COVID-19 Cases and Impact on Public Transportation in Montgomery County, MD

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1. Introduction

The spread of the COVID-19 pandemic since early 2020 brought changes such as stay-home orders, social distancing, and travel restrictions, all which has impacted daily life including transportation behaviors. Public transportation is an indispensable mode of transportation especially in urban areas, and has been particularly impacted by the pandemic (Bliss et al., 2020), and the steep drop in ridership continues to have a significant impact on transit agencies. As cases soared local authorities enforced mobility restrictions, but what sort of relationships are there between daily COVID-19 cases and transportation behavior in Montgomery County?

2. Background

2.1 Pandemic timeline in Montgomery County

The explosion of cases in early 2020 brought a flurry of stay-home mandates and other orders across various levels of government, including in Montgomery County, MD. The state of Maryland declared a state of emergency on Mar. 5(which is still in effect as of Dec. 11, 2021), and restrictions were introduced beginning with closure of public schools on Mar. 12, followed closely with an executive order to close non-essential businesses on Mar. 16, and a statewide Stay at Home order on Mar. 30 (Maryland.gov, 2021). As cases eased somewhat, Montgomery County gradually reopened through Phase 1 in early June (which allowed restaurants to reopen with outdoor seating), Phase 2 about three weeks later (which expanded to indoor retail and restaurant seating at 50% maximum capacity), and continued to expand and contract as daily cases fluctuated (Shahzad, 2021).

2.2 Transit ridership during the pandemic

Nearly two years since the start of the COVID-19 pandemic, there have been several studies exploring the impact that COVID-19 has had on transit ridership. Previous studies have explored relationships between ridership impact and socioeconomic explanatory factors (Hu and Chen, 2020). The transit navigation app Transit reported that usage of its app dropped by 77% at the beginning of the pandemic (Transit, 2020) (Disclaimer: I work for a competitor, Citymapper). The local public transportation agency Washington Metropolitan Area

Transit Authority (WMATA), which covers the greater DC area including Montgomery County, reported that the ridership of its buses and trains are down by nearly 80%, with Montgomery County stations dropping from 80-92%. (WMATA, 2020)

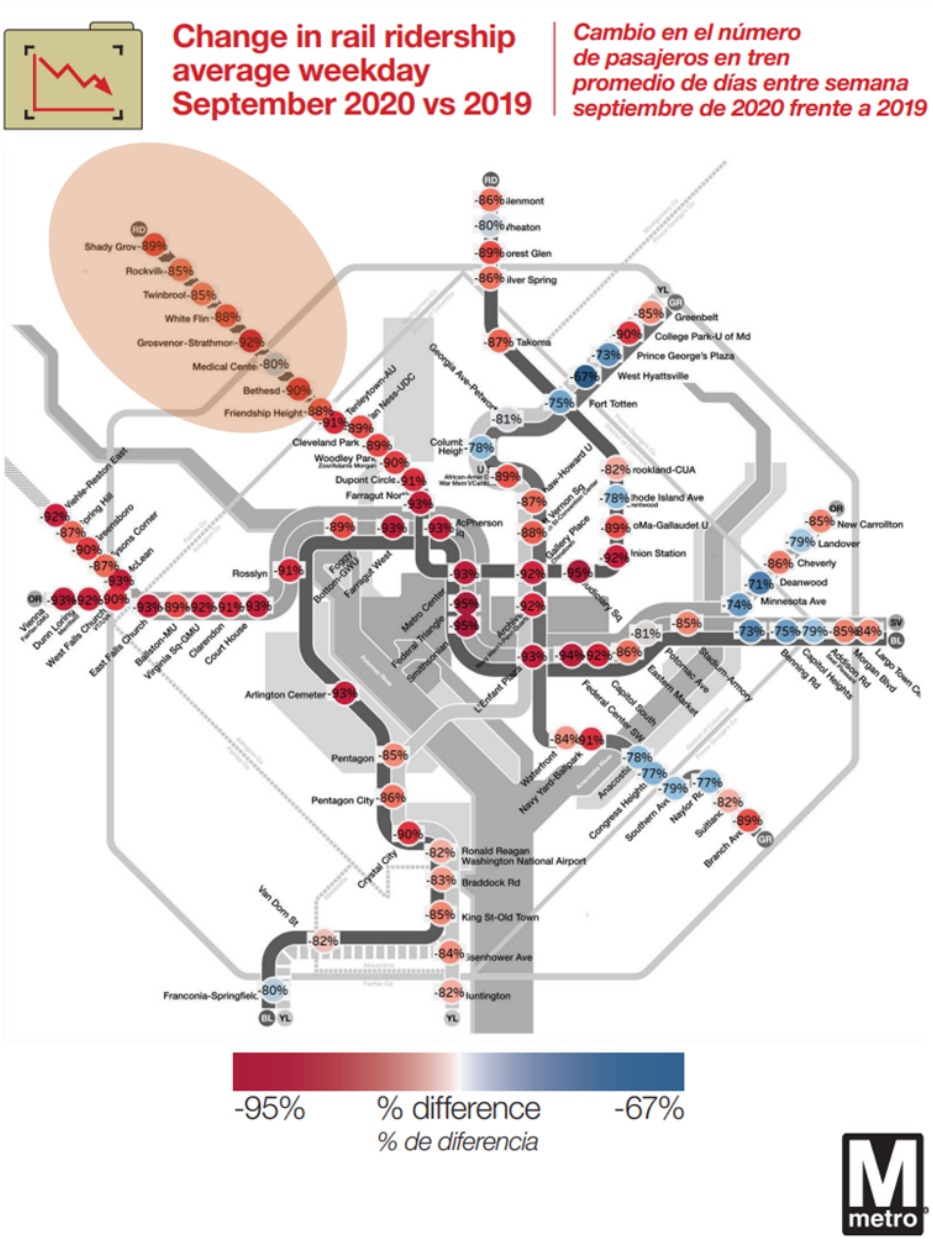


Fig 1: Changes in WMATA ridership between Sept. 2020 vs 2019 (shaded area=Montgomery County stations)

3. Methodology

The focus of this project was to explore the relationship between changes in daily COVID-19 cases and changes in ridership- whether the increase in cases would drive down ridership, and whether an improvement in daily

cases would likewise recover ridership as either stay-home mandates eased, or people generally felt more comfortable to return to daily routine.

Previous work explored relationships between masking mandates, masking compliance, and daily COVID-19 cases, as well as relationships between collisions and daily COVID-19 cases in Montgomery County.

3.1 Data used

COVID-19 Daily Cases

Daily cases data comes from Johns Hopkins University's COVID-19 Data Repository hosted on kaggle.com. The data covers daily confirmed cases on county level, and is updated daily at 6am UTC

Transit Ridership

Daily ridership data comes from WMATA's COVID-19 Ridership Monitoring page. This dataset shows the estimated ridership for rail and buses based on either the faregates for rail, or Automatic Passenger Counter systems (APC) which count passengers as they enter the bus using infrared sensors. Bus ridership is adjusted for "noise factor" to estimate a more reliable passenger count (WMATA, 2021). The dataset is updated weekly and is available from Jun. 2020. .

Other data used but not included in final project

Masking mandates by county
Data is provided by the CDC, and shows state and territorial executive and administrative orders, resolutions, and proclamations, and encoded to show the mandate code on a daily basis on a county level.

Mask compliance by county
Data hosted on GitHub is curated by New York Times to capture mask-wearing compliance at a county level, and gathered through a survey of 250,000 respondents in July 2020.

Montgomery County Crash Reporting- Incidents Data
Data is provided by Montgomery County Department of Police, which provides details of all traffic collisions occurring on county and local roadways in Montgomery County. The dataset is updated weekly and is available from Jan. 2015.

3.2 Methods used

To explore whether there is a relationship between changes in daily COVID-19 cases and changes in ridership, a simple linear model was used with the change in daily cases as the independent variable, and changes in bus, rail, and total (bus + rail) ridership as the dependent variable.

4. Findings

4.1 Exploratory Data Analysis

Initial EDA showed that when plotting daily COVID-19 cases against daily transit ridership, there seemed to be some sort of correlation between the variables- as daily cases increased into the end of 2020 with easing mandates, ridership dropped into early 2021, and gradually recovered as cases flattened.

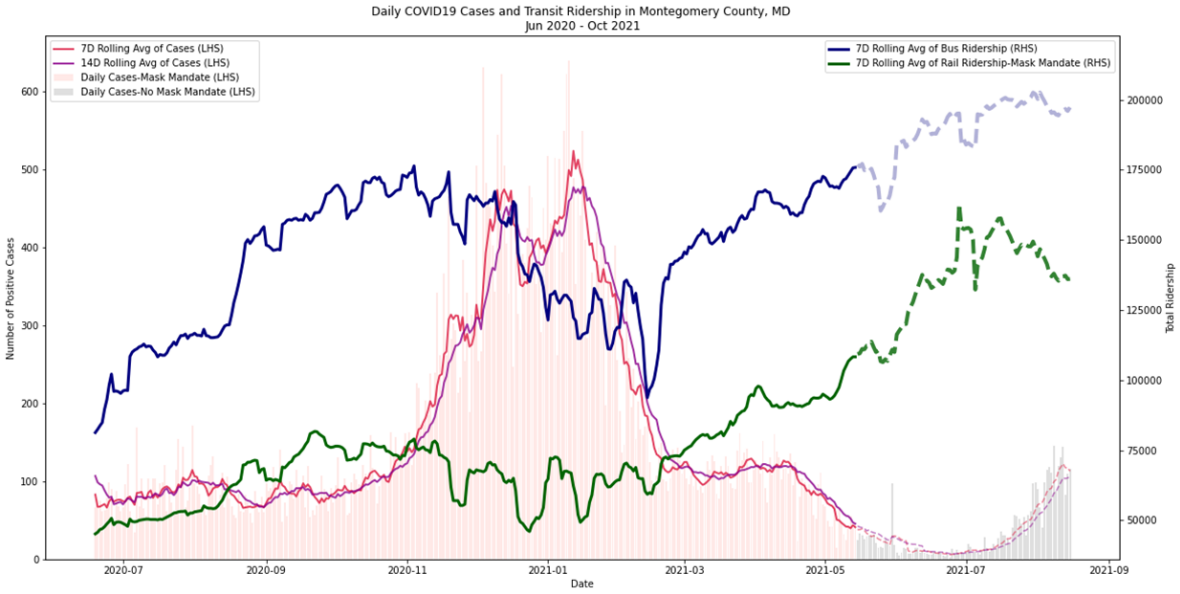
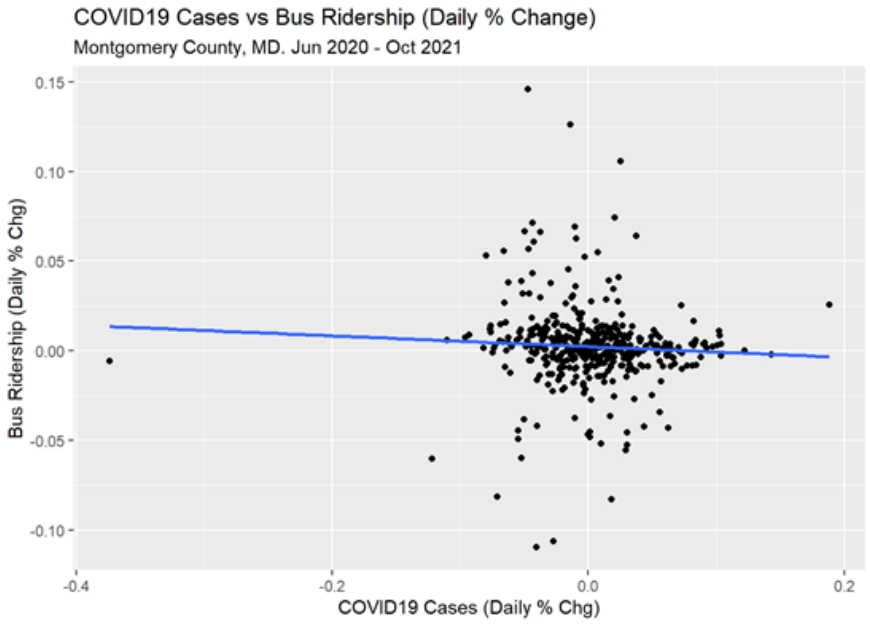


Fig 2: Daily COVID-19 Cases and Transit Ridership in Montgomery County, MD

4.2 Bus Ridership



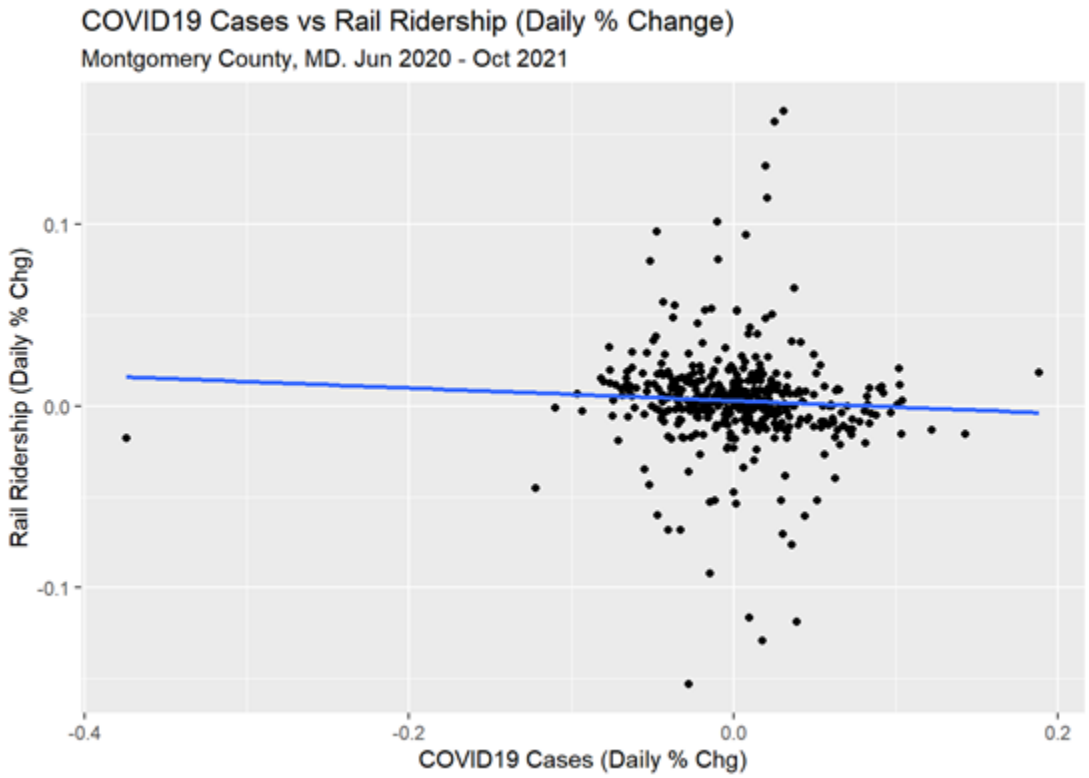
```
m_bus = lm(ravg_bus_pct ~ ravg_cases_pct, data=transit)
summary(m_bus)
```

```
##
## Call:
## lm(formula = ravg_bus_pct ~ ravg_cases_pct, data = transit)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.113339 -0.007056 -0.000265  0.006158  0.141983
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     0.002401   0.001130   2.125   0.0341 *
## ravg_cases_pct -0.030049   0.025076  -1.198   0.2315
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0232 on 420 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.003407,   Adjusted R-squared:  0.001034
## F-statistic: 1.436 on 1 and 420 DF,  p-value: 0.2315
```

Fig 3: Plotting and regression results (Bus ridership ~ Daily cases)

A linear regression with change in bus ridership as the dependent and change in daily COVID-19 cases as the independent variable is plotted as above. The model did not show a significant relationship, with the p-value at 0.2315.

4.3 Rail Ridership



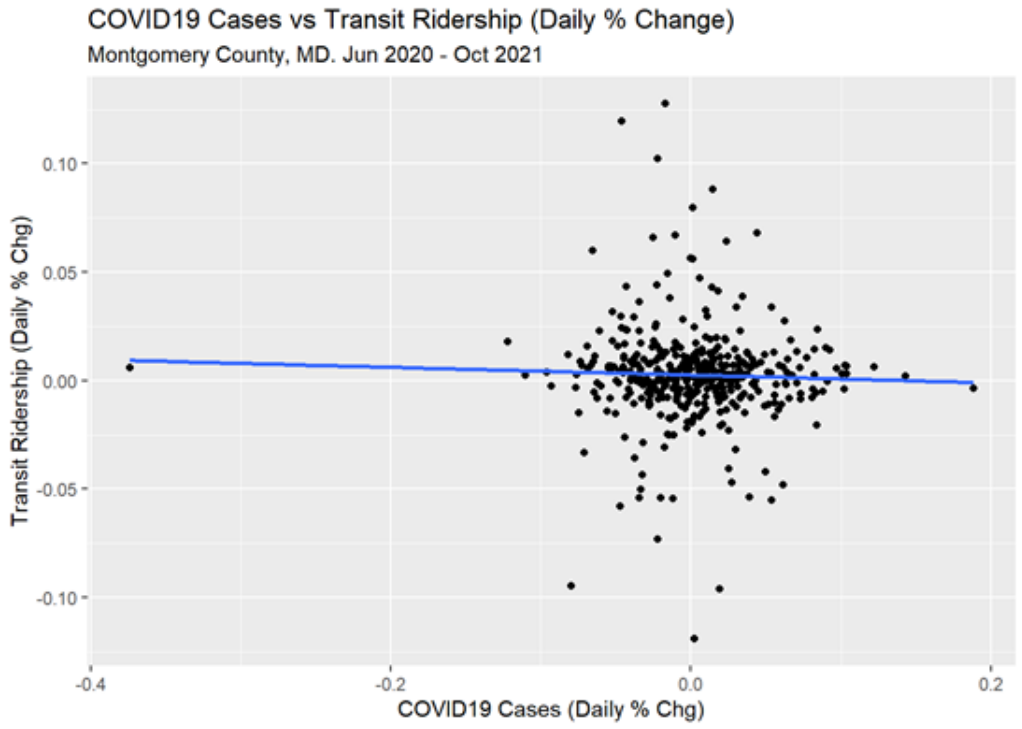
```
m_rail = lm(ravg_rail_pct ~ ravg_cases_pct, data=transit)
summary(m_rail)
```

```
##
## Call:
## lm(formula = ravg_rail_pct ~ ravg_cases_pct, data = transit)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.157326 -0.009422 -0.000205  0.008636  0.160313
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     0.003063   0.001391   2.201   0.0283 *
## ravg_cases_pct -0.034999   0.030879  -1.133   0.2577
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.02857 on 420 degrees of freedom
##   (1 observation deleted due to missingness)
## Multiple R-squared:  0.003049,   Adjusted R-squared:  0.0006756
## F-statistic: 1.285 on 1 and 420 DF,  p-value: 0.2577
```

Fig 4: Plotting and regression results (Rail ridership ~ Daily cases)

A linear regression with change in rail ridership as the dependent and change in daily COVID-19 cases as the independent variable is plotted as above. The model did not show a significant relationship, with the p-value at 0.2577.

4.4 Total Ridership



```
m_all = lm(ravg_all_pct ~ ravg_cases_pct, data=transit)
summary(m_all)
```

```
##
## Call:
## lm(formula = ravg_all_pct ~ ravg_cases_pct, data = transit)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.121723 -0.007932 -0.000269  0.007085  0.124643
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)     0.002606   0.001118   2.331   0.0202 *
## ravg_cases_pct -0.017978   0.024887  -0.722   0.4705
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.02279 on 414 degrees of freedom
##   (7 observations deleted due to missingness)
## Multiple R-squared:  0.001259,   Adjusted R-squared:  -0.001154
## F-statistic: 0.5218 on 1 and 414 DF,  p-value: 0.4705
```

Fig 5: Plotting and regression results (Total ridership ~ Daily cases)

A linear regression with change in total ridership (sum of bus and rail ridership) as the dependent and change in daily COVID-19 cases as the independent variable is plotted as above. The model did not show a significant relationship, with the p-value at 0.4705.

5. Discussion

While the daily cases and daily ridership chart suggest that there could be a relationship between the independent and dependent variables, the plotting of the paired variables as daily changes rather than magnitude shows that there may not be such a strong relationship as suggested, and the regression results also do not support the initial hypothesis.

6. Limitations

There are several limitations with this analysis.
Timeframe: The ridership data begins in June 2020, when the pandemic arguably has already reached its first peak before surging to its next wave during the winter of 2020. Missing that initial wave as well as the most stringent lockdown mandates may mean that the relationship between ridership and cases is still obscured.

Model selection: As an exercise, a very simple linear model was selected to test the relationship between the independent and dependent variables. As Fig. 2 shows, there seems to be a lag in peaks for the two variables (for both bus and rail), which could mean that perhaps there is a positive correlation with the daily cases as the dependent variable, and ridership as the leading independent variable. This would make intuitive sense- increase

in ridership could suggest more transmission opportunities, and decrease in ridership through stay-home mandates could work to push down the case counts.

7. Conclusion

While the COVID-19 pandemic has had and continues to have an undeniable impact on public transportation ridership, there was not a significant relationship between the two variables, using change in daily bus, rail or total ridership. One caveat of this study is that ridership figures begin well after the start of the pandemic, which could mean that a relationship is missed- especially considering how severe the daily routine changes were early in the pandemic. The visualization of daily ridership and positive cases suggest that there may be a lagged relationship instead. As more data are gathered for both ridership figures and positive cases, next steps could be explored such as looking at transit ridership and positive cases for the entire Washington DC metropolitan area, and studying whether there are time lag issues that first need to be addressed.

8. References

Bliss et al., 2020

Bliss, L., Lin, J.C.F., Patino, M., 2020. Pandemic Travel Patterns Hit at Our Urban Future, https://www.bloomberg.com/graphics/2020-coronavirus-transportation-data-cities-traffic-mobility/.

Hu and Chen, 2020

Songhua Hu, Peng Chen, "Who left riding transit? Examining socioeconomic disparities in the impact of COVID-19 on ridership," *Transportation Research Part D: Transport and Environment*, Volume 90, 2021, 102654, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2020.102654.

Maryland.gov, 2021

Maryland.gov, 2021. COVID-19 Pandemic: Orders and Guidance, https://governor.maryland.gov/covid-19-pandemic-orders-and-guidance/.

Montgomery County, 2021

Montgomery County, 2021. COVID-19 Information Portal, https://www.montgomerycountymd.gov/covid19.

Transit, 2020

Transit, 2020. Who's left riding public transit? A demographic deep-dive., https://archive.transitapp.com/whos-left-riding-public-transit-hint-it-s-not-white-people-d43695b3974a

WMATA, 2020

WMATA, 2020. Covid-19 budget impacts, https://www.wmata.com/initiatives/budget/index-covid19budget.cfm

WMATA, 2021

WMATA, 2021. Ridership Data Portal Washington Metropolitan Area Transit Authority, https://www.wmata.com/initiatives/ridership-portal/.

9. Data Sources

COVID-19 Data Repository (Johns Hopkins University)
COVID19 Transit Ridership (WMATA)
Masking mandates by county (CDC)
Mask compliance survey results (New York Times)
Montgomery County Collisions Data (Montgomery County Department of Police)