Impact of Local Government's COVID-19 Reopening Guidelines on Chicago Public Transportation

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Abstract

COVID-19 has impacted transportation worldwide with public transportation seeing some of the largest decreases. This paper focuses on the impact that COVID-19 has had on Chicago Transit Authority (CTA) public train transportation in Chicago. We break down the overall ridership into segments based on the associated income levels of neighborhoods near each CTA train station. We explore geospatial, temporal, and correlational relationships between daily ridership and median household income levels for all of Chicago during the COVID-19 pandemic. Temporal patterns across income groups were similar but decreases in ridership were much larger in higher income areas. Median income acted as a strong predictor of ridership changes when delineating disparate income groups but becomes weaker when viewing correlations within income groups, especially among the wealthiest riders. This indicates income acts as a strong predictor of ridership but becomes weaker as ridership behavior becomes homogenous beyond a certain income level.

Keywords: COVID-19, transportation, urban

Introduction

The COVID-19 pandemic has resulted in large overall decreases in urban transportation with public transportation seeing some of the largest decreases (Molloy et al. 2020). People tend to use safer transportation modes during a pandemic with factors that generally affect mode choice like travel time, comfort, and cost becoming less important compared to risk mitigation factors like social-distancing, cleanliness, face-mask usage (Abdullah et al. 2020). Public transportation is perceived as a high risk mode for a multitude of reasons including confinement to limited space, an inability to identify sick passengers, and the existence of multiple surfaces that easily transfer germs (Tirachini & Cats 2020). Given these perceived risks associated with public transit, it is no surprise public transportation has seen large decreases around the world as a form of risk mitigation behavior. Despite overall decreases in public transportation usage between all levels of income, the decrease is not uniform: higher income households saw larger decreases in public transportation usage than low-income households (Wilbur et al. 2020). While this general pattern is prevalent, there are stark differences between cities which seem

to be the result of a combination of individual choices to avoid public transportation as well as differences in local government guidelines (Tirachini & Cats 2020).

Researchers have also demonstrated that low-income individuals are among the most vulnerable to COVID-19. In the first few weeks of the pandemic in New York City, zip codes in the bottom 25% of average incomes represented 36% of COVID-19 while the wealthiest 25% represented under 10% of cases (Wilson 2020). The reasons for these disparities include a disproportionate number of low-income and minorities workers represented in essential work settings (Center for Disease Contol 2020) and low-income individuals being less likely to take social distancing measures (Reeves & Rockwell 2020). On top of these reasons for higher cases among low-income individuals, COVID-19 is more likely to lead to death among low-income individuals due to lack of access to healthcare (Berchick et al. 2018) and higher rates of pre-existing conditions (Center for Disease Control 2020). Some researchers found no robust association with COVID-19 mortality and public transportation usage (Bryan et al. 2020) and other countries that enforce the use of face masks have had no COVID-19 outbreaks related to public transportation even without capacity or physical distancing measures (Tirachini & Cats 2020). However, without the use of a face mask, public transportation can potentially be a prime virus spreader. One study found that on a bus with 67 passengers, one asymptomatic passenger spread the virus to 22 other passengers where no one was wearing a mask (Shen et al. 2020).

Public transportation ridership changes are different from city to city with some cities seeing large decreases like New York City which saw a decrease of about 90% (Teixeira & Lopes 2020) while other cities saw smaller decreases of 60% in Stockholm and 40% in Västra Götaland (Jenelius & Cebecauer 2020). When developing plans to reopen an economy, policymakers need to be aware of public transportation usage and how their decision can have repercussions that impact the most vulnerable populations.

In May of 2020, Chicago announced a five-phase plan for reopening during the COVID-19 pandemic that lists rules for businesses and guidelines for individuals when leaving their homes (City of Chicago Website 2021). During Phases I & II, only essential workers went to work while everyone else worked from home; only at Phase III did non-essential workers start to return to work. The Chicago Transit Authority (CTA) has publicly reported that the stay-at-home order resulted in an 80% decrease in ridership, that there is no typical rush hour during the pandemic as most rides now occur during the day, and that they launched a dashboard that allows riders to view how crowded a bus or train is in real-time (Pathiew & Jordan 2020). The CTA is taking precautions to keep passengers safe with rigorous sanitation procedures but without an ability to completely enforce social distancing, public transit will always have some risk during a pandemic.

The aim of this paper is to identify how COVID-19 impacted Chicago transit daily ridership and how ridership behaviors relate to income levels of the areas which the train stations serve. Other researchers have completed similar analyses in Nashville and Chatanooga (e.g. Wilbur et al. 2020), so having this information can allow for direct comparisons between a relatively large city (Chicago – city population 2.7 million) against smaller cities (Nashville – city population 0.69 million and Chatanooga – city population 0.18 million according to the US Census Bureau) with different demographics. We also explore the role that local government reopening plans has on ridership and whether guidelines impact

riders of varying income levels differently. We explore geospatial, temporal, and correlational relationships between daily ridership and median household income levels for all of Chicago in the first several months of the 2020 COVID-19 pandemic.

Methodologies

Daily CTA train ridership data were taken directly from the Chicago Data Portal APIi. Rides from all of 2019 to November 2020 were included for analysis. There are 144 train stations in the data, but stations outside of Chicago, stations that are no longer in use, and stations within census tracts with no population (e.g. O'Hare and Midway airports) were excluded from analysis. This left 121 stations included for analysis. Total rides for 2019 for these 121 stations were 161,881,143 (442,981 per day) while 2020 totals through November were 52,614,534 (157,058 per day). 2015-2019 median household income level by census tract were obtained from the U.S. Census bureau's ACS 2019 surveyii. Population data per census tract were also included and were used to exclude CTA stations where populations were zero (e.g., O'Hare and Midway airports). Shapefiles of CTA transit stations and Chicago 2010 census tracts were obtained from the Chicago Data Portal.

After joining Chicago census tract boundaries with census tract economic data and transforming shapefiles to a map projection, Euclidean distances from each CTA station to the centroid of each census tract were calculated and the census tract with the smallest distance from the station was assigned to the station. This allowed for an approximation of the income level of the population that each train station serves. Each station was then assigned to a quartile based on the median household income value associated with the tract assigned to the station.

For graphics exploring ridership behavior between different income levels, we used similar methodologies to other researchers (Tirachini & Cats 2020, Jenelius & Cebecauer 2020). We developed a baseline period as the first 5 weeks of 2020 starting from January 3rd to February 6th 2020 to compare ridership changes over time. The median value of daily rides for the corresponding day of the week within this 5-week period was used as the baseline value to calculate percentage change for each subsequent day of the week after the baseline. A 7-day moving average was then applied to smooth the data and remove weekly seasonality. For the geospatial analysis, data were aggregated by month, so each month in 2020 was compared to its corresponding 2019 month.

Relationship Between Median Income and Ridership

Figure 1 highlights differences in CTA train usage between different income levels during the pandemic. COVID-19 was classified as a pandemic on March 11th, 2020 (World Health Organization 2020), and this coincides with the beginning of the dramatic decrease in CTA train ridership. At the start of the stay-at-home order, stations near the high-income census tracts (top 25%) decreased approximately 89.6% while stations near the low-income tracts (bottom 25%) only decreased 68.4%. In the week of April 27th, just prior to Phase 2 in Chicago, stations near high-income tracts were down 91.9% and stations near low-income tracts were down 76.4%. For the same week, researchers in Tennessee found a 77% decrease in ridership among train stations near high-income census tracts and 58% decrease for stations near low-income census tracts in Nashville. The highest income riders in Nashville had a behavior change most similar to low-income riders in Chicago. Separability, as measured by the difference

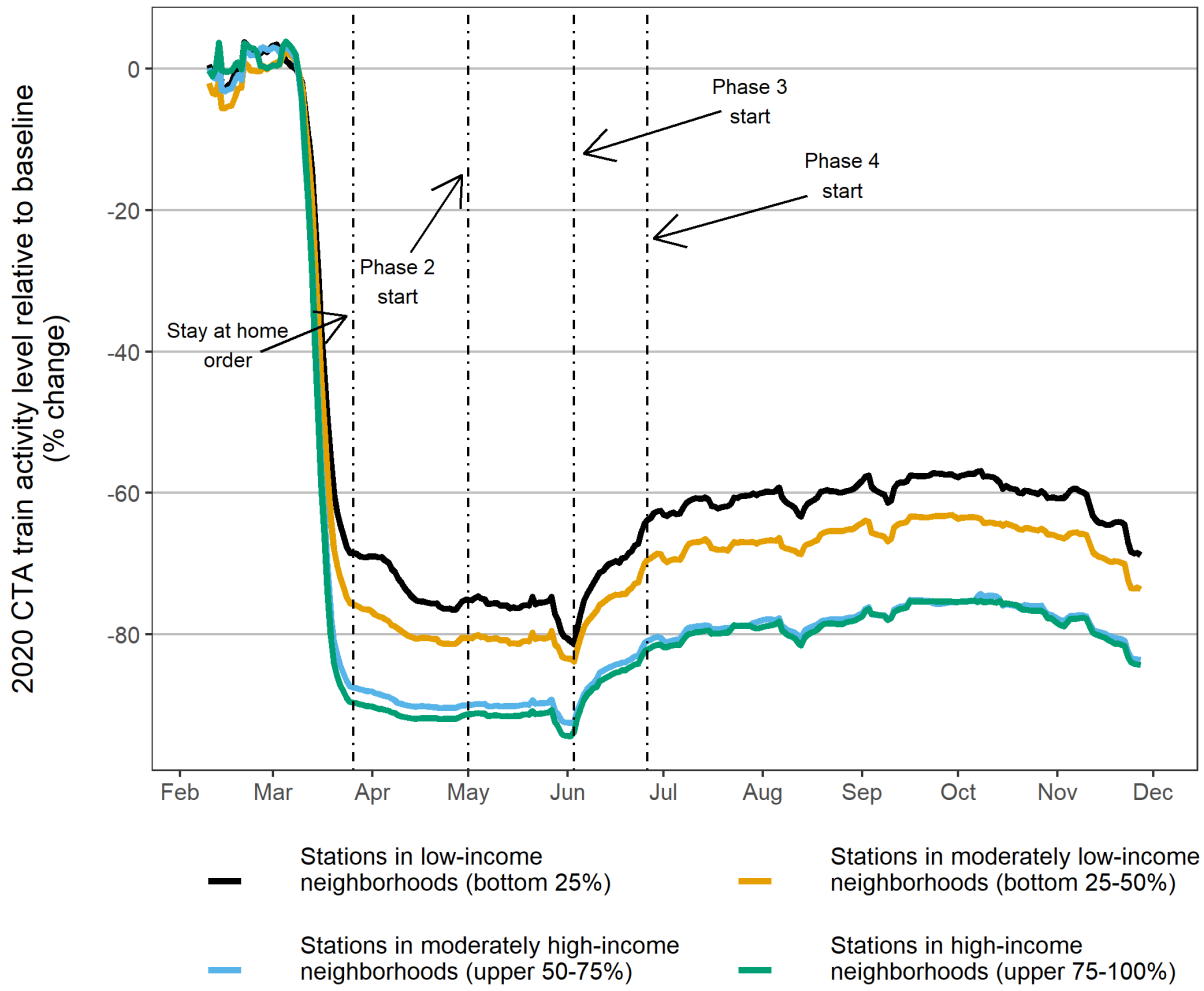

FIGURE 1. Percent change in ridership from the pre-COVID-19 levels for CTA train stations in different median income census tracts for 2020 with a 7-day moving average applied (segmented by quartiles)

between two income groups, was consistently around 15-18 percentage points throughout this period with the gap widening slightly in later months between the lowest and highest income tracts. Near the middle of October, ridership had a decreasing trend, coinciding with reports COVID-19 case peaks and warnings on reverting to Phase 3 (Gallardo et al. 2020). A One-Way ANOVA test also confirmed the overall differences in means were statistically different between each income group (p-value <.01).

Figure 2 shows the proportion of rides that occurred during weekdays between different income levels. A purely uniform proportion would be equal to 5/7, or 0.714, and all income levels are above this uniform proportion throughout the pandemic. The proportion of weekday rides decreased across all income levels through the pandemic as the typical weekday rush hour became a non-occurrence. Initially, low-income riders had the smallest proportion of weekday rides but eventually increased above the highest income riders. Moderately high-income users had the highest weekday through all time periods shown. By mid-June, the two middle quartiles utilized stations most during the week with the

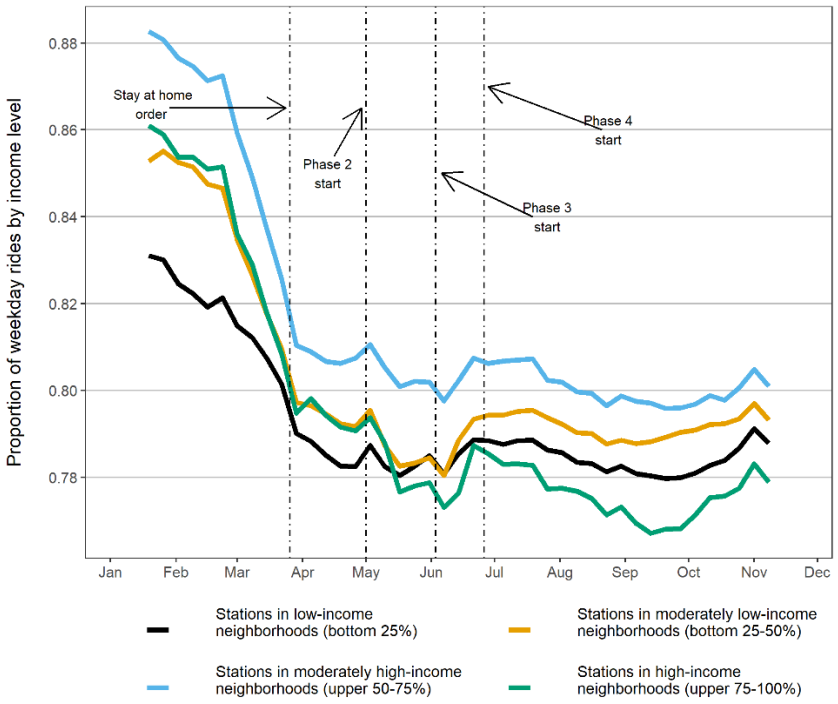

FIGURE 2. Proportion of weekday rides for each week between income groups from January through November with a 5-period moving average applied. The moderately high-income had the largest proportion of weekday rides prior to and during the pandemic

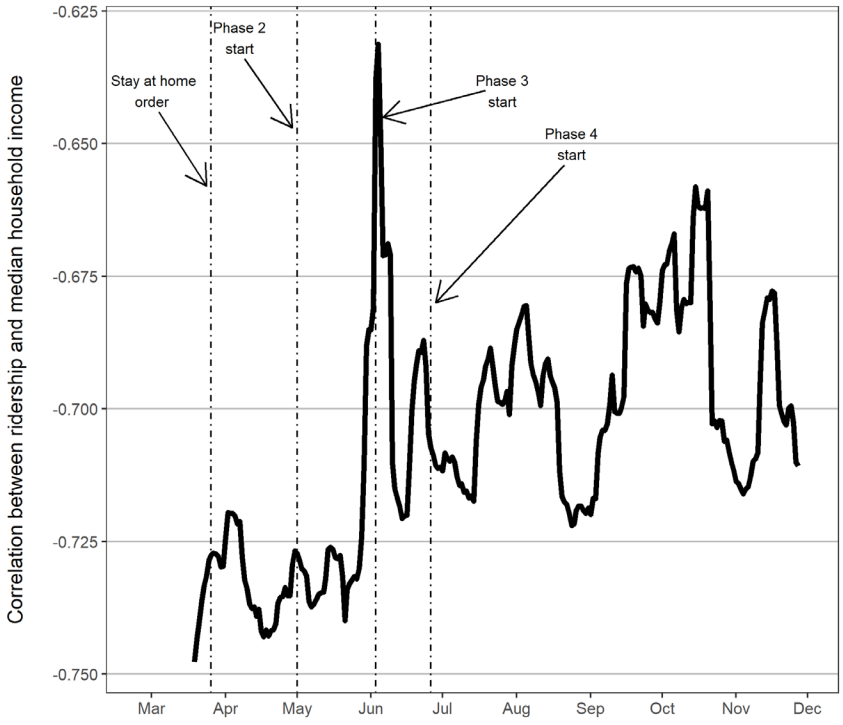

FIGURE 3. Daily correlation values between percentage change in ridership and median income level for all CTA train stations included in analysis with a 7-day moving average applied. Correlations remain strong through the end of November but have a generally weak trend towards zero

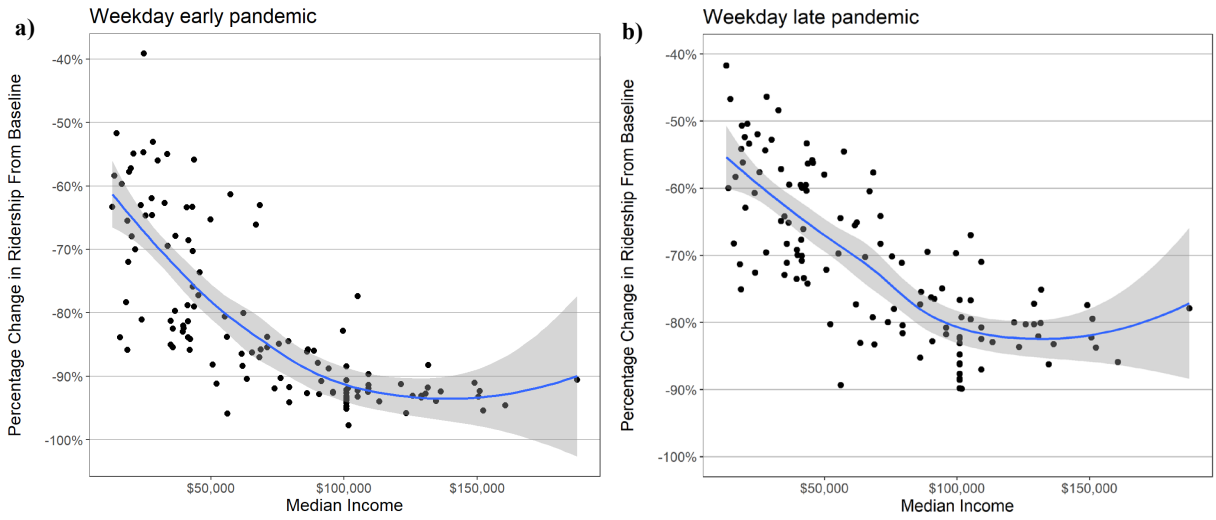

FIGURE 4. Each data point represents one station for one day of 2020 (graphic 4.a is a day in April and 4.b is a day in October)

Station's Neighborhood Income Level		Average Correlation Between Ridership and Income
Low:	$12,905 – 36,439	**-0.250**
Moderately Low:	$36,439 – 65,354	**-0.271**
Moderately High:	$65,354 – 101,000	**-0.568**
High:	$101,000 – 187,614	**-0.123**

TABLE 1. Table showing the average correlation of percentage change in ridership and median income each day for all stations within an income group between March 18th and November 30th 2020. Correlations become weaker for high income riders as the ridership behavior becomes relatively homogeneous

separability becoming most clear after the phasing in of non-essential workers. A One-Way ANOVA test found the proportion means were statistically different between each income group (p-value <.01).

Figure 3 shows the relationship between median income level and ridership over time by means of Pearson correlations. Pearson correlations were calculated for each day using the percentage change from baseline values for each station against the median income household values associated with the closest census tract to each station. Correlations started near 0.0 prior to the start of the pandemic and the expectation is that as ridership behavior becomes more similar to baseline levels, correlations will approach 0. Correlations remained strong throughout 2020 but there is a noticeable trend towards 0 when viewing the trend from the beginning of the pandemic in March through November 2020. Figure 4 shows scatterplots for individual days which the plot in figure 3 was built off of. Percentage change in ridership tends to decrease as income goes up, but this becomes relatively weak once median incomes are $100,000 or greater. A two-sample t-test found the average change in ridership to be significantly different between the two time periods (p-value < .01). There is also increasing variability around the trend line later in the pandemic compared to early in the pandemic but the difference in variability is not statistically significant based on an F-test (p-value = .27).

Table 1 shows average correlations between percent ridership change and median income from March 18th to November 30th 2020 separating groups by median income quartile level. Average correlation

was weak for the high-income group, moderately weak for the two lowest income groups, and moderately strong for the second highest income group.

Geospatial analysis of ridership changes

For the geospatial-temporal analysis, we determined the 5 closest 2010 census tracts to each CTA station using Euclidean distance to the census tract centroids. Using these calculated distances, we assigned ridership to each tract based on weighted distancing: census tracts closer to the station were assigned a higher proportion of that station's rides while further tracts were assigned lower proportions. Ridership values were aggregated by month and were compared to the previous year's corresponding monthly total for each tract by calculating the percentage change. This allowed for visual comparison of ridership over time without seasonality being a confounding variable. Chicago's downtown and near-northside stations saw the largest decrease in usage that has persisted throughout the pandemic while the westside and southside stations saw the smallest decrease in usage. By September 2020, usage had generally increased throughout all areas of Chicago while maintaining this pattern between downtown and the northside vs. westside and southside. Stations near downtown and the northside primarily serve more affluent riders while westside and southside riders are more low-income as shown by the map displaying median income levels for the corresponding census tracts.

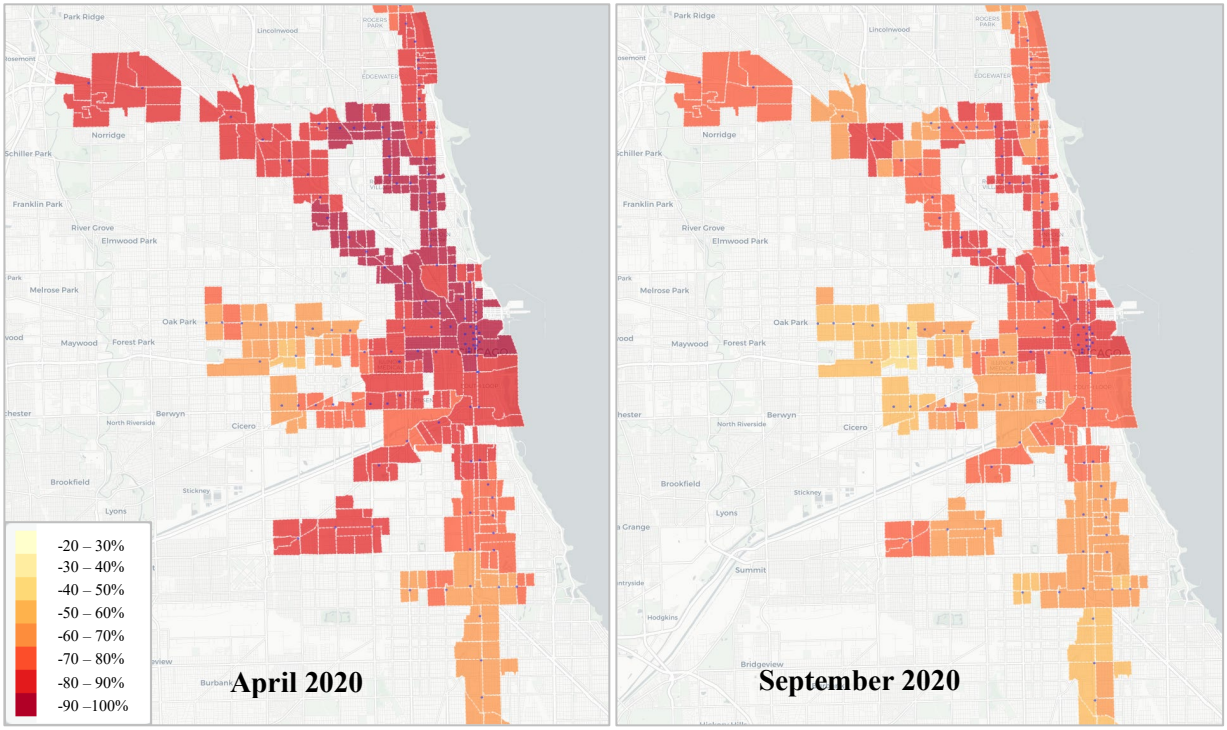

FIGURE 5. These two maps show the change in ridership from pre-COVID-19 levels for census tracts near CTA stations early in the pandemic in April (left) and later in the pandemic in September (right). Darker shading corresponds to larger decreases in ridership from 2019

Concluding Remarks

Despite evidence of higher rates of public transportation usage among Chicago's lowest-income communities, evidence suggests local government actions can influence ridership behavior across all

income levels. The first order by local government in Chicago regarding COVID-19 was publicized March 18th 2020 (COVID-19 Orders 2021) which coincides with the largest drop in CTA train ridership. This order plus the combination of risk mitigation behaviors influenced by forms of media, layoffs due business disruption, and changes in commuting behavior can account for the initial large decrease in ridership. From March 18th until the protests in late May (Figure 1), ridership was relatively stable for wealthier communities while poorer communities saw a gradual decline. However, nearly all employment declines occurred between March 14th and 28th and were driven by low-wage services (Bartik et. Al 2020) so the gradual decrease among low-income riders in April may be attributed to factors other than increasing unemployment during this time. The sharp increase after June 3rd across all income levels can mostly be attributed to the phasing in of non-essential workers. This is indicative of the power local government has in influencing behavior even weeks into a pandemic where public awareness has made risks salient.

The separability between the two highest and two lowest median income quartiles in figure 1 demonstrate median income's predictive power in determining ridership usage. However, while correlation analysis indicates income may be good at separating ridership behaviors between groups, results are mixed when viewing ridership changes within groups. The high-income (4th quartile) group had an average correlation of -0.123 indicating homogeneous behavioral changes for all riders within this quartile. In the moderately high-income group (3rd quartile), correlation was -0.568 indicating that within this group, there are stark differences in behavior. Given that the other two low-income groups also had relatively low correlations indicating homogeneity, the moderately high-income group likely has stations that serve more of a mixture of non-essential who can work from home and essential workers who rely on public transportation. Figure 3 showing the correlation of all stations' change in ridership with median income levels trending over time demonstrates that income will likely continue to act as a strong predictor of ridership until more non-essential workers return to their pre-COVID ridership behavior. This is corroborated by figure 4 which shows that while income is a strong predictor in ridership behavior, but variability is wider later in the pandemic compared to early on.

When analyzing the proportion of rides that occurred during weekdays across different income levels (figure 2), weekday rides decreased at a higher rate than weekend rides for all income levels. Proportions were strongly delineated initially but were mostly a mix until phase 4 in Chicago began. After phase 4, proportions were strongly delineated and remained stable with the moderately high-income group seeing the highest proportion of weekday rides and the high-income group seeing the lowest proportion of weekday rides. This further corroborates the point mentioned earlier regarding the moderately high-income group: given that weekday rides are more closely associated to work commutes there seems to be a strong mix of essential and non-essential workers in the group with the essential workers driving the proportion of weekday rides up. Geospatial analysis further confirms patterns seen in other visualizations. Areas with similar ridership decreases tend to cluster together indicating a strong geographic relationship with ridership. Ridership patterns between different areas of the city match closely to median income levels across the city demonstrating the strong correlation between changes in ridership and income level.

When comparing Chicago to other cities, ridership decreases were larger for all income levels than Nashville, but overall ridership was not as large as New York City. New York and Chicago have similar demographics but COVID-19 hot spots were more concentrated in middle-class areas New York while hot spots were more concentrated in low-income areas in Chicago (Maroko et al. 2020). Nashville

demographics are significantly different from Chicago and it is likely other factors other than income level determining these differences since Chicago's lowest-income areas had decreases in ridership most similar to Nashville's highest income areas. Future research may investigate how cultural differences may account for changes in transportation behavior due to COVID-19 across different cities.

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[ii] American Community Survey 5-Year Estimates of Median Income by Census Tract was provided by the U.S Census Bureau and downloaded from https://data.census.gov/cedsci/