING the COVID-19 PANDEMIC?

- [ ] Face Mask (2)
- [ ] Gloves (3)
- [ ] Face Shield (4)
- [ ] Sanitizer (5)
- [ ] Other (7) _____

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q23 23. Have you or any other members of your household been confirmed to have the COVID-19 virus?

- ○ Yes, one or more persons in my household had COVID-19 (2)
- ○ No, no one in my household had COVID-19 (3)
- ○ Unsure, one or more persons in my household demonstrated COVID-19 symptoms but was not tested (4)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q24 24. What is your employment status?

	Employed full time (1)	Employed part-time (2)	Homemaker (4)	Student, unemployed (5)	Student, employed (6)	Retired (7)	Unable to work (8)
BEFORE THE COVID-19 PANDEMIC (10)	○	○	○	○	○	○	○
DURING THE COVID-19 PANDEMIC (11)	○	○	○	○	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q25 25. Which of the following categories best described your primary job BEFORE THE COVID-19 PANDEMIC?

- ○ Retail, sales, or service industry (2)
- ○ Clerical or administrative support (3)
- ○ Manufacturing construction, maintenance, or farming (4)
- ○ Professional, managerial, or technical (5)
- ○ Something else (please fill in) (7) _____
- ○ I prefer not to answer (8)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q26 26. If employed, how often do you commute to work?

	Commute every day (1)	Tele-worked every day (2)	Partial commute/teleworked (4)
BEFORE THE COVID-19 PANDEMIC (7)	○	○	○
DURING THE COVID-19 PANDEMIC (8)	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q27 27. What is your main mode of transportation for commuting to work or school? Identify the main mode of transportation you plan to take AFTER THE COVID-19 PANDEMIC ENDS.

	Auto/driving (1)	Auto/passenger (2)	Public transit (3)	Walk (4)	Bike/bike-share (5)	Rideshare (including Uber and Lift) (6)	Tele-work (7)	Not Applicable (8)
BEFORE THE COVID-19 PANDEMIC (11)	○	○	○	○	○	○	○	○
DURING THE COVID-19 PANDEMIC (12)	○	○	○	○	○	○	○	○
AFTER THE COVID-19 PANDEMIC ENDS (13)	○	○	○	○	○	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q28 28. What type of public transit do you use?

	Bus (1)	Light Rail (2)	Metro/Subway (4)	Other (5)
BEFORE THE COVID-19 PANDEMIC (7)	☐	☐	☐	☐
DURING THE COVID-19 PANDEMIC (8)	☐	☐	☐	☐

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q29 29. What time of day do you typically use public transit?

	Early Morning: 12 AM to 5 AM (1)	Morning: 5 AM to 9 AM (2)	Late morning: 9 AM to 12 PM (4)	Afternoon: 12 PM to 4 PM (5)	Evening: 4 PM to 7 PM (6)	Night: 7 PM to 12 AM (7)
BEFORE THE COVID-19 PANDEMIC (9)	☐	☐	☐	☐	☐	☐
DURING THE COVID-19 PANDEMIC (10)	☐	☐	☐	☐	☐	☐

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q30 30. Thinking about your travel before the pandemic, what changes will you make to your trip AFTER THE COVID-19 PANDEMIC?

- ☐ Change in the time of day of the trip (2)
- ☐ Change in routes taken (3)
- ☐ Change in the mode/type of transportation used (4)
- ☐ Other (5)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q31 31. How long (minutes) was your commute BEFORE AND DURING THECOVID-19 PANDEMIC?

	Minutes of commuting per day (4)
BEFORE THE COVID-19 PANDEMIC (7)	
DURING THE COVID-19 PANDEMIC (8)	

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q32 32. Mark the frequency of crowding on public transit BEFORETHE COVID-19 PANDEMIC.

	Never (1)	Occasionally (2)	Often (3)	Always (4)
Able to maintain 6 ft distance (2)	○	○	○	○
Unable to maintain 6 ft distance but I am seated alone in the row (3)	○	○	○	○
Someone is seated next to me (4)	○	○	○	○
Standing room only (5)	○	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q33 33. Mark the frequency of crowding on public transit DURINGTHE COVID-19 PANDEMIC.

	Never (1)	Occasionally (2)	Often (3)	Always (4)
Able to maintain 6 ft distance (2)	○	○	○	○
Unable to maintain 6 ft distance but I am seated alone in the row (3)	○	○	○	○
Someone is seated next to me (4)	○	○	○	○
Standing room only (5)	○	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q34 34. For what purpose do you take public transit?

	Work (1)	Medical (2)	Recreation (4)	Social activities (5)	Other (8)	Not Applicable (9)
BEFORE THE COVID-19 PANDEMIC (2)	☐	☐	☐	☐	☐	☐
DURING THE COVID-19 PANDEMIC (3)	☐	☐	☐	☐	☐	☐

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q35 35. Compare the frequency of using public transit DURINGTHE COVID-19 PANDEMIC with BEFORE THE COVID-19 PANDEMIC for the followingactivities.

	More (1)	The same (2)	Less (3)
Work trip (2)	○	○	○
Family (3)	○	○	○
Personal (4)	○	○	○
Social (5)	○	○	○
Medical (7)	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q36 36. How safe do you feel while riding the public transit DURINGTHE COVID-19 PANDEMIC?

- ○ Not at all (2)
- ○ Somewhat safe (3)
- ○ Very safe (4)
- ○ Unsure (5)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q37 37. Does your employer provide you with the following free services DURING THE COVID-19 PANDEMIC?

- ☐ Transportation (2)
- ☐ Hotel (3)
- ☐ Foods (4)
- ☐ Amenities (5)
- ☐ Face Mask (7)
- ☐ Gloves (8)
- ☐ Other (9)

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q38 38. AFTER THE COVID-19 PANDEMIC is no longer a threat, how might your participation in the activities below change relative to what you did before COVID-19?

	Much less than before (1)	Somewhat less than before (2)	About the same (3)	Somewhat more than before (4)	Substantially more than before (5)
Online shopping (2)	○	○	○	○	○
Social Gathering (3)	○	○	○	○	○
Going to the Cinema (4)	○	○	○	○	○
Travel (5)	○	○	○	○	○
Tele-working (7)	○	○	○	○	○
Online meeting (8)	○	○	○	○	○

Display This Question:

If 20. Are you a Car Driver or a Transit Rider? = I am a Transit Rider (I usually ride public transit vehicles, and I may or may not have a personal car)

Q39 39. What Recommendations or policies do you suggest for increasing safety on public transit during the COVID-19 pandemic?

_____

End of Block: Default Question Block