NYU CUSP Urban Science Intensive II
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Final Report

Senior Pedestrians in NYC: A Diff-in-Diff Approach to Evaluating Safe Streets for Seniors

Abstract

Urban senior populations are expected to grow significantly in the coming decades. This demographic trend requires adjustments to policy and infrastructure in cities. New York City has implemented its Safe Streets for Seniors (SSfS) program, which includes identifying Senior Pedestrian Focus Areas (SPFAs) and making structural improvements designed to improve safety for senior pedestrians to address its aging population. This study investigates whether or not the established SPFAs improved safety for seniors. Using difference-in-difference estimators, we find that setting up SPFA zones in NYC leads to a decrease of about 34 percent in the number of seniors killed in motor vehicle accidents. The number of accidents involving senior pedestrians relative to non-SPFA zones decreased too, however only by 5 percent. Overall, our results show that New York City's programs addressing senior citizens is successful and suggest that other cities in the US and abroad should adopt transportation policies similar to NYC's in order to protect senior citizens.

Introduction

Motivation

Nations around the world are continuing to see more and more people flocking to cities. The year 2008 marked the first time in human history when more than half of the global population could be found in cities or towns rather than rural environments (Netherland et al.

2011). And that number is only expected to grow: by 2030, two thirds of the global population will reside in cities (Buffel et al. 2016).

At the same time, many countries are aging. In member nations of the Organization for Economic Co-operation and Development, the proportion of citizens aged 65 and older has grown from 7.7% in 1950 to 17.8% in 2010 and will reach 25% by 2050. This same trend applies directly to New York, where the number of senior citizens will grow to 1.35 million by 2030 (Buffel et al. 2016).

Pedestrian Safety as a Key Aspect of Senior Health

One critical aspect of the age-friendliness of NYC will be the walkability of its streets. Studies have helped to reveal the challenges, though, that seniors face in NYC when it comes to navigating the city on foot. Senior pedestrians suffer higher fatality rates in pedestrian accidents in NYC than any other part of the US: while NYC and the rest of the US have similar percentages of senior residents, the rate of senior pedestrian deaths in NYC is 16% higher than the rest of the nation. Pedestrians, more generally, are particularly vulnerable in the City - while 12% of all motor vehicle deaths in the U.S. are pedestrians, that rate jumps to 50% in NYC (Nicaj et al. 2019).

In another study, a group of researchers quantified the cost of pedestrian accidents involving relatively serious bodily injuries (i.e. to the head, torso, and legs). The study showed that costs due to pedestrian accidents are varied in nature and include several factors, from the cost of treating the injuries themselves, to lost work and productivity, and overall decreases in quality of life. Seniors have the highest hospitalization and fatality rates and an estimated cost of $135,563 per senior per accident (Miller et al. 2004).

NYC Policy and Relevant Literature

The NYC Department of Transportation is not ignorant of the dangers that senior pedestrians face. A study conducted by the DOT acknowledged that senior pedestrians suffer fatalities four times more often than younger pedestrians (“NYC DOT - Safe Streets for Seniors”, 2019). To combat this problem, NYC DOT came up with its Safe Streets for Seniors program (SSfS), which is designed to reduce traffic accidents that result in serious injuries to or the death of senior pedestrians. Since 2008, the DOT has implemented changes in 41 “Senior Pedestrian Focus Areas” (SPFAs), which the agency identified as areas with high densities of vulnerable senior pedestrians based on the density of crashes involving senior pedestrians, senior pedestrian traffic, and the locations of senior centers and senior housing.

Once SPFAs had been identified, the DOT added new structural changes (called “Street Improvement Projects” aka SIPs) to these SPFAs, such as “extending pedestrian crossing times at crosswalks to accommodate slower walking speeds, constructing pedestrian safety islands, widening curbs and medians, narrowing roadways, and installing new stop controls and signals” (“NYC DOT - Safe Streets for Seniors”, 2019). Researchers have found, though, that not all of these infrastructure changes can be tied to measurable improvements. In one study, researchers showed that some types of SIPs, such as midblock pedestrian fencing, were not associated with reduced senior pedestrian accidents (Chen et al. 2013). And a separate study found 10 candidate community districts in NYC with relatively high concentrations of senior residents that had not been targeted as SPFAs ("Aging with Dignity: A Blueprint for Serving NYC's Growing Senior Population").

Hypothesis

Ultimately, we had three primary hypotheses that we chose to investigate:

- The total number of seniors involved in fatal motor vehicle accidents in SPFAs decreased than in non-SPFA areas.
- The number of seniors who die in SPFAs decreased at a faster rate than in non-SPFA areas.
- The number of senior pedestrians who die in SPFAs decreased at a faster rate than in non-SPFA areas.

Data

Our analysis relied primarily on two data sets - traffic fatality data collected from the National Highway Traffic Safety Administration (NHTSA) and SPFA spatial data from NYC DOT (see Table 1 in the Appendix for an overview of the NHTSA and SPFA datasets).

NHTSA Data

The NHTSA publishes nationwide motor vehicle crash data going back decades as part of its Fatality Analysis Reporting System (FARS). Crashes reported in FARS "must involve a motor vehicle traveling on a trafficway customarily open to the public and must result in the death of at least one person (occupant of a vehicle or a non-motorist) within 30 days of the crash" ("Fatality Analysis Reporting System", 2016). The NHTSA publishes data on each accident (date, time, and location of the crash, for example) along with other, related data (number of pedestrians involved, health outcomes, etc.). We collected crash data from 2001 to 2017, some of which was kept strictly for experimental control purposes (see Figure 1 in the Appendix for the variables used as controls in our modelling.)

Crash data was aggregated at the level of the census tract to allow for a more meaningful and appropriate comparison of accident rates in different parts of the city. It should be noted that for any census tract that contained any part of an SPFA, we counted all the accidents occurring within that census tract as having occurred within an SPFA. This is, admittedly, an imprecise calculation because census tracts and SPFAs often did not perfectly overlap. After consulting with senior researchers, though, it was determined that this methodology would be our most appropriate solution for our purposes.

SPFAs

Data for the 41 SPFAs identified by NYC DOT is published online by NYC Open Data and includes SPFA names and spatial data. The following is a visualization of the available data:

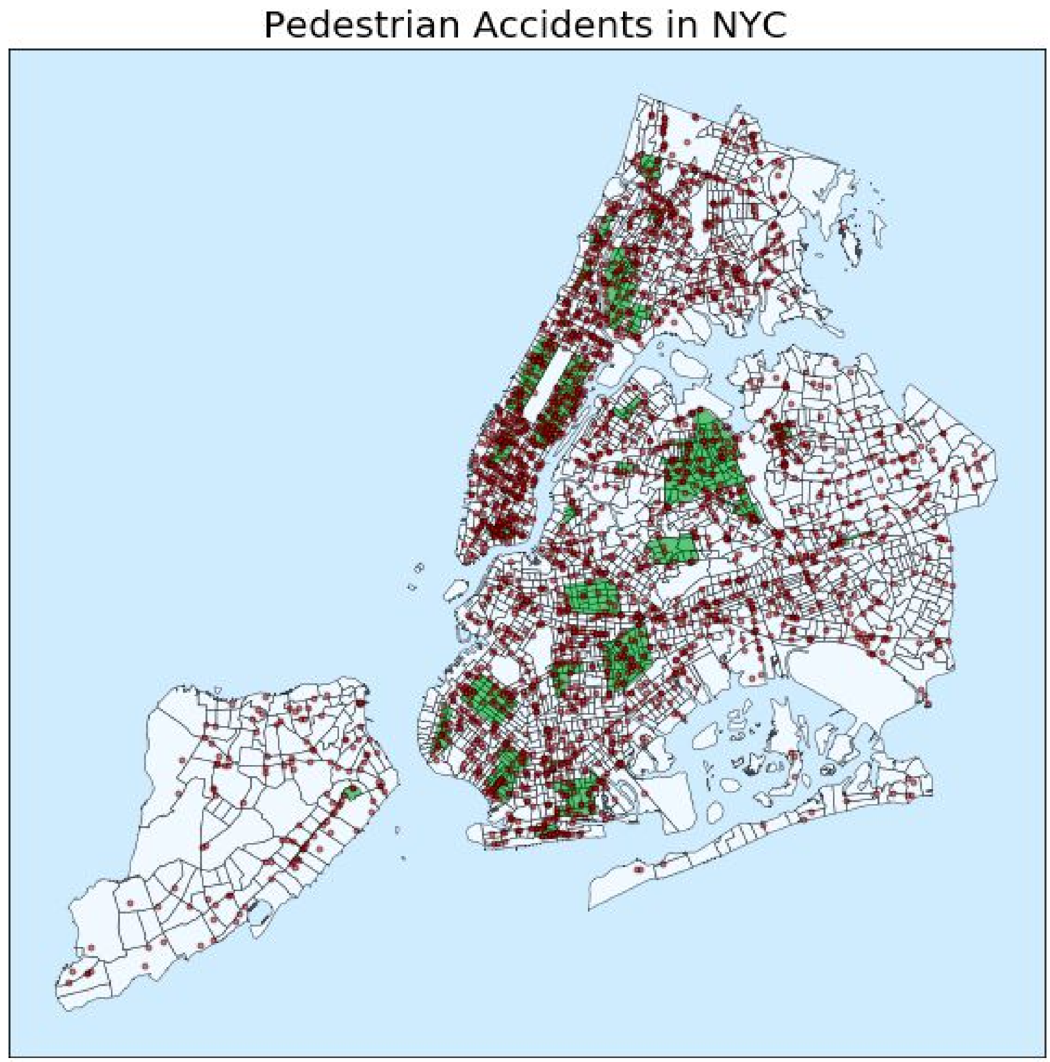

Figure 2: Plot of pedestrian accidents in NYC in red with SPFAs plotted in green over a base layer of NYC census tracts. DOT's official map of SPFAs can be found at the following link: https://www1.nyc.gov/html/dot/html/pedestrians/safeseniors.shtml.

It should be noted that our analysis focused on the first two rounds of SPFAs (2008 and 2012-2013). The NHTSA has not published FARS data for 2018 or 2019. We are therefore unable to determine any observed effect on pedestrian crashes following the third round of SPFA implementation that took place in 2017. (For more information on our data gathering and cleaning process, refer to our project materials posted at: https://github.com/agingcapstone.)

Methodology

The difference-in-difference (diff-in-diff) method is a statistical technique used in econometrics and quantitative research in the social sciences that attempts to mimic an experimental research design using observational study data by analyzing the differential effect of a treatment on a "treatment group" versus a "control group" in a natural experiment. It calculates the effect of a treatment on an outcome by comparing the average change over time in the outcome variable for the treatment group compared to the average change over time for the control group ("How Much Should We Trust Differences-In-Differences Estimates?").

Previous research has neglected to apply diff-in-diff methodology specifically to the analysis of SPFA effectiveness despite the apparent applicability of the method to this subject area. We therefore decided to analyze traffic accidents in NYC involving senior pedestrians using a diff-in-diff methodology, where we would compare accident rates over time between neighborhoods that received the SPFA (the treatment group in this study) and those that did not (the control group).

Results

Descriptive Statistics

The initial results from our analysis revealed similar trends over time in terms of accident rates both within and outside of SPFAs. This was an important finding for our study as diff-in-diff analyses include a "parallel trend assumption", which requires that the control and experimental groups show similar trends (in our case, senior pedestrian accident rates) before the treatment has been implemented ("Difference-in-Difference Estimation | Columbia University Mailman School of Public Health", 2019). Our study satisfies this criterion for all three of the endogenous variables relevant to our analysis (see Figures 3-5 in the Appendix).

Initial findings from our study also showed that, starting in 2009, there was a significant decrease in the number of accidents involving seniors, which makes intuitive sense since the first implementation of SPFAs occurred in 2008. The first round of SPFAs were likely not completed until later in the year or possibly into early 2009 so the effect of SPFA implementation on pedestrian safety should only be seen starting in 2009.

For more information on general trends within our dataset, including the average number of senior pedestrians killed in fatal motor vehicle accidents (6% of such accidents), the average number of fatal accidents occurring on weekdays (11%), and other similar statistics, please refer to Table 2 in the Appendix.

Regression

We analyzed the results from different regression models for each of three separate endogenous variables: the number of seniors involved, the number of seniors killed, and the number of senior pedestrians killed in fatal motor vehicle accidents in NYC. For each of the three endogenous variables, we created models of varying complexity in order to determine how explanatory power would differ between relatively simple models (few exogenous variables) and more complex ones (with more exogenous variables).

Ultimately, we found that the simplest models provided insufficient explanatory power with relatively low R-squared values while the more complex models saw large gains in explanatory power (higher R-squared values). We have therefore highlighted the results from our more complex regression models for each of the three endogenous variables (see regression results in Table 3 of the Appendix). Across all three models, we see a statistically significant negative correlation between SPFAs and accident rates - that is, fatal motor vehicle accidents occur at lower rates in census tracts after implementing SPFAs than in census tracts without SPFAs.

We also found that for all three endogenous variables, the coefficients for our interaction variables met an alpha level standard of .1. Two of three models even meet an alpha threshold of .01. Although they are not represented in Table 3, each of the three models included a set of exogenous variables such as weather conditions, time of day, and more. (For a complete list of exogenous variables used in these models, see Figure 1.) Overall, the regressions confirm all three hypotheses: we find that the policy introduced by NYC DOT reduced accidents involving seniors by 5%, reduced the number of seniors killed in accidents by 34%, and reduced senior pedestrian deaths by 10%.

Robustness Check

To validate the results of our regression models, we performed a robustness check to better pinpoint the effects of SPFAs on fatal pedestrian accidents. Similar to our linear regression models, our robustness check involved creating a series of regression models using the same dependent and independent variables. However, our robustness models added yearly effects whereas our previous models only had one variable indicating whether an accident occurred before or after SPFA implementation.

The results from our robustness check (seen in Table 4 in the Appendix) show a statistically significant negative correlation between our dependent variables and our yearly interaction variables (year * Round 1 SPFA) for almost every year. The coefficients for the interaction between year and accidents occurring within SPFAs are, in many cases, negative and statistically significant at alpha = .01. These results were highly comparable with the results from our previous regression modelling, suggesting that the policy had a relatively consistent impact across time.

Limitations

Several limitations may, ultimately, have some effect on the results of our analysis. The FARS data, though relatively robust, included some missing information. We were forced to remove any rows missing precise geographical data since we would be unable to analyze these accidents (approximately 1% of rows were missing geographical data).

The FARS data was also limited by the fact that it only includes accidents in which at least there was one fatality. NYC's Safe Streets for Seniors program is concerned not only with reducing pedestrian fatalities but also serious injuries to pedestrians. Our study, therefore, cannot provide an exhaustive analysis of the effectiveness of the program. We found no public data, though, for non-fatal motor vehicle accidents that also included age-related information.

Other study limitations concern the SPFA data. As previously described, for any census tract that even partially contained an SPFA, we counted all accidents that occurred within that census tract as having occurred within an SPFA, which likely resulted in some overcounting of accidents within SPFAs. Similarly, the precision of our models would have benefitted from more information regarding the exact timing of SPFA implementation. The information published by the DOT online only includes the year in which SPFAs were implemented. And DOT was, unfortunately, unwilling to provide this information even after repeated contacts with their office. Had we known exactly when each SPFA was completed, we would have been able to further refine our models.

Conclusions

In summary, our regression models suggest that NYC's SSfS program is helping to reduce the number of seniors killed each year by motor vehicles. There are statistically significant negative correlations between SPFAs and the number of seniors involved, number of seniors killed, and number of senior pedestrians killed in fatal motor vehicle accidents. Not only this, but our robustness check confirmed that the policy has been steadily effective across time.

Our study has multiple implications. First, the success of applying diff-in-diff methodology to understanding the effect of a particular public policy could serve as a guide to other researchers. In any urban context, there are a myriad of interrelated factors that can have an effect on a given population. But with diff-in-diff methodology, we can help to isolate the effects that can be directly attributed to a particular policy, which is essential to forming effective policy in the future.

Finally, our study suggests that other cities should consider adopting programs similar to Safe Streets for Seniors in order to protect their own senior populations. Navigating urban environments on foot can be extremely challenging but also essential to the life and well-being of seniors. As urban senior populations grow in the coming decades, it will be especially important to ensure their safety. There is no “one size fits all” solution to any public policy measure. However, NYC’s Safe Streets for Seniors has made a significant step in the right direction.

Appendix

Type of Data	*Datasets*	*Relevant Fields*
FARS Data	**Accident Dataset**	**ST_CASE, Date, Latitude, Longitude**
FARS Data	**Person Dataset**	**Age, Sex, Person Type, Date of Death, Drinking involvement, Drug involvement, Related Factors, Dead at scene or not, Injury severity**
SPFA Data	**SPFA shapefile**	**SPFA Name, SPFA Implementation Round, Shape area, Longitude, Latitude**

Table 1: This table describes each of the two primary data sets used in our analysis of NYC's SPFAs - FARS traffic safety data from the NHTSA and SPFA data from the NYC DOT.

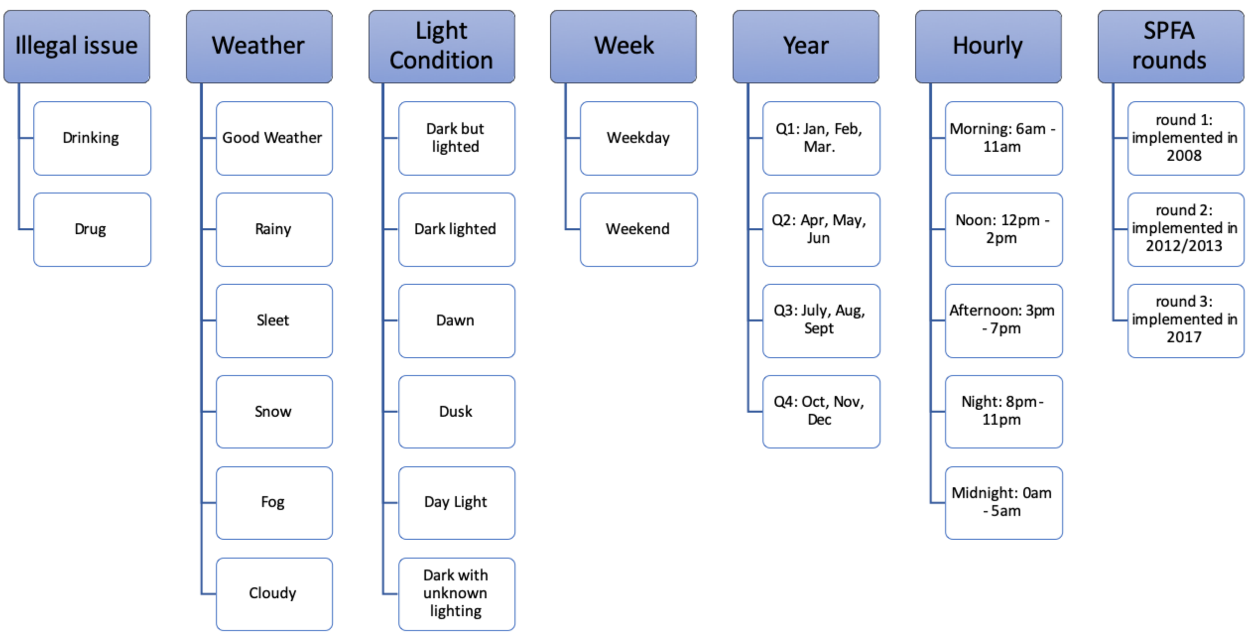

Figure 1: Graph of variables used for linear regression modelling in order to control for the influence of outside factors on trends in pedestrian accident rates within NYC.

Variable	Mean	Standard Deviation
SENIOR	10.63%	39.64%
S_PED	6.20%	25.61%
S_PED_DEAD	6.10%	25.25%
S_DEAD	8.44%	33.93%
S_DRINKING	0.10%	3.16%
S_MALE	4.77%	24.35%
S_DRUG	0.02%	1.41%
WEATHER_GOOD	12.82%	36.20%
WEATHER_RAIN	1.86%	13.62%
WEATHER_SNOW	0.11%	3.26%
WEATHER_FOG	0.01%	1.15%
WEATHER_CLOUDY	0.92%	9.71%
LGT_COND_DAYLIGHT	7.33%	27.02%
LGT_COND_DARK_LIGHTED	7.07%	26.61%
LGT_COND_DAWN	0.46%	6.86%
WEEKDAY	11.72%	34.64%
YEAR_Q1	3.73%	19.44%
YEAR_Q2	3.46%	18.71%
YEAR_Q3	3.74%	19.22%
MORNING	3.52%	18.72%
NOON	2.10%	14.67%
AFTERNOON	4.17%	20.59%
NIGHT	3.25%	18.10%
MIDNIGHT	2.93%	17.27%
rounds_1	1.60%	13.03%
rounds_2	1.18%	11.76%
rounds_3	0.92%	10.34%

Table 2: Overview of summary statistics on fatal motor vehicle accidents and variables related to those accidents. We can see, for example, that 10.6% of fatal motor vehicle accidents in NYC involve at least one senior while 6% result in the death of at least one senior pedestrian.

Regression Results

Dependent variable	Number of accidents in the census tract involving at least one senior (1)	Number of seniors killed in accidents within the census tract (2)	Number of senior pedestrians killed in accidents within the census tract (3)
Post	-0.007** [0.004]	-0.043*** [0.004]	-0.004 [0.003]
Round 1	0.105*** [0.020]	0.242*** [0.019]	0.135*** [0.015]
Post * Round 1	**-0.05*** **[0.028]**	**-0.341***** **[0.027]**	**-0.098***** **[0.021]**
Observations	15028	15028	15028
R-squared	0.686	0.603	0.572

Table 3: Results from our regression modelling. The variable labelled "Post" indicates whether or not an accident occurred after the first round of SPFA implementation. "Round 1" indicates whether the census tract where an accident occurred contains at least one SPFA. "Post * Round 1" is the interaction term between these two variables. Variable coefficients are displayed along with standard errors values in brackets and significance levels as follows: * = 10%; ** = 5%; and *** = 1%.

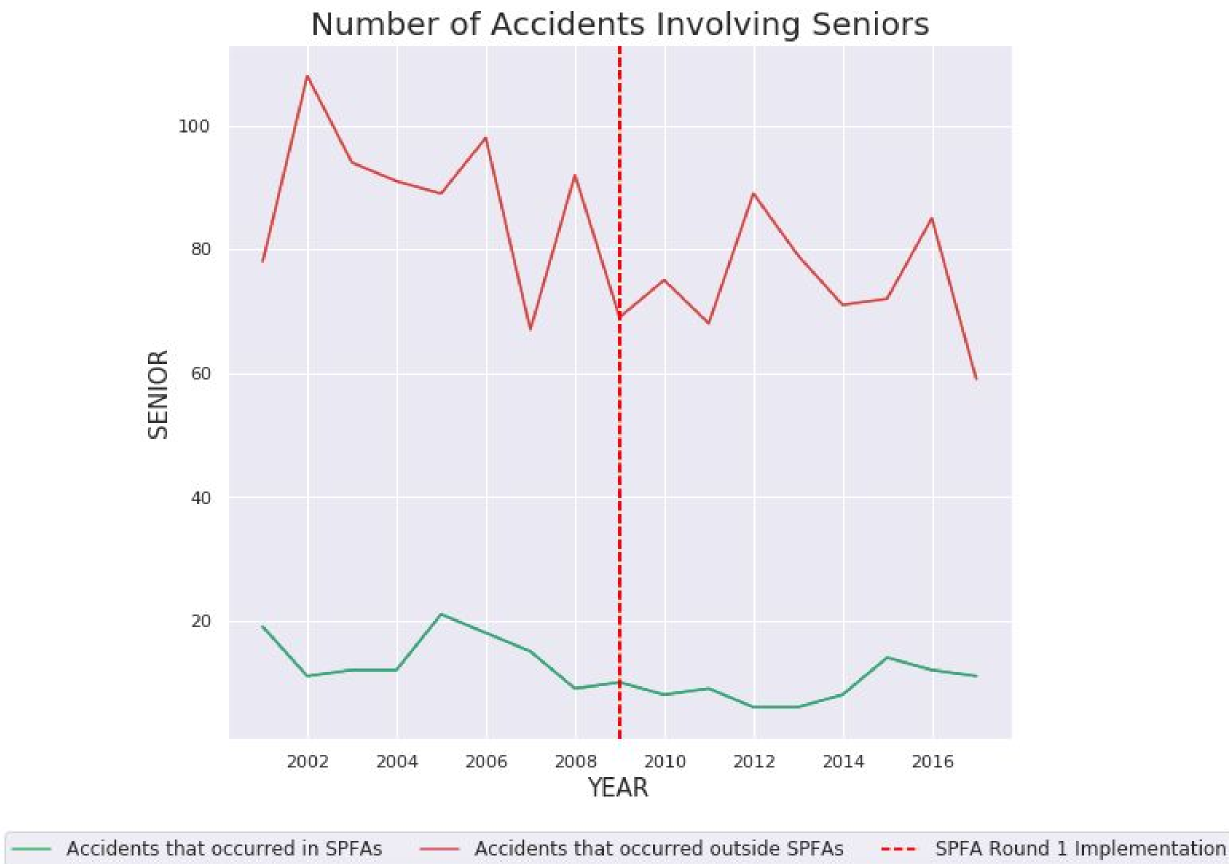

Figure 3: The number of accidents involving at least one senior. There are far more accidents involving seniors that occurred outside SPFAs, which makes sense since SPFAs only occupy a relatively small portion of NYC's land mass (see Figure 2).

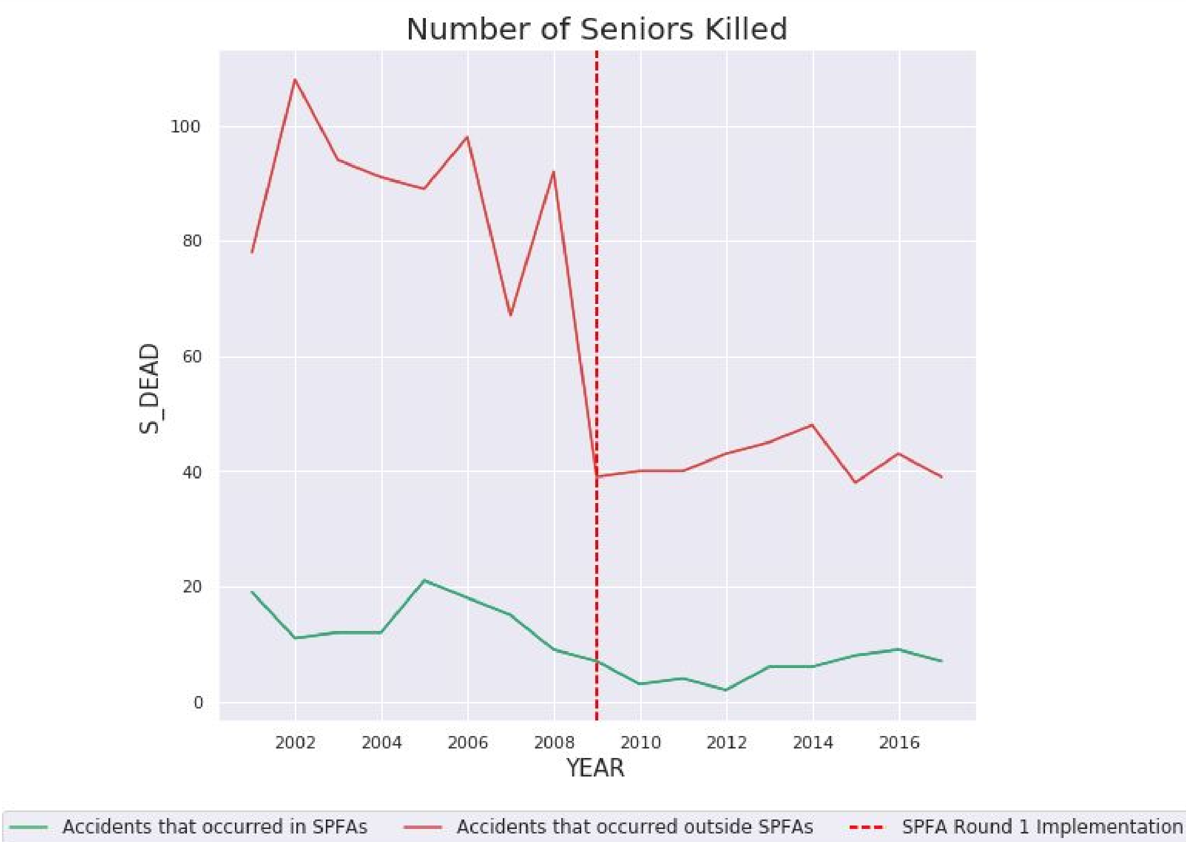

Figure 4: The number of accidents involving the death of at least one senior, who could have been a pedestrian, driver, or passenger. We see a steep decline in the number of senior deaths immediately after 2008 - the year in which the first SPFAs were implemented.

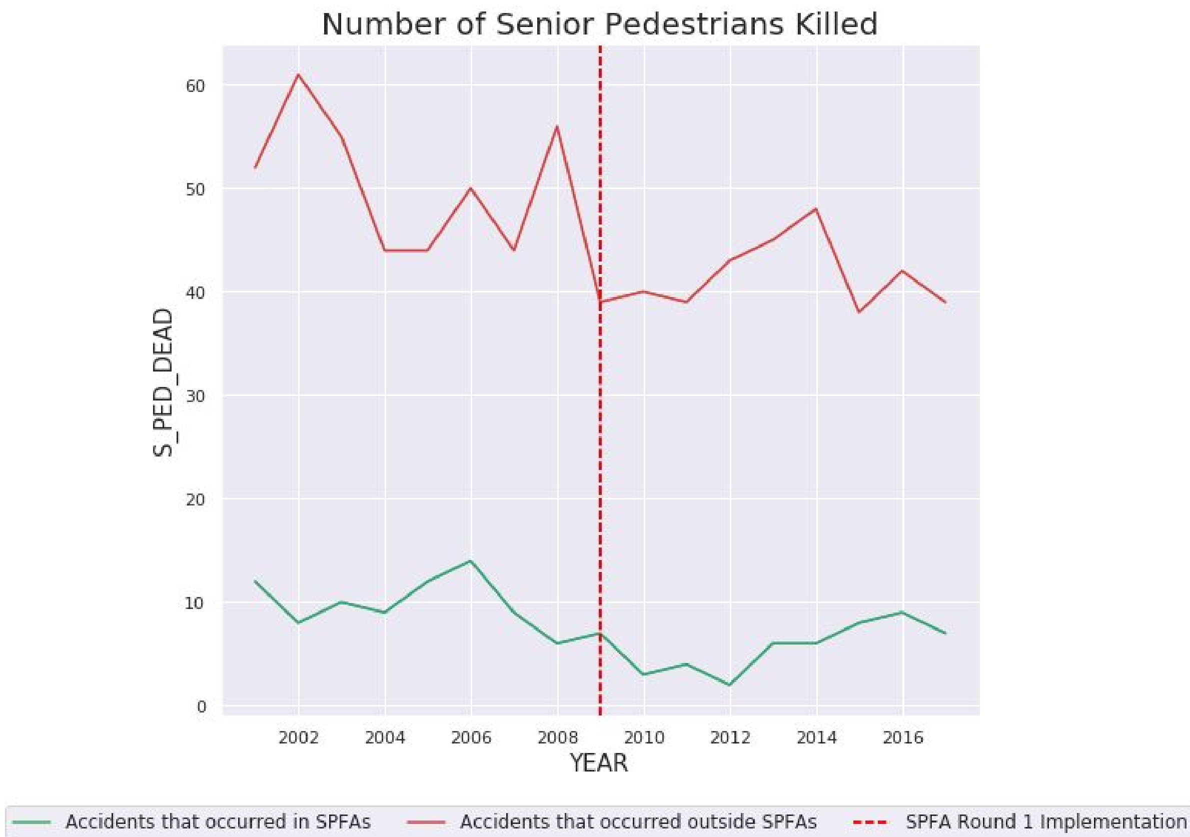

Figure 5: The number of accidents involving the death of at least one senior pedestrian. Here we can see very clear similarities in the overall trend in senior pedestrian deaths both in and outside of SPFAs, which helps to satisfy the parallel trends assumption for diff-in-diff approach.

Robustness Check

Yearly categorical variable (independent)	Number of senior-involved accident (1)	Number of dead seniors (2)	Number of dead senior pedestrian (3)
2008	0.018*	0.020**	0.008
	0.011	0.010	0.008
2009	-0.002	-0.035***	-0.007
	0.011	0.010	0.008
2010	-0.009	-0.039***	-0.013
	0.011	0.010	0.008
2011	0.014	-0.030***	-0.007
	0.011	0.010	0.008
2012	0.02*	-0.028***	-0.001
	0.011	0.010	0.008
2013	-0.024	-0.034***	-0.010
	0.011	0.010	0.008
2014	0.079	-0.017	0.005
	0.011	0.010	0.008
2015	0.010	-0.029***	-0.006
	0.011	0.010	0.008
2016	0.017	-0.028***	-0.004
	0.011	0.010	0.008
2017	0.011	-0.014	0.008
	0.011	0.010	0.008
Round 1	0.365***	0.516***	0.287***
	0.056	0.054	0.042
2008 * Round 1	-0.311***	-0.255***	-0.385***
	0.085	0.082	0.064
2009 * Round 1	-0.405***	-0.711***	-0.321***
	0.073	0.070	0.054
2010 * Round 1	-0.052	-0.590***	-0.260***
	0.086	0.082	0.064
2011 * Round 1	-0.313***	-0.699***	-0.368***
	0.086	0.082	0.064
2012 * Round 1	-0.558***	-0.860***	-0.554***
	0.082	0.079	0.061
2013 * Round 1	-0.445***	-0.545***	-0.188***
	0.082	0.079	0.061
2014 * Round 1	-0.245***	-0.439***	-0.103

	0.088	0.084	0.065
2015 * Round 1	0.107	-0.422***	-0.060
	0.088	0.084	0.065
2016 * Round 1	-0.402***	-0.550***	-0.160***
	0.079	0.076	0.059
2017 * Round 1	-0.203**	-0.564***	-0.097
	0.102	0.098	0.076
Observations	15028	15028	15028
R-squared	0.69	0.607	0.576

Table 4: Results from our robustness check modelling. “Round 1” indicates whether a census tract includes at least one first-round SPFA. Each yearly variable is an indicator equal to one if a given accident occurred in that year and zero otherwise. Standard errors are shown in brackets and significance levels are indicated as follows: * = 10%; ** = 5%; and *** = 1%.

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