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Original Contribution

Uber and Metropolitan Traffic Fatalities in the United States

Noli Brazil* and David S. Kirk

* Correspondence to Dr. Noli Brazil, Spatial Sciences Institute, University of Southern California, 3616 Trousdale Parkway, AHF B55, Los Angeles, CA 90089 (e-mail: nbrazil@usc.edu).

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Uber and similar rideshare services are rapidly dispersing in cities across the United States and beyond. Given the convenience and low cost, Uber has been characterized as a potential countermeasure for reducing the estimated 121 million episodes of drunk driving and the 10,000 resulting traffic fatalities that occur annually in the United States. We exploited differences in the timing of the deployment of Uber in US metropolitan counties from 2005 to 2014 to test the association between the availability of Uber's rideshare services and total, drunk driving-related, and weekend- and holiday-specific traffic fatalities in the 100 most populated metropolitan areas in the United States using negative binomial and Poisson regression models. We found that the deployment of Uber services in a given metropolitan county had no association with the number of subsequent traffic fatalities, whether measured in aggregate or specific to drunk-driving fatalities or fatalities during weekends and holidays.

drunk driving; mortality; rideshare; traffic fatalities; Uber

Abbreviations: TNC, transportation network company; VMT, vehicle miles traveled.

Traffic fatalities are one of the leading causes of death in the United States, particularly for teenagers and young adults. Nearly 33,000 people died from motor vehicle crashes in 2014, and another 2.3 million individuals were injured (1). A primary culprit of the magnitude of traffic fatalities in the United States is drunk driving. Data from the National Highway Traffic Safety Administration revealed that nearly 10,000 people died in the United States in 2014 as the result of a crash that involved an alcohol-impaired driver (defined as a driver with a blood alcohol concentration of 0.08 g/dL or higher), which accounted for nearly one-third of all traffic fatalities (2). Common strategies for reducing drunk driving, such as reducing thresholds for blood alcohol concentration and increasing taxes on alcohol, center on the assumption that would-be drunk drivers will be deterred by the added cost and penalty of engaging in drunk driving (3–6). Being arrested, having a license revoked and a car impounded, and being sanctioned and stigmatized by the criminal justice system can surely be costly endeavors, but only if one is caught. A mere 1.1 million arrests for driving under the influence were made by US law enforcement in 2014, compared with the roughly 121 million incidents of drunk driving (<1%) (3, 7).

However, some would argue that the phenomenal rise of Uber (Uber Technologies Inc., San Francisco, California) and its ridesharing competitors is a sign of a worldwide transportation revolution that could potentially curtail the extensive amount of drunk driving that occurs in the United States (8). Ridesharing connects passengers with owner-operator drivers through a smartphone application that also calculates and processes costs, provides real-time tracking of drivers, and feeds the passenger's destination information into the driver's navigational software, offering a service that can be more convenient than taxis and public transit (9). Uber is by far the highest valued of the so-called transportation network companies (TNCs). As of late 2015, Uber exceeded $62 billion in value (10). By April 2016, Uber was operating in more than 60 countries and 400 cities worldwide. Uber's closest competitor among TNCs in the United States is Lyft (Lyft Inc., San Francisco, California), which is valued at $5.5 billion and, as of April 2016, operated in just over 200 US cities (11). In the vast majority of US metropolitan areas, Uber was the first TNC to the market. In the few major markets in which Lyft service launched before Uber, Uber's launch usually followed quickly.

Uber's model is designed to ensure that the supply of Uber drivers keeps up with the demand for rides. When demand increases, the cost of a ride increases—known as surge pricing—in order to encourage more drivers to become available. In this sense, Uber at least reduces the challenges of finding a sober ride, although whether Uber is cheaper than a taxi service depends upon the prevailing demand at a given time.

If would-be drunk drivers were rational, then lowering the difficulty of finding alternate transportation options and the cost of those options would, in theory, reduce the number of drunk driving occurrences and fatalities. This is the promise of Uber and other TNCs, particularly in terms of increasing the supply of transportation options. Indeed, Uber claimed that it provides "more than just a convenient transportation option. The choice, reliability and flexibility it affords also make [it] a powerful tool in the quest to protect families from drunk driving" (12). Uber has further asserted, "A city with Uber has . . . fewer drunk drivers on the streets" (https://www.uber.com/). Given these broad claims and the significant challenges remaining in curbing drunk driving and associated fatalities, the implications of this so-called transportation revolution for traffic fatalities warrant empirical study.

In the lone piece of academic research that we could find on the relationship between Uber services and drunk driving, the authors used a difference-in-differences methodology similar to the one that we utilized in the present study to examine the association between quarterly county-level alcohol-related fatalities and the deployment of Uber's low-cost UberX and luxury UberBlack services in California from 2009 to 2013 (13). They concluded that the deployment of UberX, but not UberBlack, yielded a significant reduction in traffic-related fatalities. Moreover, the authors reported that there was no association between Uber availability and the number of fatalities when Uber's surge pricing was in effect, suggesting that Uber was only a substitute for drunk driving when the cost of a Uber ride was relatively reasonable. However, the authors noted that their analysis was limited by its sole geographic focus on California and the possibility that confounding factors influenced the results.

Although there are theoretical reasons to suggest that the introduction of Uber in a market will lead to a reduction in drunk driving, there are alternate positions as well. First, because drivers are unlikely to get caught drinking and driving, paying for a rideshare service may still be far more costly than driving drunk for many individuals. Second, individuals inclined to drink and drive may not be very rational. Third, although Uber's growth in terms of markets and drivers has been unprecedented, the number of Uber drivers in a market may still be too small to have much of an influence on the 121 million incidents of drunk driving that take place each year in the United States (3). Based on these counter perspectives, as well as the inconclusiveness of research to date, we examined the relationship between the deployment of Uber and subsequent traffic fatalities within the 100 largest metropolitan areas across the United States from 2005 to 2014, using a research strategy designed to minimize the possibility of confounding influences.

METHODS

Sample

We used an observational panel study design to examine within-county changes in monthly motor vehicle fatalities after implementation of Uber services for the period from 2005 to 2014. The analytic sample contained monthly observations for the most populated county in each of the 100 most populated metropolitan areas in the United States (see Web Table 1, available at http://aje.oxfordjournals.org/, for the list of counties) (14). To determine the top 100 most populated metropolitan areas in the country, we used the latest delineation of metropolitan areas as defined by the US Census Bureau (15). We then used 2010 US Census population counts by metropolitan area to rank order these metropolitan areas and constructed our sample based on the top 100 most populated areas (14).

Because traffic fatality data are available by county, we used a Census geographic crosswalk to identify the most populated county within each of the top 100 metropolitan areas in the country, and this county represented our geographic unit (16). The exception was the New York metropolitan area. Given the population size of the New York metropolitan area, we included the 5 separate counties in our data set that corresponded to the 5 boroughs of New York (Bronx, Kings, New York, Queens, and Richmond Counties).

Dependent variable: traffic fatalities

We examined the association between Uber deployment and 3 categories of traffic fatalities: total, drunk driving–related, and weekend- and holiday-specific. We examined fatalities that occurred during the weekend—that is, traffic fatalities between 5:00 PM on a Friday and 5:00 AM on the following Sunday—and major US holidays because alcohol consumption is likely greater during these days, potentially increasing the demand for rideshare services (17). Monthly county-level data on traffic fatalities were obtained from the Fatality Analysis Reporting System (18), which is produced by the National Highway Traffic Safety Administration. The data represent a census of all fatal injuries resulting from motor vehicle accidents in the United States. Information on the details of each accident and whether alcohol was involved was obtained from a variety of sources, including police reports, driver licensing files, vehicle registration files, state highway department data, emergency medical service records, medical examiner reports, toxicology reports, and death certificates. Information on drunk driving–related fatalities were available only from 2009 to 2014.

Independent variable: Uber deployment

Our measure of Uber deployment was a binary indicator of whether, in a given month and year, Uber had established services in a county. Uber was founded in 2009 and began pilot testing its service in January 2010 (19). Uber service officially launched on May 31, 2010, in San Francisco. In 2011, Uber was introduced in 6 more metropolitan areas and rapidly dispersed thereafter. Figure 1 shows the number of principal counties in the top 100 metropolitan areas with available Uber services by year through 2014 (see Web Table 1 for county deployment dates).

We determined the location and timing of Uber's services using a combination of sources. First, we used information published on Uber's website, specifically an up-to-date listing of service locations and a "newsroom" section in which the company publicizes the launch of services in new markets. As a for-profit company, Uber has a vested interest in advertising where it has service in order to attract consumers and drivers, and thus the

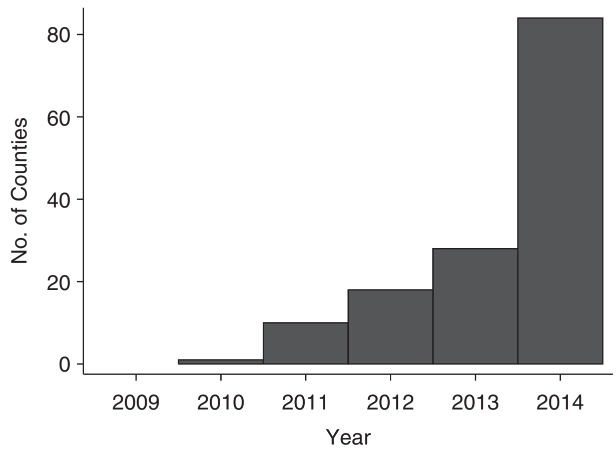

Figure 1. Number of the most populated counties in the top 100 metropolitan areas in the United States with available Uber services by year ($n = 84$), 2009–2014.

information contained in these sections is regularly maintained. Second, we searched local media outlets for further information about the timing of implementation and any suspensions of services. For any locations in the top 100 metropolitan areas not listed as a location on the Uber website, we searched local media outlets online to confirm that Uber had not yet been launched.

Control variables

We controlled for factors associated with crash risk. In previous studies, investigators found evidence that state-level traffic-related policies influenced the rate of driver fatalities (20–24). We included binary indicators for whether the following policies were present in a county's state in a given month and year: legalization of medical marijuana; the decriminalization of marijuana use; a graduated driver-licensing law, which forces young drivers to safely gain experience before obtaining full driving privileges; per se administrative license revocation, which allows states to revoke driving privileges before court action related to drunk driving; bans on texting and regulations on hands-free cell phone use while driving; and primary seatbelt laws. We obtained information on implementation dates of primary seatbelt and graduated driver-licensing laws from the Insurance Institute for Highway Safety (25). Dates of drug per se laws were obtained from previous studies and updated using information from the National Conference of State Legislatures (20, 26). We obtained information on effective dates for bans on texting and handheld cellphone use while driving, the legalization of medical marijuana, and the decriminalization of marijuana use from previous studies and updated the data using LexisNexis (27–29).

We also controlled for states' yearly beer tax rates in 2014 US dollars per gallon, which have been linked to alcohol consumption and traffic fatalities (30, 31). Because economic conditions influence factors associated with crash risk, such as alcohol consumption and the number of miles driven, we controlled for county monthly unemployment rates, which measure the percentage of the labor force 16 years of age or older that is unemployed (32, 33). Lastly, because the availability of taxis may influence the demand for Uber, we controlled for the yearly number of taxi drivers per 100,000 persons employed in a county's metropolitan area weighted by the county's proportion of its metropolitan area's total population. We obtained data on beer taxes from the Beer Institute's *Brewers Almanac* (34) and unemployment rates and the number of taxi drivers from the Bureau of Labor Statistics (35).

Statistical analyses

We used a difference-in-differences strategy with county, month, and year dummy variables to assess the relationship between the presence of Uber and the number of traffic fatalities across the principal counties of the 100 largest metropolitan areas. Because some counties in our study had Uber and some did not, our empirical strategy compared the changes in fatality counts within counties that had Uber service with the contemporaneous changes in fatality counts in counties that did not.

We examined the relationship between traffic fatalities and Uber availability using negative binomial regression models. We used a negative binomial specification to account for the extreme skewness of the traffic fatality data, which included many observations with few or no fatalities. Our measure of exposure was the number of vehicle miles traveled (VMT) in a county-month, which we estimated by multiplying the state's monthly VMT by the county's proportion of its state's total roadway mileage. VMT is a common measure of crash fatality risk because it captures time and number of persons exposed to driving (36). We obtained VMT and roadway length data from the Federal Highway Administration (37). Negative binomial models for drunk driving–related fatalities did not converge; we instead report results from Poisson models, which have the same distributional assumptions but do not correct for overdispersion. Results from Poisson and negative binomial models for total and weekend- and holiday-specific fatalities did not significantly differ.

We included individual county, month, and year fixed effects in our models. County fixed effects controlled for all time-invariant county-specific factors that are potentially correlated with traffic fatalities, such as land area and geographic location. The month fixed effects controlled for factors that vary month to month but are county and year invariant, such as travel patterns. The year fixed effects controlled for factors that affected all counties in all months in a given year, such as changes in national car safety standards. We adjusted standard errors for clustering at the county level.

Sensitivity analyses

We ran a set of additional models to test the robustness of our main results (Web Appendix 1). First, we tested the sensitivity of our results to the measure of crash risk by replacing VMT with another popular measure of exposure: county yearly Census population (Web Tables 2 and 3). Second, in order to test whether findings were sensitive to distributional assumptions, we fitted Poisson models to go along with the negative binomial models presented in the main analysis (Web Table 4). Third, because prior evidence revealed that Uber's association with traffic fatalities becomes stable after 9 months (13), we tested for a lagged association by replacing the binary Uber indicator from the main analysis with a variable categorizing observations into no Uber service present, Uber service present for less than

Table 1. Descriptive Statistics for County-Month Sample, Principal Counties of the Top 100 US Metropolitan Areas, 2005–2014

Variable	County-Months With Uber ($n = 1{,}218$), Mean (SD)	County-Months Without Uber ($n = 11{,}262$), Mean (SD)
Traffic fatalities		
Total	8.75 (10.44)	6.93 (7.80)
From drunk driving[a]	2.22 (3.02)	1.80 (2.21)
On weekends and holidays	2.88 (3.81)	2.23 (2.86)
County unemployment rate, %	7.07 (2.14)	7.04 (2.62)
State beer tax, 2014 dollars per gallon	0.23 (0.18)	0.26 (0.19)
Taxi drivers per 100,000 persons	25.23 (21.87)	34.78 (54.18)
State laws		
Marijuana decriminalization	0.55 (0.50)	0.38 (0.49)
Medical marijuana legalization	0.30 (0.46)	0.17 (0.38)
Graduated driver licensing law	0.99 (0.12)	0.97 (0.18)
Hands-free driving law	0.46 (0.50)	0.18 (0.38)
Ban on texting	0.69 (0.46)	0.27 (0.45)
Drug per se law	0.37 (0.48)	0.33 (0.47)
Seatbelt law, primary enforcement	0.80 (0.40)	0.62 (0.48)

Abbreviation: SD, standard deviation.
[a] From 2009 to 2014.

9 months, and Uber service present for 9 months or longer (Web Tables 5 and 6). Fourth, we accounted for the presence of Lyft, Uber's largest competitor, by testing a variable that indicates whether either company was present in a county (Web Tables 7 and 8). We also tested the number of rideshare services by including a variable that categorizes counties as having neither Uber nor Lyft, either Uber or Lyft, or both Uber and Lyft (Web Tables 9 and 10). Lyft was present in 65 counties in our sample, with 60 of these counties also having Uber service by the end of 2014. Although other TNCs exist, Uber and Lyft capture the bulk of the market in the United States, with Uber being the market leader by a considerable margin (38, 39). Finally, we tested whether the results were sensitive to the dramatic decline in traffic fatalities that occurred between 2007 and 2008, which has been attributed to the Great Recession and improved air bag standards (40), by limiting the time period to 2009–2014 (Web Tables 11 and 12). Results for these robustness tests were consistent with the main results, particularly for the final models that included fixed effects and control variables. We conducted all analyses in Stata, version 14 (StataCorp LP, College Station, Texas).

RESULTS

Table 1 presents the descriptive statistics for our sample of 12,480 county-months disaggregated by Uber presence. Uber was present in 10% of the total county-month observations. Counties experienced slightly more traffic fatalities during months when Uber was present (8.75 vs. 6.93). Differences were much smaller for drunk driving–related (2.22 vs. 1.80) and weekend- and holiday-specific (2.88 vs. 2.23) fatalities.

Results from negative binomial models of Uber's association with total fatalities are shown in Table 2. We present the coefficients as incidence rate ratios. An incidence rate ratio less than 1 indicates a reduction in traffic fatalities after Uber entry, whereas a ratio greater than 1 suggests an increase. Model 1 shows results for an unconditional model with the measure

Table 2. Incidence Rate Ratios for the Number of Total Traffic Fatalities ($n = 12{,}480$) Regressed on Uber Deployment From Negative Binomial Models[a], Principal Counties of the Top 100 US Metropolitan Areas, 2005–2014

Variable	Model 1		Model 2[b]		Model 3[b]	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Uber service available	1.06	0.93, 1.21	1.01	0.97, 1.06	1.02	0.98, 1.06
County unemployment rate, %					0.97[c]	0.95, 0.98
State beer tax, 2014 dollars per gallon					0.73[d]	0.60, 0.89
Taxi drivers per 100,000 persons					1.00	1.00, 1.00
Marijuana decriminalization					1.04	0.94, 1.15
Medical marijuana legalization					1.00	0.82, 1.22
Graduated driver licensing law					0.92	0.82, 1.04
Hands-free driving law					0.95	0.89, 1.01
Ban on texting					0.98	0.94, 1.03
Drug per se law					1.03	0.98, 1.09
Seatbelt law, primary enforcement					0.97	0.92, 1.03

Abbreviations: CI, confidence interval; IRR, incidence rate ratio.
[a] Each model accounts for county monthly vehicle miles traveled.
[b] Includes county, month, and year fixed effects.
[c] $P \leq 0.001$.
[d] $P \leq 0.01$.
[e] $P \leq 0.05$.

Table 3. Incidence Rate Ratios for the Number of Drunk Driving–Related Traffic Fatalities From Poisson Models (2009–2014) and for Weekend and Holiday-Related Traffic Fatalities From Negative Binomial Models (2005–2014) Regressed on Uber Deployment, Principal Counties of the Top 100 US Metropolitan Areas

Variable	Drunk-Driving Fatalities[a] ($n = 7{,}488$)						Weekend and Holiday Fatalities[a] ($n = 12{,}480$)					
	Model 1		Model 2[b]		Model 3[b]		Model 1		Model 2[b]		Model 3[b]	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
Uber service available	0.96	0.83, 1.10	1.03	0.97, 1.10	1.03	0.97, 1.10	1.07	0.95, 1.21	1.05	0.98, 1.12	1.05	0.99, 1.12
County unemployment rate, %					0.96[d]	0.94, 0.99					0.97[d]	0.95, 0.99
State beer tax, 2014 dollars per gallon					1.08	0.83, 1.39					1.06	0.83, 1.37
Taxi drivers per 100,000 persons					1.00	1.00, 1.00					1.00	1.00, 1.00
Marijuana decriminalization					0.93	0.78, 1.10					1.09	0.94, 1.26
Medical marijuana legalization					0.79[c]	0.75, 0.82					0.97	0.77, 1.22
Graduated driver licensing law					1.22[e]	1.03, 1.45					0.91	0.75, 1.10
Hands-free driving law					0.88	0.76, 1.03					0.95	0.88, 1.03
Ban on texting					1.00	0.94, 1.07					0.95	0.90, 1.01
Drug per se law					1.02	0.79, 1.31					1.04	0.94, 1.16
Seatbelt law, primary enforcement					0.95	0.78, 1.15					0.95	0.88, 1.03

Abbreviations: CI, confidence interval; IRR, incidence rate ratio.
[a] Each model accounts for county monthly vehicle miles traveled.
[b] Includes county, month, and year fixed effects.
[c] $P \leq 0.001$.
[d] $P \leq 0.01$.
[e] $P \leq 0.05$.

of Uber service as the sole predictor. This model shows that on average, the presence of Uber was associated with a 2.0% (95% confidence interval: 0.98, 1.06) increase in traffic fatalities among all drivers; however, this association was not statistically significant at conventional levels.

Model 2 in Table 2 introduces county, month, and year fixed effects. This model shows no statistical association between the presence of Uber and crash-related fatalities. We found a similar result in model 3, which includes control variables. Consistent with prior evidence (30–33), higher county unemployment rates and state beer tax rates were associated with decreases in traffic fatalities. The presence of Uber, however, had no statistically significant association.

The first 3 columns in Table 3 present results from Poisson regression models on drunk driving–related fatalities. There was no significant association between Uber deployment and drunk driving–related fatalities in any of the 3 models. Columns 4–6 in Table 3 present results for negative binomial regression models on traffic fatalities occurring during weekends and major US holidays. Similar to what was seen for total and drunk driving–related fatalities, Uber had no statistically significant association with weekend- and holiday-specific fatalities across all modeling specifications.

DISCUSSION

Findings

Our findings reveal that the deployment of Uber services in a given metropolitan county had no association with the number of subsequent traffic fatalities, whether measured in aggregate or specific to drunk driving–related fatalities or fatalities that occurred on weekends and holidays. We undertook a variety of robustness checks and found similar results across a number of different model specifications.

There are several explanations for the apparent lack of reduction in traffic fatalities after the implementation of Uber service. First, Uber may have no association with traffic fatalities because it represents a relatively small share of transportation usage in the United States. If the share of total VMTs by Uber drivers increases, then perhaps there will be a greater possibility for an association with the number of traffic fatalities in the future (whether positive or negative). Indeed, the number of active Uber drivers in a given month increased exponentially between January 2013 and April 2016, from a few thousand drivers to 450,000 monthly drivers (41, 42). However, given that there are 210 million licensed drivers in the United States (43), as well as an estimated 4.2 million adults who drive while impaired by alcohol in a given month (3), it is hard to conceive of Uber making a substantial change in aggregate traffic fatalities when its users make up such a minimal share of total drivers.

Second, Uber may be a substitute for taxis and other forms of public transportation but not a substitute for drunk driving. Accordingly, Uber passengers may have formerly been taxi and public transit users, and thus the number of at-risk drivers on the road would not substantially change. Prior evidence has suggested this substitutability (44, 45).

Relatedly, Uber users may not be representative of the average metropolitan driver. For example, the principal consumers of Uber in New York are upper-income passengers who do not own a vehicle (45). Although cheaper than a taxi ride on average, Uber is still considerably more expensive than is public transit (46). Therefore, lower-income individuals and those near public transit may be less likely to consider Uber as a practical form of transportation. In this case, Uber may have a greater association with the number of traffic fatalities in smaller areas where transportation options are limited. In future research, investigators should examine whether the association between Uber's presence and traffic fatalities depends upon the availability of alternative transportation options.

Finally, the average inebriated individual contemplating drunk driving may not be sufficiently rational to substitute drinking and driving for a presumably safer Uber ride; it is also possible that many drunk drivers rationally conclude that it is too costly to pay for an Uber ride (or taxi) given that the likelihood of getting arrested for drinking and driving is actually quite low.

Strengths and limitations

Certain limitations of the present study should be acknowledged. First, absent data on individual Uber usage and related fatalities, it is not possible to explicitly examine Uber's relationship with traffic fatalities at the individual level. This limitation prevented us from examining traffic fatalities disaggregated by pertinent driver characteristics, specifically sex, race, socioeconomic status, and age. Relatedly, accurate data on Uber usage volume would likely strengthen our multivariate findings by allowing us to capture a more precise measure of Uber presence in an area. Also, given the relative novelty of Uber, we were unable to examine the long-term association with fatalities. Finally, we did not examine Uber's association with other traffic outcomes, including drunk driving incidences and nonfatal crashes. Future research should investigate these relationships to further expand our understanding of rideshare services.

Despite these limitations, the present study adds to the limited empirical knowledge about the association of rideshare services with traffic outcomes. We extended previous research, which was focused on a single state, by examining multiple counties across the United States. By using panel data on multiple counties with timing differences in Uber deployment, we were able to control for county-, month-, and year-invariant effects, which allowed us to purge any unobserved systematic variation from the analysis.

Conclusion

In summary, our results suggest that the entry of Uber services into a metropolitan area has no aggregate association with the number of traffic fatalities. Our results should provoke skepticism of broad claims regarding the citywide effects of rideshare services in reducing traffic fatalities. At least through the first 5 years after the advent of Uber's rideshare services, this transportation revolution has not yet translated into aggregate declines in metropolitan-area traffic fatalities.

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Author affiliations: Spatial Sciences Institute, University of Southern California, Los Angeles, California (Noli Brazil); and Department of Sociology, Nuffield College, University of Oxford, Oxford, United Kingdom (David S. Kirk).

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