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Ridesharing and Alcohol-Related Assaults in NYC: A Spatial Ecological Case-Crossover Study

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Abstract

Objective: Ridesharing has changed urban transportation and the distribution of some health outcomes, including alcohol consumption. Studies relating ridesharing to crime and violence at low space-time resolution (e.g., county-months) find mixed results. The aim of this study was to examine whether ridesharing was associated with increased incidence of alcohol-related assaults within highly resolved space-time units.

Methods: This spatial ecological case-crossover study used rideshare and taxi trip data from the New York City (NYC) Taxi and Limousine Commission for 2017-2018 and assault data from the NYC Police Department, aggregated within taxi zone-hours. Conditional logistic regression models estimated the odds of observing an assault for case taxi zone-hours in which an assault occurred compared to two control units of the same taxi zone-hour one week before (−168 hours) and one week after (+168 hours) relative to the number of rideshare trips. Separate analyses assessed assaults occurring at bars and restaurants.

Results: From 2017 to 2018, there were 47,124 nighttime assaults in the 262 taxi zones. There were 2,482 taxi zone-hours at a bar and 693 taxi zone-hours at a restaurant that contained at least one nighttime assault. Ridesharing was positively associated with nighttime assaults at bars (OR: 1.050; 95% CI: 1.002 to 1.100) but not at restaurants (OR: 1.049; 95% CI: 0.943 to 1.168).

Conclusions: Additional ridesharing trips are associated with increased incidence of assaults at on-premise alcohol outlets in NYC at the precise hour and taxi zone of trip origins.

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Keywords

ridesharing; assaults; spatial epidemiology; crime

1. INTRODUCTION

Ridesharing has had a major impact on many aspects of human health and behavior. Ridesharing companies—including Uber and Lyft—use dynamic pricing and GPS tracking and navigation to match drivers of privately-owned vehicles to consumers who request pickups on demand (Azevedo and Weyl, 2016). These companies have facilitated more than 20 billion rides worldwide since services began in 2010 (Lyft, 2018; Uber, 2020). Early findings suggest some of ridesharing's impacts are beneficial for public health, including reducing alcohol-impaired driving and crashing (Dills and Mulholland, 2018; Greenwood and Wattal, 2015), and providing transportation options that may be cheaper and with faster response times than taxis (Cetin and Deakin, 2019). Other impacts are detrimental to public health, such as increasing alcohol consumption (Teltser et al., 2021), increasing pedestrian crashes (Morrison et al., 2020) and increasing congestion and pollution through the greater use of private vehicles that may draw individuals away from public transportation (Diao et al., 2021; Parry et al., 2007). One outcome of great public health significance that ridesharing could affect that is alcohol-related assault. In 2016, globally, 0.9 million injuries were attributable to alcohol, with 90,000 of those injuries due to interpersonal violence (World Health Organization, 2018). Over 40% of adults on probation, who were convicted in local jails, and in State prisons report alcohol use was a factor at the time of their assault (Greenfeld, 1998).

Availability theory predicts ridesharing will lead to increased incidence of assaults. This theory states that individuals' willingness and ability to obtain and consume alcohol are a function of full costs, including financial and convenience costs (Babor et al., 2010). Ridesharing will reduce the full costs of accessing alcohol through on-premise retail outlets (i.e., bars and restaurants) because it is cheaper and easier to access than taxis and may have fewer prospective costs than driving while impaired. One study found that in areas where bars are located near transit stations, availability of a new transportation option increased alcohol-related arrests (Jackson and Owens, 2011). This means that ridesharing lowers the cost of traveling to an on-site alcohol outlet and could increase demand for alcohol (Dills and Mulholland, 2018; Jackson and Owens, 2011). Thus, availability theory predicts that access to ridesharing will increase the frequency of drinking in on-premise alcohol outlets, and the quantity of alcohol consumed when individuals attend on-premise outlets (Freisthler and Gruenewald, 2013; Mair et al., 2013). There is evidence pointing to increased alcohol consumption associated with ridesharing (Teltser et al., 2021). Teltser et al. examined the relationship between UberX, Uber's taxi-like service, and alcohol consumption by conducting a difference-in-difference analysis that modeled the entry and exit of the service in U.S. metro areas. Using survey data on alcohol consumption, authors found that for those aged 21 to 64, there was an increase in the average number of drinks per drinking day, increase in drinking days, and total drinks. The impact of ridesharing was larger in those aged 21 to 34, and there was no effect of UberX in those above 65.

Increases in alcohol consumption are important to note, as increases in alcohol consumption may lead to increased incidence alcohol-related harm within at on-premise outlets, including intentional and unintentional injuries (Babor et al., 2010).

There is, however, a gap in the literature examining ridesharing and assaults at alcohol outlets. Most studies have focused primarily on sexual crime or used difference-in-difference analyses that did not incorporate environmental characteristics affect crime rates, such as the examination of alcohol outlet density or overall traffic (Dills and Mulholland, 2018; Martin-Buck, 2017; Park et al., 2020). An unpublished differences-in-differences analysis found ridesharing was associated with fewer sexual and physical assaults in US cities (Martin-Buck, 2017). Another study found little difference between robbery, assault, or drunkenness rate before and after Uber presence in a city (Dills and Mulholland, 2018). Additionally, most studies were conducted using large space-time units, such as county-months. Aggregating assault incidence and rideshare availability to a high level limits opportunities to detect associations that occur within small geographic areas at precise times. Common limitations may have affected the results of these studies, and important further questions remains.

The aim of this study was to examine associations between ridesharing and alcohol-involved assault. We address some of the limitations of previous studies using a spatial ecological case-crossover design that controls for environmental conditions that confound the relationship between exposure and outcome, such as pedestrian or vehicular traffic. New York City (NYC) releases publicly available trip-level rideshare data and historic crime reports that allow for the examination of the association between ridesharing and assault. Further, NYC has a wide variation in geographic contexts that allow us to examine the association of ridesharing and associations at high temporal and spatial resolution. To specifically examine potential alcohol-related assaults, we examined this association at bars and restaurants — two types of on-premise alcohol outlets.

2. METHOD

2.1 Setting and data

NYC has a population of approximately 8.34 million people (NYC Department of City Planning, 2021) and land area of 302.6 square miles (NYU Furman Center for Real Estate and Urban Policy, 2021). There are 262 taxi zones outlined by the NYC Taxi and Limousine Commission (NYC Taxi and Limousine Commission, 2019) which produces trip-level data for all taxi trips and rideshare trips. The average size of a taxi zone is 1.16 square miles. The study universe was 17,520 hours (the number of hours in two years) x 262 taxi zones = 4,590,240 taxi zone-hours, the space-time unit of the study.

2.2 Study Design

We compared taxi zone-hours where a nighttime assault occurred to a taxi zone-hour at the same time and on the same day in a different week. We defined nighttime assaults as those occurring between the hours of 10 p.m. and 6 a.m. (Kypri et al., 2014). We matched each case taxi zone-hour to two control taxi zone-hours; one that was one week before

the case (−168 hours) and one that was one week after the case (+168 hours). This study design controlled by design for vehicular traffic and pedestrian flow by using matched space-time units. If a matched unit that originally selected to serve as a control was a taxi zone-hour with an assault (case), we then selected controls two weeks before (−336 hours) and two weeks (+336 hours) after the case. We added weeks until all case taxi zone-hours were matched to two control taxi zone-hours. The spatial ecological case-crossover design controlled for time-invariant characteristics, such as neighborhood environmental characteristics, average foot traffic, and population density of a taxi zone, which do not vary greatly within a one-week period.

2.3 Exposure

In order to measure the exposure, we obtained publicly available trip-level information from the Taxi and Limousine Commission from December 1, 2016 to January 31, 2019. Trip locations are reported within taxi zones for confidentiality purposes. We aggregated rideshare trips per taxi zone-hour for analysis.

2.4 Outcome

Outcomes of interest were assaults that occurred between January 1, 2017 and December 31, 2018. The New York Police Department (NYPD) publishes historic complaints that can be accessed via NYC Open Data (City of New York, 2021). The dataset includes felony, misdemeanor, and violation crimes reported to the NYPD. Additional variables include date and time of crime occurrence, date and time when crime was reported to the police, an internal classification code, premise descriptions, demographic information about the victim and suspect, and the geographical location of the crime. Using the coordinates provided, we successfully geocoded 99.5% of crimes reported to the 262 taxi zones in ArcMap. We categorized assaults according to NYPD reporting categories. NYPD includes the following assault types in their dataset: assault in the first, second, or unknown degrees (one classification code), assault in the third degree, assault on a police/peace officer, assault on other public service employees, vehicular assault, and assault on a traffic agent. Details on assault differences and definitions are described elsewhere (“Assault in the first degree,” 2021; “Assault in the second degree,” 2021; “Assault in the third degree,” 2021). We included assaults with reported premise types “Bar/Night Club” and “Restaurant/Diner.” The NYPD categorizes events as those occurring inside, opposite of, front of, or rear of a given premise.

2.5 Confounders

Potential confounders of the association between rideshare trips and assaults were taxi trip counts and time-varying variables —temperature, precipitation, government holidays, and school holidays. Temperature and precipitation affect overall vehicular traffic and assault frequency; therefore, these variables are not accounted for by the crossover design of the study. The same logic applies to government and school holidays. Traffic, both vehicular and pedestrian, are also associated with increased rideshare trip frequency and create more opportunities for crime, such as assaults; however, without a direct measure of traffic, we use taxi trips as a proxy for traffic. The Taxi and Limousine Commission publishes trip-level data for yellow and green taxis reported on the taxi zone-level. We

aggregated taxi trips as counts per taxi zone-hour. We obtained data on hourly temperature and precipitation from the National Centers of Environmental Information NYC Central Park Weather Station (National Centers for Environmental Information National Oceanic and Atmospheric Administration, 2021). These data were available for 99.8% of space-time units. If data were missing, we obtained the information from the La Guardia International Airport Weather Station (0.2% of space-time units). Using information from the NYC Department of Education and NYC Office of Payroll Administration (NYC Department of Education, 2021; NYC Office of Payroll Administration, 2021), we indicated which taxi zone-hours belonged on days that were government or school holidays.

2.6 Statistical Analysis

To estimate the odds of observing a nighttime assault relative to number of rideshare pickup trips in taxi zone-hours, we fit conditional logistic regression models separately for bars and restaurants. For both premise types, we conducted three different models. Model 1 measured the odds of all nighttime assaults. Model 2 measured the odds of assaults in the first, second, or unknown degrees. Model 3 measured the odds of assaults in the third degree. We can interpret results as the odds of observing a nighttime assault for each 100 additional rideshare pickup trips at a bar or at a restaurant. In all models, we controlled for temperature, precipitation, holidays, school holidays, and taxi trips. We conducted statistical analyses using SAS, V.9.4.

3. RESULTS

From 2017 to 2018, there was a total of 47,124 nighttime assaults in the 262 taxi zones. Of all nighttime assaults, 70.2% (n=33,091) were third degree assaults, 27.3% (n=12,865) were assaults in the first, second, or unknown degrees, 2.2% (n=1,051) were assaults on a police/peace officer, 0.2% (n=106) were assaults on other public service employees, 0.02% (n=8) were vehicular assaults (intoxicated driving), and 0.006% (n=3) were assaults on a traffic agent. Examining outlet types, 6.0% (n=2,837) of the nighttime assaults in the study period occurred at a bar or nightclub and 1.7% (n=787) occurred at a restaurant or diner. Nighttime assaults at bars and restaurants were constant over the study period (Figure 1). From 2017 to 2018, the TLC reported 372,957,845 rideshare trips and 232,230,256 taxi trips. Over the study period, the number of rideshare trips increased while the number of taxi trips per week (proxy for traffic) decreased slightly and then stayed relatively constant (Figure 2).

The study universe for this spatial ecological case-crossover study was 4,590,240 taxi zone-hours (2 years). Of the study universe, 2,482 (0.054%) taxi zone-hours contained at least one nighttime assault at a bar and 693 (0.015%) taxi zone-hours contained at least one nighttime assault at a restaurant. Figure 3 displays the geographic distribution of nighttime assaults in the first, second, third and unknown degrees at a bar or restaurant in NYC and the geographic distribution of rideshare trips across the 262 taxi zones in NYC. Among the bar assaults, there were minimal differences in the mean number of rideshare trips [187.0 (standard deviation (SD)=240.5) for case units and 177.1 (SD=232.1) for control units]. Similarly, among the restaurant assaults there were nonsignificant differences in the

mean number of rideshare trips [156.6 (SD=188.8) for case units and 150.1 (SD=188.0) for control units] (Table 1). For assaults at bars and restaurants, there were no significant differences between case and control units when examining taxi trips, temperature, or precipitation. For bars, more control units fell on days that school was not in session (p=0.008). For restaurants, more control units fell on holidays than the case units (p=0.009).

Table 2 includes the results of the conditional logistic models examining the odds of observing a nighttime assault at a bar relative to ridesharing in a taxi zone-hour. Taxi trips were not significantly associated with nighttime assaults, which means that the case crossover design adequately controlled for vehicular traffic. The number of rideshare trips was positively associated with all nighttime assaults at bars (OR=1.050, 95% CI: 1.002 to 1.100); that is, each increase of 100 additional rideshare trips was associated with a 5% increase in the odds of observing a nighttime assault at a bar. The number of rideshare trips was not significantly associated with first, second, or other degree assaults or third degree assaults at bars (OR=1.074, 95% CI: 0.910 to 1.176; OR=1.043, 95% CI: 0.988 to 1.101, respectively). Table 3 includes the results of the conditional logistic models examining the odds of observing a nighttime assault at a restaurant relative to ridesharing in a taxi zone-hour. The number of rideshare trips was not significantly associated with all nighttime assaults at a restaurant (OR=1.049, 95% CI: 0.943 to 1.168). Similarly, the number of rideshare trips was not significantly associated with first, second, or other degree assaults or third degree assaults at a restaurant (OR=1.077, 95% CI: 0.825 to 1.406; OR=1.036, 95% CI: 0.916 to 1.172, respectively).

4. DISCUSSION

This spatial ecological case-crossover study identified that greater frequency of rideshare trips are positively associated with nighttime assaults that take place in and immediately around bars. The parameter estimates produced in the examination of the relationship between ridesharing trips and nighttime assaults at restaurants were comparable to those produced in the examination at bars; however, confidence intervals were wider and included the null value of 1. With the rapid increase in rideshare volume worldwide over the last decade disrupting the traditional taxi market (Cetin and Deakin, 2019) and the impact of new transportation methods on alcohol-related outcomes (Jackson and Owens, 2011), these findings suggest that ridesharing could be an important contributor to additional alcohol-involved assaults.

Findings from the current study are consistent with prior analyses of ridesharing and alcohol consumption. Miller et al. found that self-reported alcohol consumption increased for recipients of a subsidized ridesharing coupon (Miller et al., 2020). Another study examining the Behavioral Risk Factor Surveillance System data and the introduction of UberX in U.S. metro areas, found that although ridesharing may reduce drunk driving, there is evidence that points to the increase in quantity and frequency of alcohol consumption in social settings, or on a “night out (Teltser et al., 2021). With documented associations between alcohol and violence (Graham and Livingston, 2011), in addition to evidence of associations between ridesharing and the increased frequency and quantity of alcohol consumed, this study demonstrates that ridesharing may contribute to an increase in alcohol-related crime.

Nevertheless, findings of an increase in nighttime assaults associated with ridesharing is contradictory to some studies that have examined sexual assault and crime/violence (Dills and Mulholland, 2018; Martin-Buck, 2017; Park et al., 2020). For example, Dills and Mulholland found that residents of cities in which Uber has operated are “no more or less likely to become victims of robbery, assault, or drunkenness” after Uber’s entry (2018). Methodological differences may explain these discrepant results. The previous studies were conducted at much larger spatial and temporal scale (e.g., county-month) than the taxi zone-hours used for the current analysis, and the dichotomous measures of exposure to ridesharing were much cruder than the highly spatially and temporally resolved trip counts available in New York City. The associations identified here may be undetectable due to aggregation bias when using larger space-time units and less refined measures of exposure to ridesharing.

Our results support the predictions based on availability theory, which predicts that individuals’ likelihood of consuming alcohol is linked to financial and convenience costs (Babor et al., 2010). By this mechanism, ridesharing will increase alcohol consumption at alcohol outlets because it reduces the full costs of traveling to a bar or restaurant and staying later after arriving at the destination. Our findings may support this theory due to observation of an increased likelihood of a nighttime assault at a bar. There is existing evidence that points to differences in levels of alcohol consumption and assaults when examining bars in comparison to restaurants (Gruenewald and Remer, 2006; Naimi et al., 2009; Sacks et al., 2020). For example, Naimi et al. found that the risk of driving after binge drinking was greater in bars or clubs than in restaurants when comparing to drinking in one’s home (Naimi et al., 2009). Gruenewald and Remer found that places with more bars were associated with increased rates of assault but this association was not found in places with more restaurants (Gruenewald and Remer, 2006). This study supports the literature base highlighting differences in assault based on alcohol outlet type.

The study’s strengths include the use of trip-level data for ridesharing and a strong study design that controls methodologically for the flow of populations through small space-time units. The availability of trip-level ridesharing data, along with taxi trip data, is a strength of selecting NYC as the study setting, as many cities do not have these kinds of data widely available. The availability of these data allows us to assess dose-response relationships between ridesharing and nighttime assaults. Further, the study design controls methodologically for the time-invariant characteristics of taxi zones, a common limitation of observational studies, by comparing cases and controls in the same taxi zone-hour. There may be residual confounding from time-varying characteristics not directly addressed by the study design; however, many sources of confounding are adjusted for in the model.

The results of our study should be interpreted with its limitations in mind. Although taxi zones were the smallest spatial unit available for use, the appropriate spatial scale to assess the relationship between ridesharing and nighttime assaults remains unknown, introducing the possibility of aggregation bias. Assaults and rideshare trips are co-located in the same taxi zone-hour; however, we do not know whether the individuals who either committed an assault or experienced an assault were those who chose not to use ridesharing or whether those who avoided committing an assault or experience an assault were those

who used ridesharing. The study did not include information on bar and restaurant density, which may impact the availability of ridesharing services and nighttime assaults in a given area. Controlling for taxi trips may have captured some of the impact of alcohol outlet density on nighttime assaults, but we cannot be sure it full captures the effect of outlet density. Furthermore, the assaults included in the study are those where the NYPD received an official complaint, thereby likely underestimating the true number of alcohol-related assaults. As with all observational studies, there potential for unmeasured confounding. Although we included taxi trips as a proxy for traffic due to the limited data on traffic publicly available, we cannot be sure that this proxy fully captures pedestrian traffic.

4. CONCLUSION

Studies on ridesharing's impact on human health are increasingly common, including studies examining associations with drunk driving, sexual assaults, alcohol consumption patterns, and injuries (Dills and Mulholland, 2018; Morrison et al., 2020; Park et al., 2020; Teltser et al., 2021). This study adds that ridesharing is positively associated with nighttime assaults at bars. With ridesharing's immense influence on the urban transportation landscape, given the number of users and geographic extent of its influence, the impact of ridesharing has potential implications for the burden of alcohol-related assaults in metropolitan areas.

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HIGHLIGHTS

- Ridesharing has changed the landscape of transportation.
- Ridesharing's impacts are beneficial to public health (i.e., reduced alcohol-impaired driving and crashing) and detrimental to public health (i.e., increased alcohol consumption, pedestrian crashes).
- Ridesharing is associated with nighttime assaults at bars.

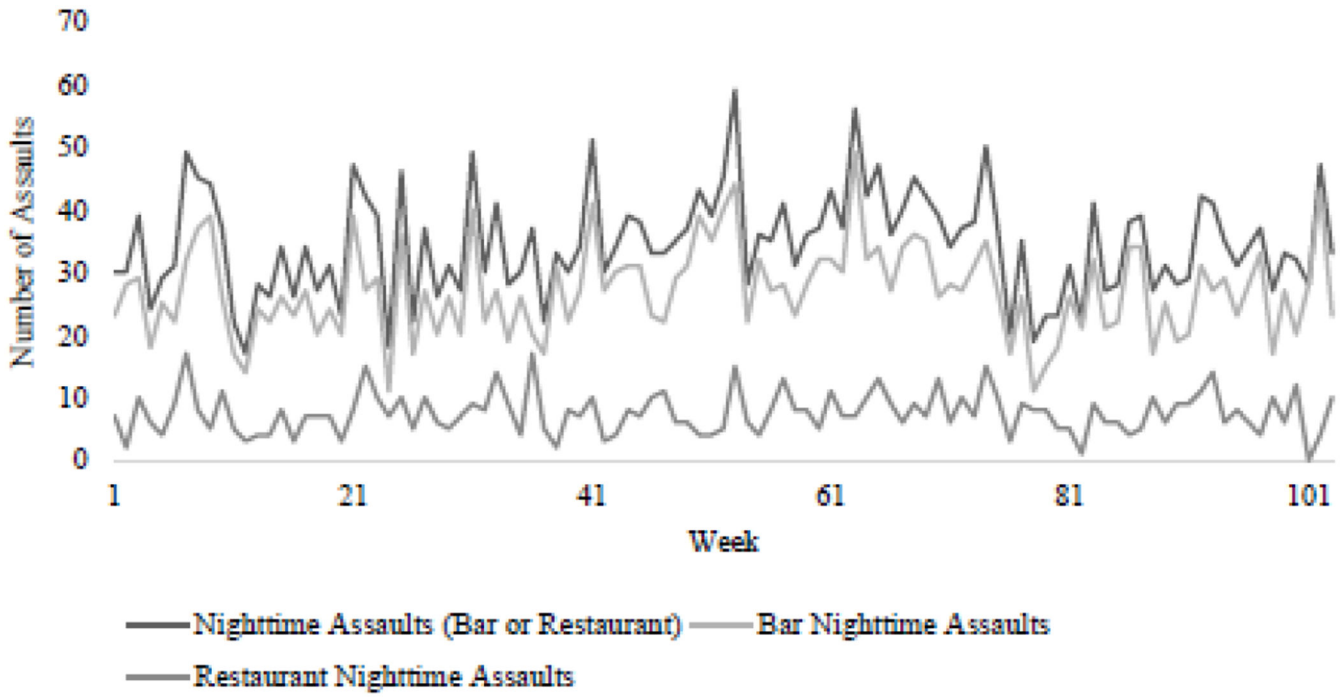

Figure 1:
Nighttime assaults in a bar or restaurant per week from January 1, 2017 to December 31, 2018.

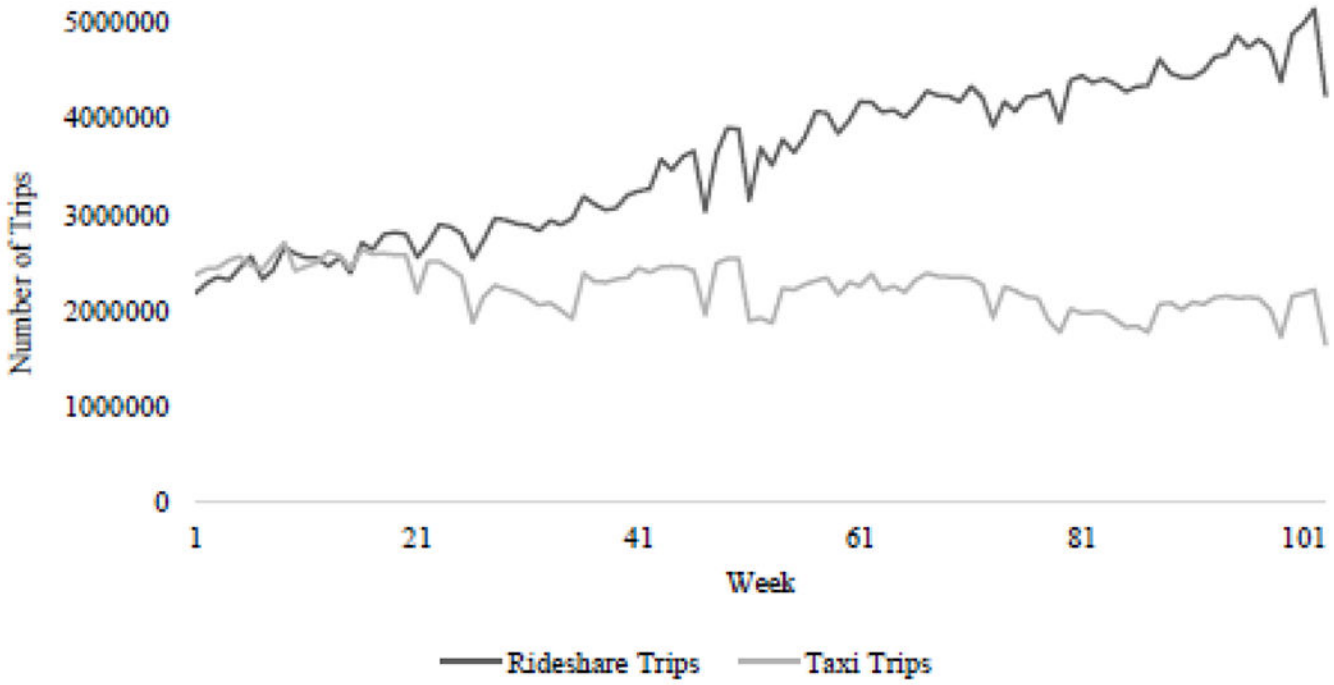

Figure 2:
Number of rideshare and taxi trips per week from January 1, 2017 to December 31, 2018.

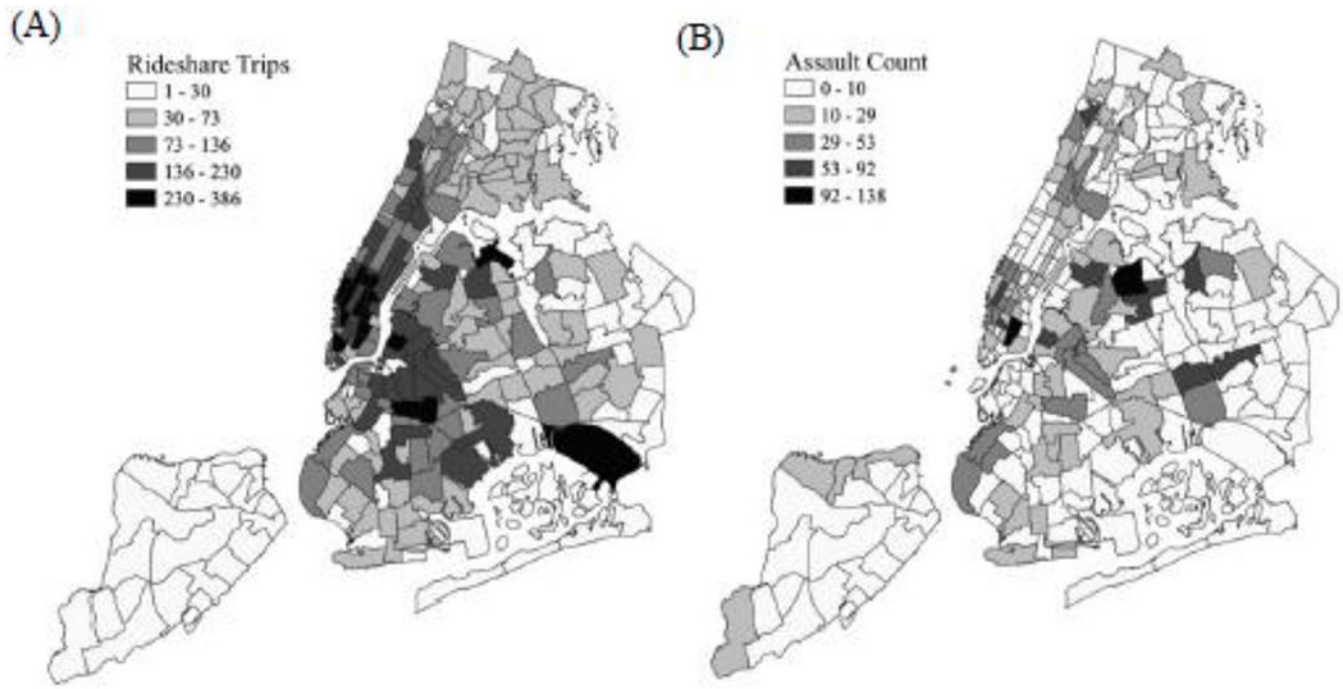

Figure 3:

(A) Mean rideshare trips per hour per NYC taxi zone and (B) NYC nighttime assaults at a bar or restaurant in the study period January 1, 2017-December 31, 2018/

Table 1.

Descriptive statistics for case taxi zone-hours in which a nighttime assault in the first, second, third, or unknown degree occurred at a bar or restaurant and two matched control taxi zone-hours from January 1, 2017 to December 31, 2018.

	Bars					Restaurants				
	Case (n=2482)		Control (n=4964)			Case (n=693)		Control (n=1386)		
	Mean	(SD)	Mean	(SD)	P value	Mean	(SD)	Mean	(SD)	P value
Rideshare trips	187.0	(240.5)	177.1	(232.1)	0.090	156.6	(188.8)	150.1	(188.0)	0.463
Taxi trips	131.1	(244.3)	124.6	(240.1)	0.278	100.4	(193.2)	96.8	(193.6)	0.690
Temperature (degrees Fahrenheit)	51.5	(17.2)	51.6	(16.7)	0.763	52.8	(17.2)	53.1	(16.8)	0.675
Precipitation (inches)	0.004	(0.02)	0.004	(0.02)	0.805	0.003	(0.02)	0.004	(0.02)	0.353
	n	%	n	%		n	%	n	%	
Any holiday	115	4.6	192	3.9	0.117	39	5.6	45	3.3	0.009
School not in session, not holiday	130	5.2	194	3.9	0.008	36	5.2	73	5.3	0.945

Table 2.

Conditional logistic regression models for taxi zone-hours in which any nighttime assault at a **bar** occurred compared with two matched control taxi zone-hours from January 2017 to December 2018. We can interpret results as the odds of observing a nighttime assault at a bar for each 100 additional rideshare pickup trips.

	Model 1: All assaults (n=7446 taxi zone-hours)	**Model 2: Assaults in the first, second, and unknown degrees *only* (n=2196 taxi zone-hours)**	**Model 3: Assaults in the third degree *only* (n=5400 taxi zone-hours)**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Rideshare trips (per 100 increase)	1.050 (1.002 to 1.100)	1.074 (0.91 to 1.176)	1.043 (0.988 to 1.101)
Taxi Trips (per 100 increase)	1.002 (0.954 to 1.052)	1.005 (0.914 to 1.105)	1.000 (0.944 to 1.059)
Temperature (per 10 degree increase)	0.999 (0.970 to 1.029)	1.016 (0.959 to 1.076)	0.996 (0.962 to 1.032)
Precipitation (per 0.1-inch increase)	0.965 (0.789 to 1.180)	0.856 (0.582 to 1.260)	0.968 (0.760 to 1.233)
Any holiday	1.144 (0.897 to 1.459)	1.142 (0.727 to 1.795)	1.084 (0.816 to 1.441)
School not in session holiday	1.352 (1.069 to 1.709)	1.084 (0.689 to 1.706)	1.502 (1.145 to 1.970)

Table 3.

Conditional logistic regression models for taxi zone-hours in which any nighttime assault at a **restaurant** occurred compared with two matched control taxi zone-hours from January 2017 to December 2018. We can interpret results as the odds of observing a nighttime assault at a restaurant for each 100 additional rideshare pickup trips.

	Model 1: All assaults (n=2079 taxi zone-hours)	**Model 2: Assaults in the first, second, and unknown degrees *only* (n=585 taxi zone-hours)**	**Model 3: Assaults in the third degree *only* (n=1533 taxi zone-hours)**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Rideshare trips (per 100 increase)	1.049 (0.943 to 1.168)	1.077 (0.825 to 1.406)	1.036 (0.916 to 1.172)
Taxi Trips (per 100 increase)	0.998 (0.882 to 1.128)	0.935 (0.694 to 1.260)	1.019 (0.887 to 1.172)
Temperature (per 10degree increase)	0.992 (0.934 to 1.054)	0.941 (0.825 to 1.072)	1.007 (0.926 to 1.083)
Precipitation (per 0.1-inch increase)	0.798 (0.458 to 1.389)	0.930 (0.491 to 1.764)	0.672 (0.297 to 1.522)
Any holiday	1.806 (1.156 to 2.823)	1.683 (0.795 to 3.564)	1.916 (1.096 to 3.347)
School not in session holiday	0.909 (0.598 to 1.383)	1.148 (0.561 to 2.350)	0.790 (0.469 to 1.331)