Effects of a vision zero approach in New York City

Assessing Road Safety Outcomes for Different Land Use Contexts

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Abstract

New York City was one of the earliest jurisdictions in the United States to adopt Vision Zero, the systemic approach to traffic safety first introduced in Sweden. The efforts seem to have paid off as NYC has made good progress in reducing traffic fatalities. This study assesses fatality trends based on land use context at the census tract level and looks at the outcomes before and after Vision Zero was implemented. We identify a large and growing discrepancy in fatality rates between pedestrians, bicyclists, and car occupants in places with different land uses. Pedestrian fatalities rates in low density area were 16 times higher than that in highest density area in 2014-2018. Vision Zero has implemented more treatments in higher density areas but had little to no impact on these high rates in other places. Our research strongly suggests the need for context sensitive strategies to reduce traffic fatalities.

Keywords

Vision Zero; Meso-level Analysis; Land use; Road Safety, Pedestrians.

Introduction

In the 1990s, Sweden and the Netherlands pioneered Safe System approaches to road safety, named Vision Zero and Sustainable Safety respectively. The success of these systemic approaches has had a large impact on how road safety is perceived. These strategies emphasize a holistic way of managing traffic safety based on all components within that system including road environments, speed regimes, vehicle safety, and post-crash intervention. Particularly, the paradigm of Safe System as practiced in both countries shifted from focusing on the vulnerability of road users as the cause of crashes to developing a road environment that catered to human limits and tolerance (Khayesi, 2020). In a previous study, our research showed that the huge achievement in reducing traffic fatalities in both countries can largely be attributed to safety improvements for non-motorized users (Shi et al., 2022). This is substantially different from the trends in the USA as a whole where pedestrian fatalities have sky-rocketed since 2009. Specifically, pedestrian fatalities increased 54% from 2010 to 2020 while other fatalities increased 13% (*Pedestrian Traffic Fatalities by State: 2021 Preliminary Data*, n.d.).

Nonetheless, some places have made some progress in protecting non-motorized road users, including New York City (NYC). NYC is one of the earlier jurisdictions that adopted a safe system approach to address road safety issue in the USA. Since NYC officially launched its "Vision Zero" initiative in 2014, it has implemented a series of actions to tackle road safety issue, such as enhanced crossing, leading pedestrian intervals, left turn traffic calming, protected bike lanes, and citywide speed limit reductions (*Vision Zero Year 7 Report*, 2021). The safety outcomes resulting from this work are remarkable. In 2020, total fatalities fell 10% and pedestrian fatalities fell 37% compared to the five-year averages in 2009-2014 before the official adoption of Vision Zero (*Vision Zero Year 7 Report*, 2021). Since one of principles of Vision Zero is to track the progress by employing data-driven studies, we need to further investigate the effectiveness of Vision Zero approach at an area-wide level and examine how safety improvements are distributed across NYC. Our study attempts to answer the following questions use categorical analysis based on population and job density at the census tract level: 1) Do fatalities/fatality risk vary across types of places with different population and employment densities? 2) Do the changes in fatalities/fatality risk between before and after the adoption of Vision Zero differ across different types of places?

Data and Analysis

Data Source

Crash data were obtained and cross-referenced from Fatal Accident Reporting System (FARS) and NYC Open Data- Motor Vehicle Collisions (National Highway Traffic Safety Administration, n.d.; NYC Open Data, n.d.). Most crash data entries have coordinates for latitude and longitude, and those that did not were geocoded if they included legible street or intersection names. The data were aggregated to the census tract level over two 5-year periods (years 2004-2008 and 2014-2018). In addition to fatalities, the numbers of injuries were also available, but only from 2014 to 2018. We derived population and employment data at each census tract from Smart Location Database versions 2.0 and 3.0, respectively for our before/after Vision Zero time periods (US Environmental Protection Agency, n.d.). Originally, population data were from 2010 decennial Census and 2018 Census American Community Survey (ACS) 5-Year Estimate; employment data were from 2010 and 2017 Longitudinal Employer-Household Dynamics. To control for exposure, we used mode share data from ACS 5-year estimated commuting in 2010 and 2018.

Categorical Analysis

We examined the land use features, including population density, land use mix, road network density, and walkability score at citywide 2164 census tracts. We focus on combined density of population and jobs because it is a reliable indicator of activity in the built environment for the scale of our study. Some census tracts with unique land use types were excluded before the density classification. We categorized the remaining 2115 census tracts into four equal-sized groups based on the density in 2010. The combined density of population and jobs is calculated as follows:

$$density = \frac{population + jobs}{area\ of\ census\ tract\ (acres)} \tag{1}$$

We identified four groups ranging from low density (<45.5 count/acre), medium density (45.2-78.8 count/acre), high density (78.8-130 count/acre) and highest density (>130 count/acre). In order to evaluate safety performance by classes of road users in each group, we developed several road risk indicators using estimates of exposure.

Equation (2) shows the fatality rate for each class of road user. The first metric was used to control the number of road users in each group of census tracts. We adopted user-based exposure matrices as the estimates for the actual number of bicyclists and pedestrians, which was developed by Marshall & Garrick in 2011.

$$fatality\ rate = \frac{fatalities}{estimated\ number\ of\ road\ users/1{,}000} = \frac{fatalities}{mode\ share * (population + jobs)/1{,}000} \tag{2}$$

Equation (3) defines the risk of fatality as the ratio of fatalities to casualties. This metric is an important dimension to track the progress of Vision Zero initiative as mitigating crash severity is a vital principle of safe systems.

$$risk\ of\ fatality = \frac{number\ of\ fatalities}{number\ of\ casualties} = \frac{number\ of\ fatalities}{number\ of\ fatalities + number\ of\ injuries} \quad (3)$$

In addition to safety outcomes, we also counted the numbers or total length for different types of countermeasures and normalized them by either total number of intersections or the length of the street networks in each density group based on the type of countermeasures, as defined in Equation (4).

$$intensity\ of\ vision\ zero\ actions = \frac{number/length\ of\ eachtype\ implementation}{total\ number\ of\ intersections\ or\ total\ length\ of\ street\ network\ in\ each\ group} \quad (4)$$

Results

In this section, we calculate the metrics described in Data and Analysis section and show the results for NYC as a whole and each density group for 2004-2008 and 2014-2018. Figure 1 shows the map of density groups and special land use at the census tract level in NYC. There are unique patterns for geographical distribution of density groups across the city and in each borough.

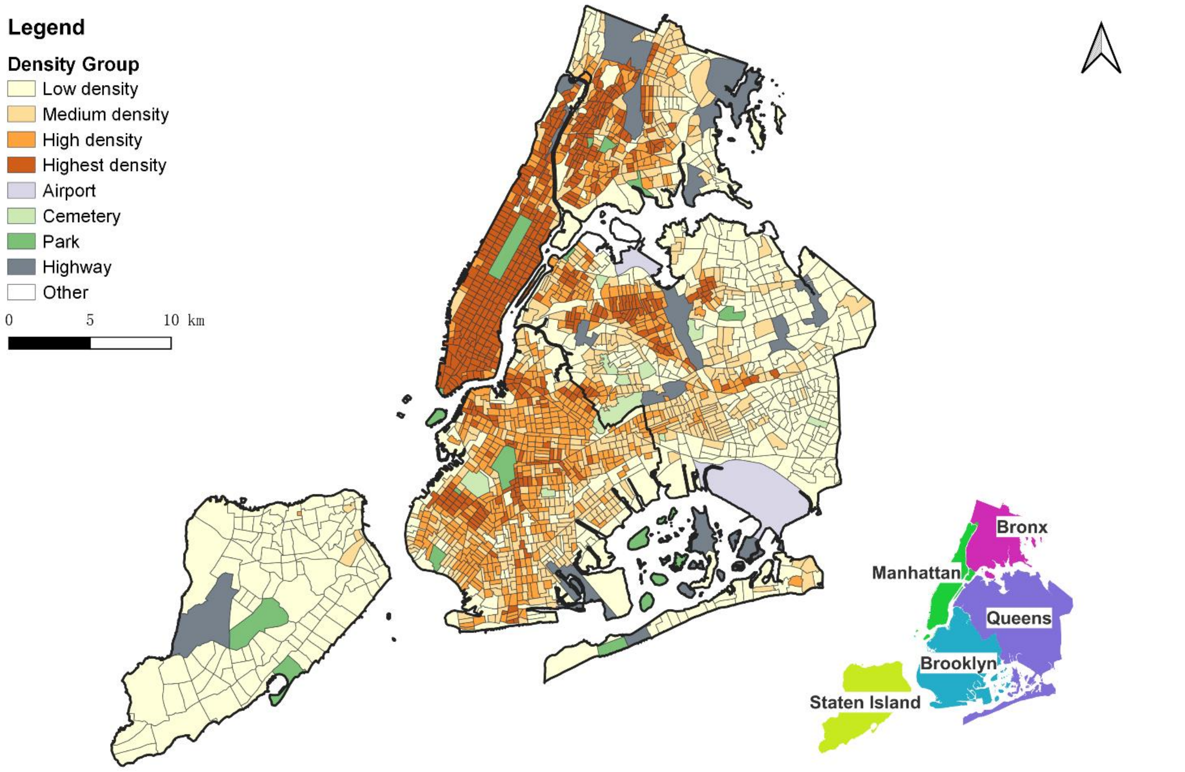
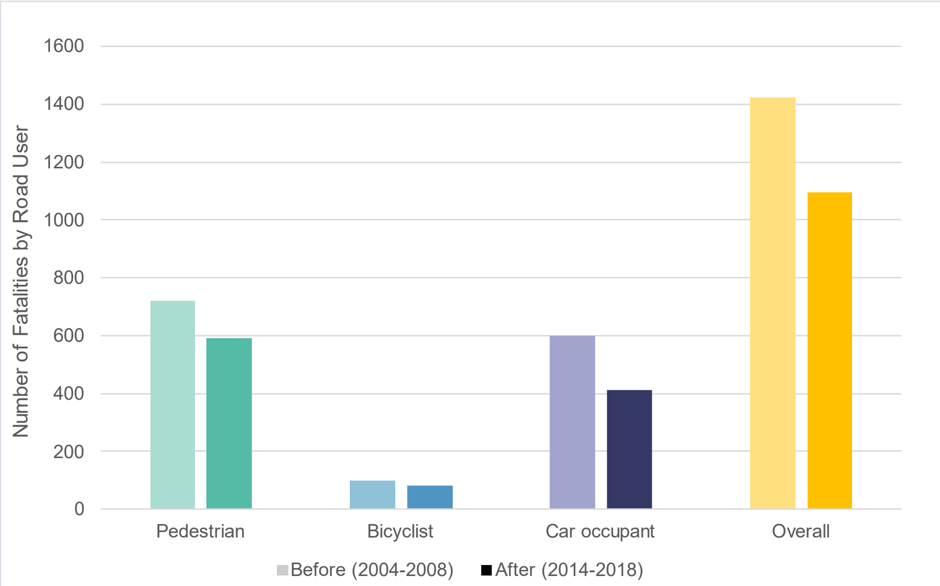


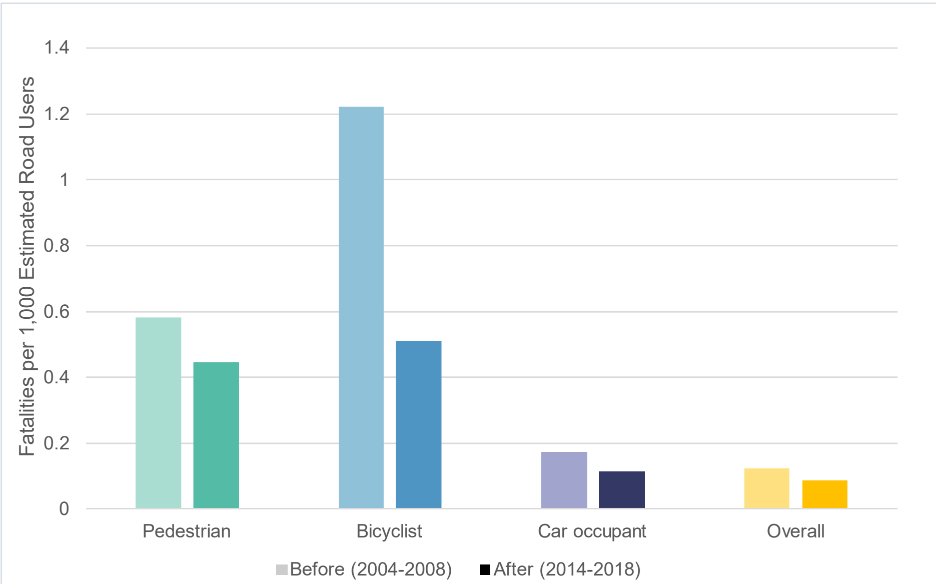
Figure 1 Map of census tract groups in NYC based on density

Citywide

As shown in **Figure 2**, NYC has made substantial progress in pursuing zero death goals from 2004-2008 to 2014-2018 after it adopted Vision Zero initiative. However, the pace of declines for different classes of road users are very different. Car occupant fatalities decreased by 32% while pedestrian fatalities and bicyclist fatalities decreased by only 18% and 16% respectively, as shown in **Figure 2a**. **Figure 2b** shows fatality rates for classes of road users based on the mode-share-based risk measure and overall fatalities per 1,000 population. It is noteworthy that the largest reduction in fatalities took place for bicyclists (58%), arguably because of the increasing use of bicycle in the recent decade**.** The statistics from a NYC report confirmed this finding by showing that bicyclist severe injuries and fatalities per ten million trips decreased by 69% from 2005 to 2018 (*New York City Cycling Risk: Changes in Cyclist Safety Relative to Bicycle Use in New York City 2000 - 2018*, n.d.). What caused the modal shift towards bicycling is interesting to find. Our assumption is that the better protected bicycle lane networks and popular bike sharing programs helps promote the bicycling trips in NYC. On the whole, non-motorized users still had substantially greater fatality rates than car occupants did in 2014-2018. The fatality per 1,000 road users for pedestrian fatalities and bicyclist fatalities were 3 and 4 times higher than that for car occupants. This indicates that the disparities of road safety exist between different classes road users in NYC.



(a)



(b)

Figure 2 Comparison of (a) number of Fatalities and (b)fatalities per 1,000 estimated road users for different classes of road users in NYC

Census Tract-level Density Groups

Figure 3 shows the raw number of fatalities for pedestrians, bicyclists, car occupants, and total fatalities aggregated at different density groups. The numbers of total fatalities were higher in the low density group compared to the other three groups both before and after Vision Zero. Strikingly, low density areas, which are not usually associated with intense pedestrian activity, had the largest number of pedestrian fatalities. Bicyclist fatality numbers tend to be larger in areas with higher density levels. The numbers of car occupant fatalities were substantially higher in low density areas compared to other density groups.

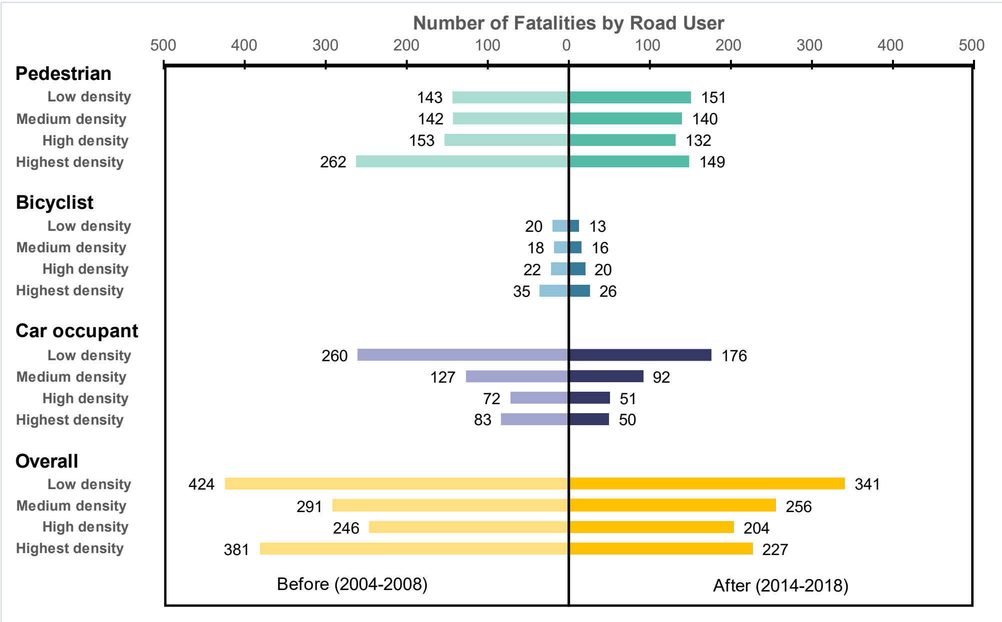


Figure 3 Comparison of fatalities for density group by class of road user

Figure 4 shows the fatalities per 1,000 estimated road users for classes of road users aggregated at different density groups. We did not include the car fatality rate here as we argued that car mode share does not align with the number of car trips at census tract level. The data reveal a huge and growing discrepancy in pedestrian, bicyclist, and overall fatality rates across different density areas. Those non-motorized users had a dramatically higher fatality rate in areas with low density. Even in 2014-2018, pedestrian fatalities per 1,000 pedestrians in low density areas were 16 times higher than that in highest density area, and 3 times higher than that in high density area. The difference for bicyclist rates between density groups was slightly smaller. The data show that both pedestrians and bicyclists—often labelled as vulnerable road users--were at greater risk in low density areas of NYC.

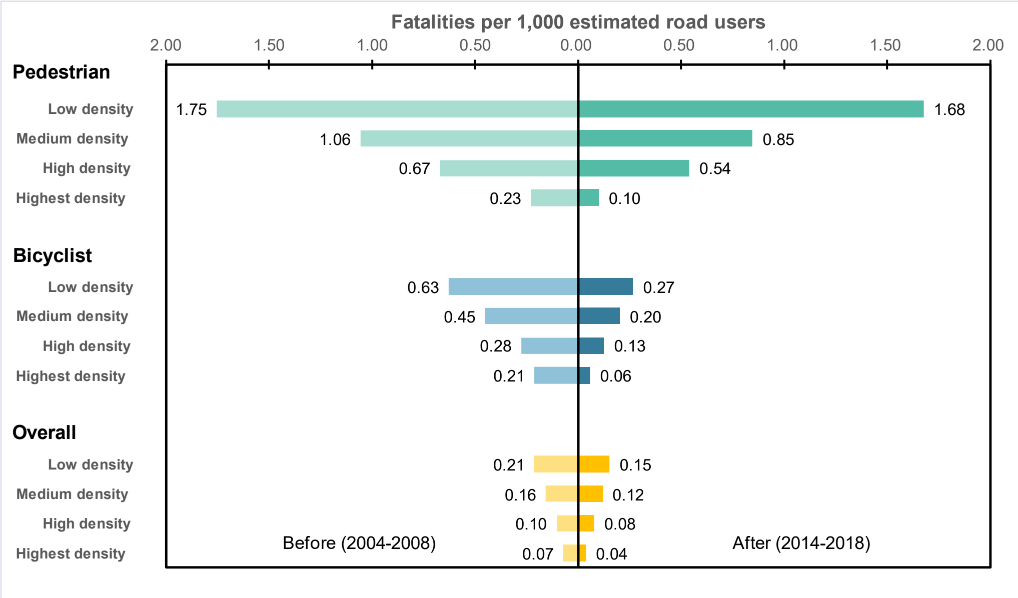


Figure 4 Comparison of fatalities per 1,000 estimated road users for density group by class of road user

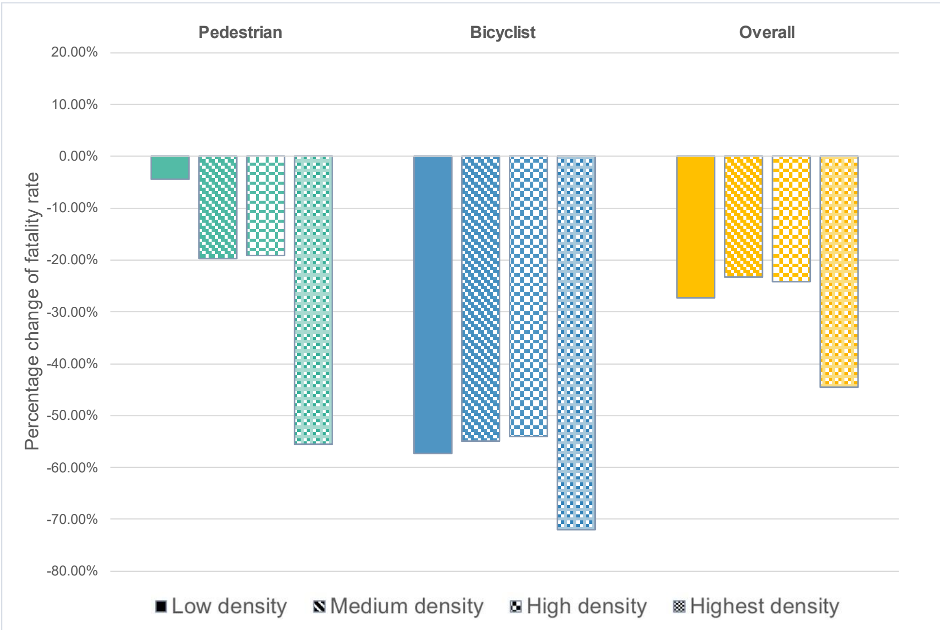


Figure 5 Percentage change of fatalities per 1,000 estimated road users for different classes of road users by density group (2004-2008 and 2014-2018)

Figure 5 tracks the changes of average number of fatalities and fatalities per 1,000 estimated road users between 2004-2008 and 2012-2018. Low-density areas strikingly saw little decrease in average pedestrian fatalities and fatality rates in the after period. This indicates that pedestrian safety in low density areas did not improve.

Figure 6 shows the risk of fatality when one person is involved in an injurious crash. The results are consistent with the general patterns from the previous metrics. The probability of being killed as a pedestrian or bicyclist involved in an injurious crash was more than two times higher in low density areas than in the highest density area. It is also noteworthy that the risk of fatality for pedestrians and bicyclists was much higher than that for car occupants wherever they are. It indicates the persistence of the “vulnerable road users” concept in NYC and a huge gap in unprotected road users’ safety between NYC and those countries such as Sweden and the Netherlands that pioneered the safe systems approach. From our previous studies (Shi et al., 2021), the Netherlands has virtually eliminated the concept of “vulnerable road users” in that the risk of fatality for pedestrian, bikers and vehicle occupants have all converged to about 23 fatalities per million users through Sustainable Safety program.

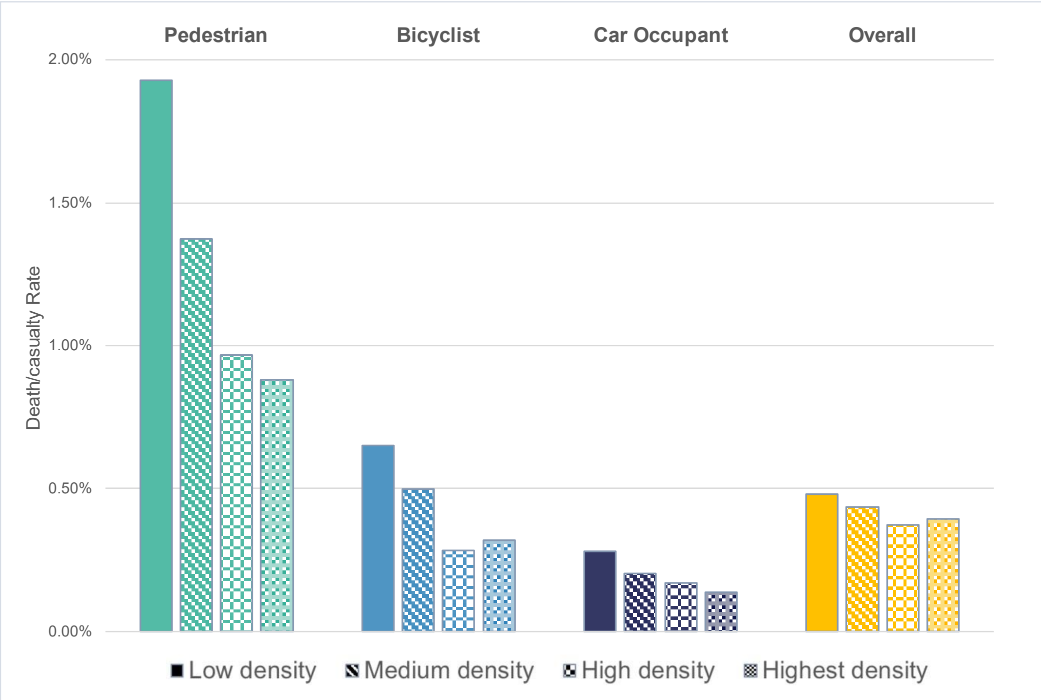
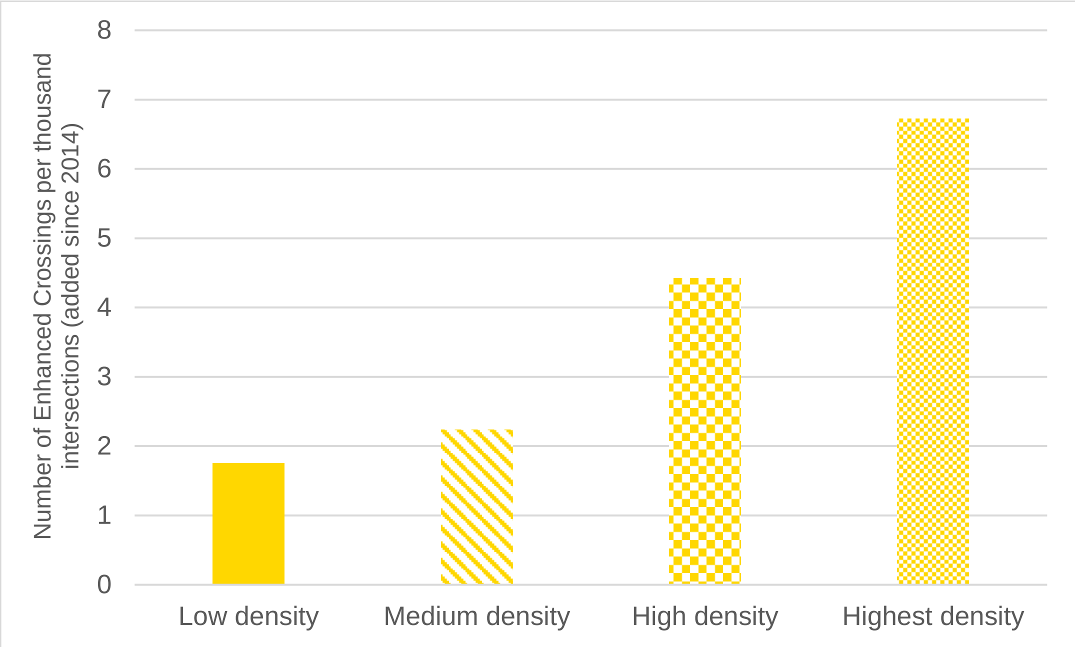


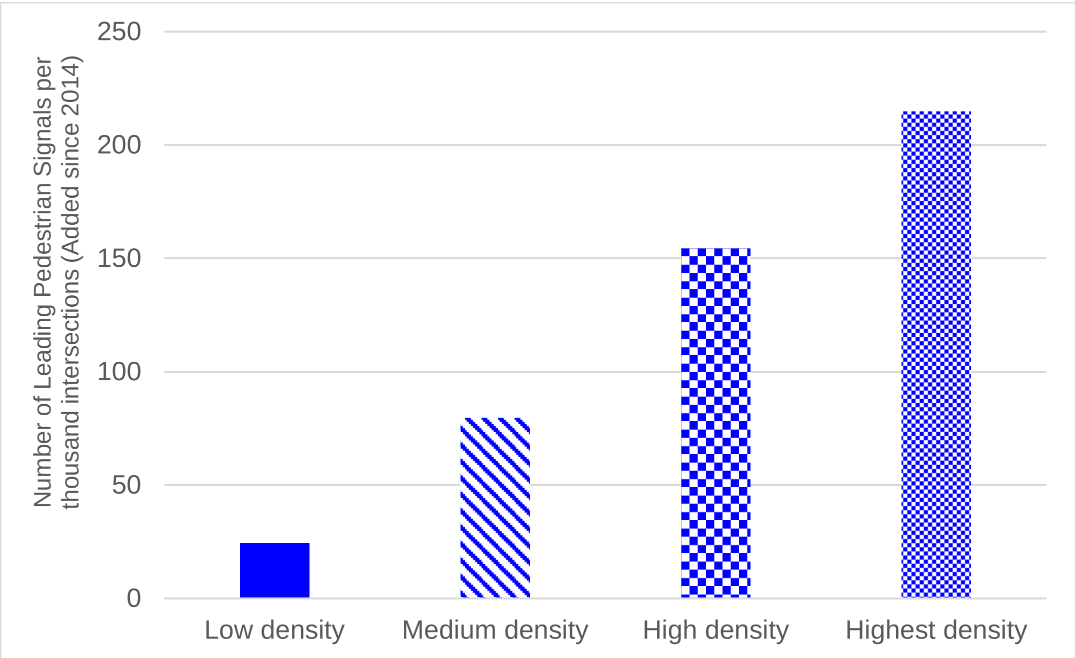
Figure 6 Death/casualty rate for different classes of road users, 2014-2018

Vision zero related actions

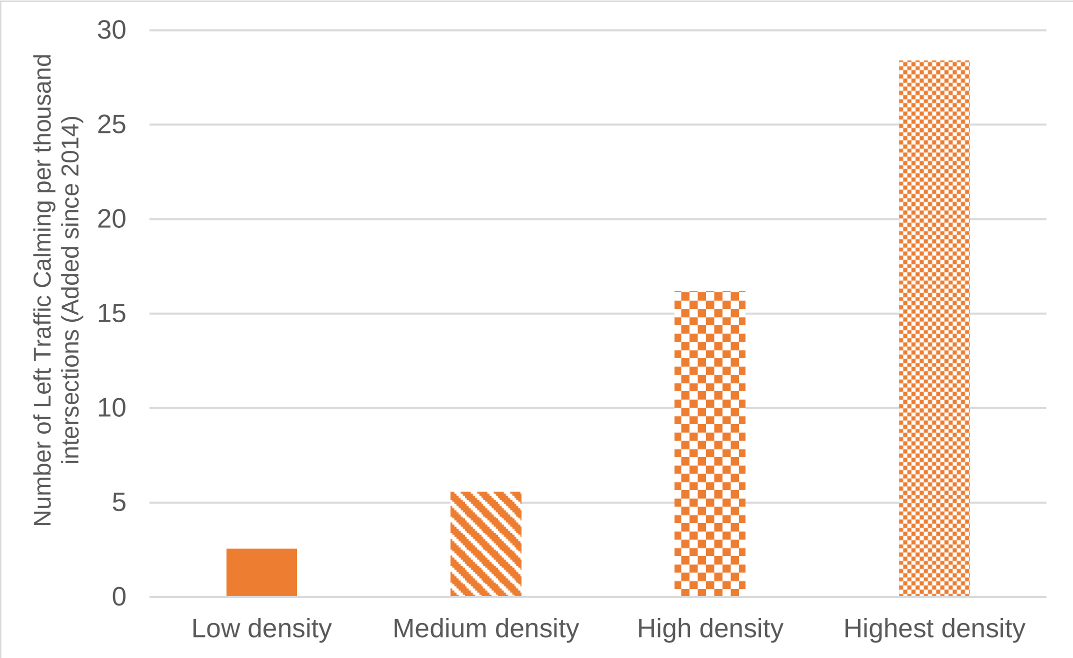
Figure 7 represents the calculated intensity of different types of vision zero tools implemented since 2014, including enhanced crossing, leading pedestrian signal, left traffic calming, speed humps, and signal retiming. One clear pattern is that the intensity of vision zero related actions increases as the density level increases. One exception is speed humps that are most prevalent in the second highest density group.



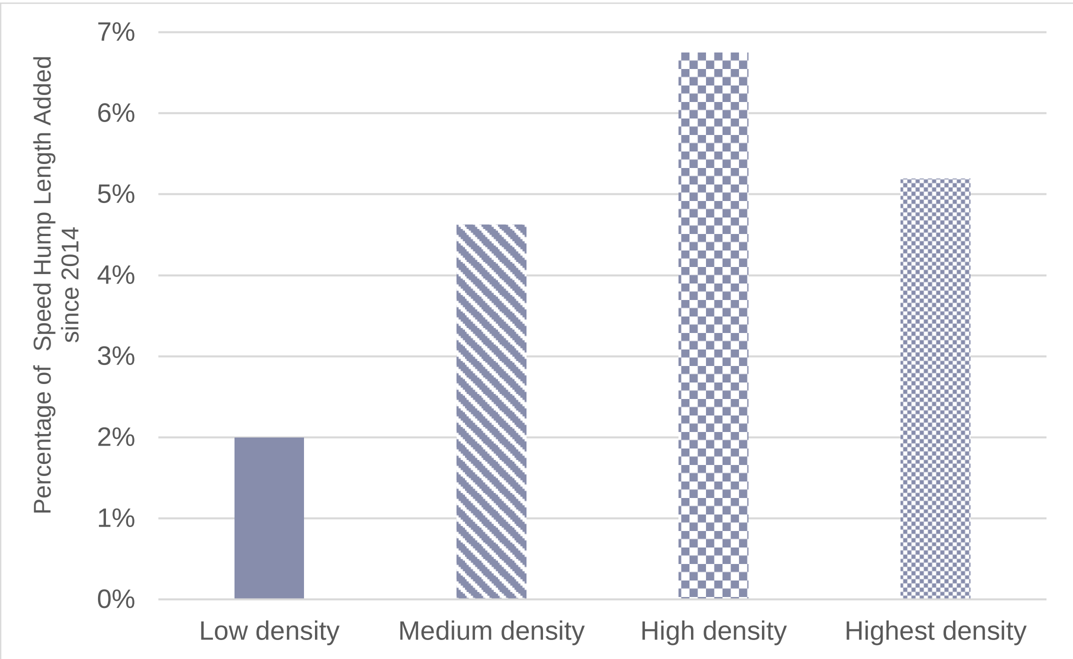
(a) Enhanced crossing



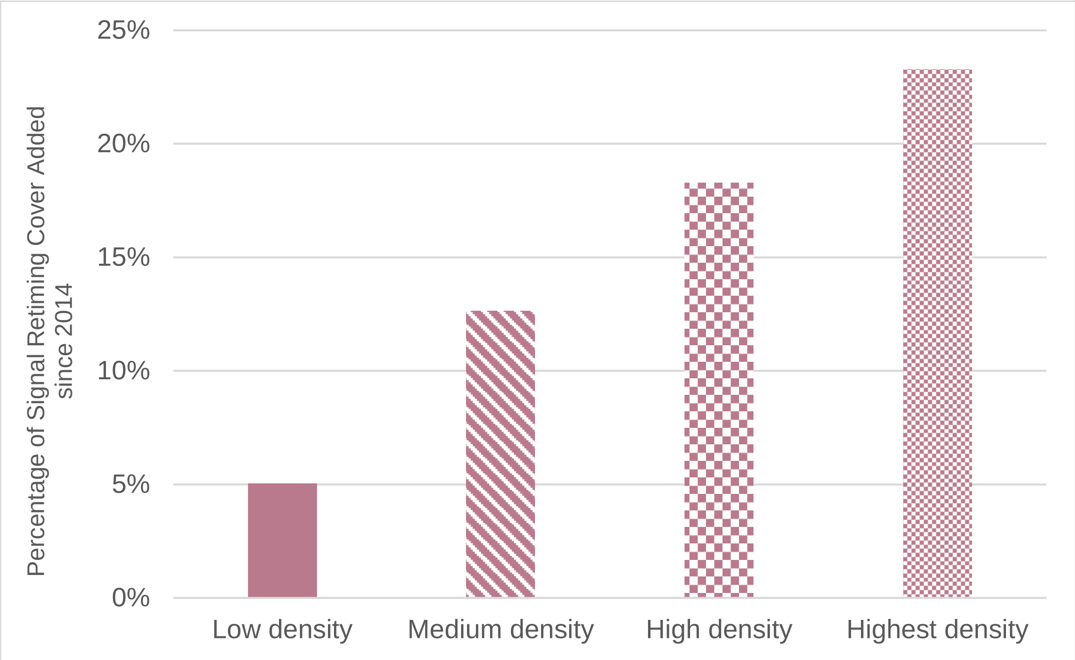
(b) Leading pedestrian signal



(c) Left traffic calming



(d) Speed humps



(e) Signal retiming

Figure 7 Intensity of different types of vision zero actions since 2014 by density group

Conclusion

We observe that NYC's implementation of Vision Zero has been successful in creating a significant reduction in fatalities for all classes of road users, not only for car occupants but also for pedestrians and bicyclists. Numbers of pedestrian fatalities and bicyclist fatalities declined by 18% and 16% respectively from 2004-2008 to 2014-2018. This is an uplifting achievement given the fact that in many other places in the USA, pedestrian fatalities have increased considerably. However, our research finds that low density areas were much more dangerous for all types of road users, particularly for non-motorized users. In 2014-2018, pedestrian fatalities per 1,000 pedestrians in low density area were 16 times higher than that in highest density area. We also identified large and growing inequalities in fatality rates between pedestrians, bicyclists, and car occupants in these areas. Number of pedestrian fatalities rose by 6% in low density group over time. These results suggest that the Vision Zero impacts to date have resulted in very different outcomes for different types of user groups and for different types of land use context. In terms of related safety treatments implemented after declaration of Vision Zero, higher density areas saw noticeably higher intensity of different kinds of vision zero actions. This difference could potentially explain the disparities between road safety outcomes across places with different densities.

This paper represents a first step in examining the impact of Vision Zero in NYC, and is focused on measuring changes of safety outcomes before and after Vision Zero by geographic area based on density. The next steps following this study will be to link those changes to Vision Zero related treatments to determine why the patterns are what they are in the city, and from there, to provide more insights into what strategies may be most appropriate for specific contexts.

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