

TRANSPORT FINDINGS

Ride-hailing through the COVID-19 Pandemic in New York City

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Findings

We explored the effects of the COVID-19 pandemic on ride hailing trips in New York City between February 1, 2019 and July 31, 2021. Using negative binomial regression models, we quantified the effects of COVID-19 indicators on daily ride hailing trip counts. We found that a 1% increase in the number of new cases and vaccines administered were associated with 16.0% decrease and 0.8% increase in trip counts, respectively. Since the initial drop of 258.2% during the stay-at-home phase of the pandemic, trip counts recovered in the subsequent phases albeit still lower than pre-pandemic levels at -85.0% and -38.7% during the reopening and vaccination phases, respectively.

1. Questions

The COVID-19 pandemic forced many travelers to break out of their travel habits and rethink how they move in cities (Chang and Miranda-Moreno 2020). Shared mobility modes that require travelers to be in close proximity with others, such as public transit and ride-hailing, have suffered the most decline in demand. A recent study of ride-hailing trips in Chicago found a significantly greater decrease in the number of ride-hailing trips compared to those using personal vehicles during the pandemic (Du and Rakha 2020). This study explores the impact of COVID-19 on the demand for ride-hailing trips in New York City (NYC). Our research questions are the following:

- How has ride-hailing demand evolved over the different phases of the pandemic?
- What is the relationship between COVID-19 cases, deaths, and vaccinations and ride-hailing demand?

2. Methods

We retrieved high volume for-hire vehicle trip records for NYC for the study period of February 1, 2019 to July 31, 2021 from NYC Open Data Portal (NYC Open Data 2020). This dataset contains historical trips served by Uber, Lyft, Via, and Juno. We used the pick-up time variable to aggregate the data to daily trip counts as presented in [Figure 1](#). We retrieved daily weather data for

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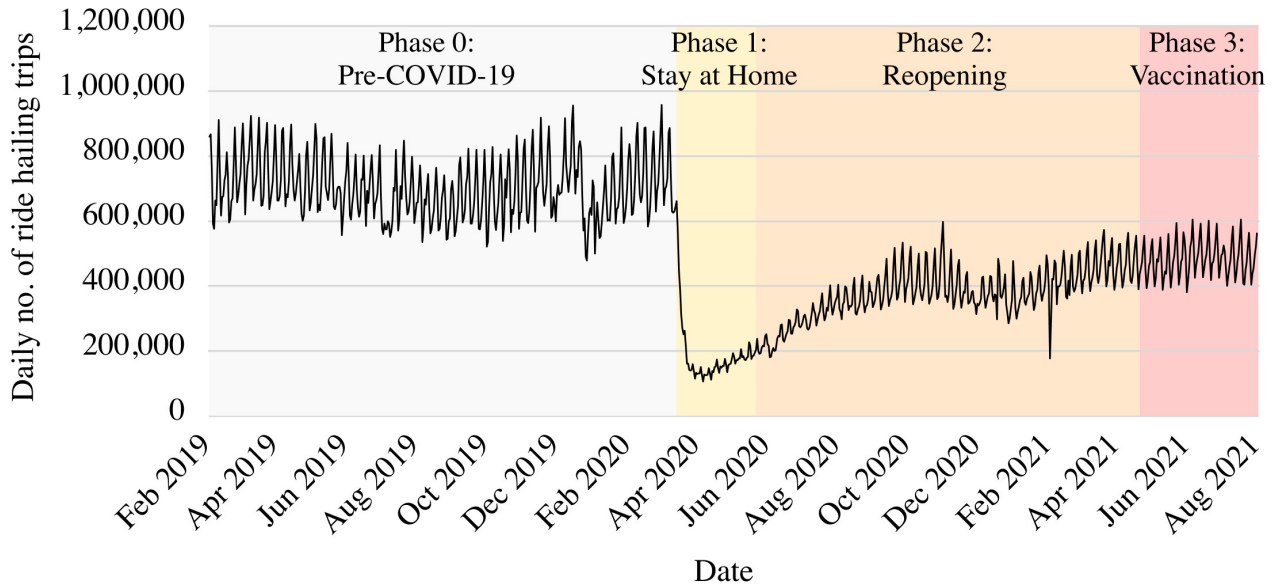


Figure 1. Daily ride-hailing trip counts in New York City

John F. Kennedy International Airport weather station from NOAA, which included temperature ($^{\circ}\text{C}$), precipitation (mm), snowfall (mm) (NOAA 2021a, 2021b). A dummy variable was created for federal holidays in the US.

We incorporated COVID-19 variables in two ways: (i) temporal phases of the pandemic; and (ii) number of cases, deaths, and vaccinations. For the temporal phases, we created dummy variables to capture the different phases of the COVID-19 pandemic, including:

- Phase 0 - pre-pandemic (February 1, 2019 to March 10, 2020). The period from the beginning of the study period to the day before the World Health Organization declares COVID-19 as a pandemic.
- Phase 1 - stay at home (March 11, 2020 to May 19, 2020). The period from the day that the World Health Organization declares COVID-19 as a pandemic and includes the period of stay-at-home orders. During this phase, NYC public schools closed starting March 16, followed by bars and restaurants on March 17, and New York State on Pause Program started on March 22.
- Phase 2 - reopening (May 20, 2020 to April 18, 2021). The period from when most U.S. cities started transitioning from stay-at-home orders to reopening. NYC entered Phase 1 reopening on June 8.
- Phase 3 - vaccination available for all adults (April 19, 2021 to July 31, 2021). The period from when the White House announced that everyone 16 years and older in every U.S. state is eligible for the COVID-19 vaccine to the end of the study period.

Table 1. Summary of variables

Variable	Mean	Type
Trips		
Daily ride-hailing trips	520,212	Count
Weather		
Temperature (°C)	13.108	Continuous
Precipitation (mm)	3.166	Continuous
Snowfall (mm)	1.323	Continuous
Calendar		
Monday	0.142	Dummy
Tuesday	0.142	Dummy
Wednesday	0.142	Dummy
Thursday	0.142	Dummy
Friday	0.144	Dummy
Saturday	0.144	Dummy
Sunday	0.142	Dummy
Holiday	0.027	Dummy
COVID-19 cases, deaths, vaccinations		
New cases (7-day moving average)	2,349.3	Continuous
New deaths (7-day moving average)	58.7	Continuous
Vaccines administered (7-day moving average)	1,531,410	Continuous
COVID-19 temporal phases		
Phase 0: Pre-COVID-19	0.443	Dummy
Phase 1: Stay at home	0.077	Dummy
Phase 2: Reopening	0.366	Dummy
Phase 3: Vaccination	0.114	Dummy

Then, we retrieved the daily number of new cases, number of new deaths, and total number of first-dose vaccines administered for New York State from the Centers for Disease Control database (CDC 2021a, 2021b). Seven-day simple moving average values were calculated for each variable to account for variability due to workdays vs non-workdays.

We chose the negative binomial regression modeling technique as the daily trip count data were not normally distributed and did not meet the equi-dispersion assumption of the Poisson model. A negative binomial regression model was calibrated for each COVID-19 variable family along with control variables such as weather conditions, day of week, and holidays. Elasticities were calculated to determine the marginal effects of the independent variables. For continuous variables, the elasticity was computed as $\beta_k \bar{x}_k$, where β_k is the estimated parameter for variable k and $\bar{x}_k$ is the mean value of variable k . Elasticities for continuous variables can be interpreted as the effect of a 1% change in the variable on the daily ride-hailing trip count. For dummy variables, the pseudo-elasticity was computed as $(EXP(\beta_k) - 1)/EXP(\beta_k)$.

Table 2. Negative binomial regression model results

	Model 1: COVID-19 Cases and Vaccines on Ride-hailing Trip Counts			Model 2: COVID-19 Phases on Ride-hailing Trip Counts		
	Coeff	Std. Error	Elasticity	Coeff	Std. Error	Elasticity
Constant	13.370**	0.037	-	13.396**	0.019	-
Temperature (°C)	-0.017**	0.001	-0.227	-0.006**	0.001	-0.079
Precipitation (mm)	0.003*	0.002	0.010	0.002**	0.001	0.006
Snowfall (mm)	-0.002	0.001	-0.002	-0.002**	0.000	-0.003
Monday			reference			reference
Tuesday	0.036	0.041	0.035	0.032	0.022	0.031
Wednesday	0.086*	0.041	0.083	0.096**	0.022	0.092
Thursday	0.130**	0.041	0.122	0.139**	0.022	0.130
Friday	0.228**	0.041	0.204	0.240**	0.022	0.213
Saturday	0.286**	0.041	0.249	0.289**	0.022	0.251
Sunday	0.142**	0.041	0.133	0.138**	0.022	0.129
Model 1 only						
New COVID-19 cases	-6.80e-05**	3.00e-06	-0.160			
Total no. of vaccines administered	5.49e-09**	0.000	0.008			
Model 2 only						
Phase 0: Pre-COVID-19						reference
Phase 1: Stay at home				-1.276**	0.023	-2.582
Phase 2: Reopening				-0.615**	0.013	-0.850
Phase 3: Vaccination				-0.327**	0.02	-0.387
AIC			24,459			23,314

Note: ** p < 0.01; * p < 0.05.

3. Findings

[Table 2](#) presents the results of the negative binomial regression models. In both models, temperature was negatively associated with daily ride-hailing trips with elasticities ranging from -22.7% to -6.6%. Precipitation was positively associated with ride-hailing with elasticities ranging from 0.6% to 1.0%. Snowfall was negatively associated with ride-hailing with elasticity of -0.3% to -0.2%. The elasticities of the day of week control variables indicate that ride-hailing trips grow as the week progresses from Monday to reach a peak on Saturday where the elasticities range from 24.9% to 25.8%.

Model 1 found that 1% increase in new COVID-19 cases and total number of first-dose vaccines administered were associated with 16.0% decrease and 0.8% increase in ride-hailing trips, respectively. Model 2 found that compared to pre-pandemic levels, Phase 1 - Stay at Home was associated with the steepest decline in trip counts with the elasticity of -258.2%. Phase 2 - Reopening was associated with a smaller drop at -85.0% and Phase 3 - vaccination was associated with an even smaller decline at -38.7%. Model 2 results demonstrate that since the initial drop in Phase 1, ride-hailing trips recovered in the subsequent phases albeit still lower than pre-pandemic levels. Model 2 has a

smaller Akaike information criterion value of 23,314 compared to 24,459 for Model 1. This indicates that Model 2 with dummy variables for COVID-19 phases is a better model in explaining changes in ride-hailing trips.

The findings from this study contributes to the limited literature on the impact of COVID-19 on shared mobility. Specifically, our methodology controls for external factors such as weather and day of week, which allows us to more accurately quantify the evolving effects of the on ride-hailing trips.

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