How is Traffic Safety Affected by Changes in Traffic Speeds Following Speed Limit Increases?

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Extended Abstract

1. Introduction

The travel speeds along a highway are affected by many factors, including the posted speed limit. Roadway geometry, traffic, and weather conditions also influence the choice of speed, while differences are also observed across various groups of and drivers [1-2]. Speed limits tend to have a direct relationship with travel speeds. Prior research has shown that raising the speed limits usually leads to higher travel speeds; however, the changes are less pronounced than the magnitude of changes in the speed limit [3-4]. These changes in travel speeds, in turn, directly affect the safety trends along the roadway. Higher travel speeds are also associated with greater crash frequency as well as a higher proportion of more severe crashes due to higher energy being dissipated during crashes at these speeds. It has been consistently shown that increasing the average speeds leads to a significant increase in crash frequency, [5-10] as well as severity [11]. Additionally, speed has been shown to be one of the most significant determinants of traffic safety. Any percentage change in mean speeds is likely to have a much greater impact on traffic fatalities than a similar change in any other factor, such as traffic volume [11]. Thus, increasing the speed limits tends to increase travel speeds which have significant carryover effects on traffic safety.

In the State of Michigan, the Public Act of 445 and 447 were passed in 2016, which led to a series of increases in posted speed limits throughout 2017. The speed limit on approximately 614 miles of freeways was increased from 70 mph to 75 mph. Speed limits for trucks were also increased to 65 mph on state roads with a passenger car speed limit of 65 mph or higher. The impacts of speed limits on traffic operations and safety have undergone extensive research; however, a strong consensus is yet to be achieved on the relationship between speed and safety. The present research evaluates this relationship by estimating a series of random effects negative binomial models for crash frequency by different severity levels while considering various speed metrics, including mean speed, standard deviation of speed, and different percentiles of speed. The safety trends are evaluated by considering both speed limit increases as well as changes in travel speeds as a result of these speed limit increases.

2. Method

A case-control analysis is conducted that compares crash frequency on roads before and after the speed limit increased in 2017. The roadway segments where the speed limits increased to 75-mph were taken as increase segments, while a group of segments with similar roadway and traffic characteristics where the speed limits were maintained at 70-mph were treated as the control group. Additional data required for analysis include crash data and speed data which are merged with the roadway information data to create a segment-level dataset.

Statewide crash data were obtained for all the segments of interest from the Michigan State Police (MSP) for the period from 2014 to 2019, excluding 2017 since speed limits increased during this year. Consequently, the before-period ranges from 2014 to 2016 while the after-period includes 2018 and 2019. The annual number of crashes occurring on each segment was calculated, both overall, as well as for the most severe level of injury severity sustained in the crash as per the 5-point KABCO scale, where K represents fatal crashes (resulting in a death within 30 days of the crash), A denotes serious injuries (e.g., severe lacerations, burns, broken bones), B

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denotes minor injuries (i.e., any injury evident less than K or A), C denotes possible injuries (no evident external injury, but potential injury noted by crash-involved victim), and O denotes property damage only (PDO) crashes (i.e., no injury). The crash data were integrated with a detailed roadway information database maintained by the Michigan Department of Transportation (MDOT). This dataset contains information detailing roadway geometric characteristics, such as lane and shoulder widths, the number of lanes by type, as well as the presence of features such as medians, among others. This resulted in a total of 2,403 roadway segments. The annual average daily traffic (AADT) was also obtained through MDOT's open data portal and was merged with the roadway information data. Additionally, information about the installation of cable median barriers along the freeway network was also obtained from a prior MDOT research study and integrated into the dataset.

Statewide speed data for limited-access roadways were obtained from probe vehicles, which provide real-time speed data through global positioning systems installed in commercial vehicles, connected passenger vehicles, and cell phones. These data are provided by MDOT through Regional Integrated Transportation Information System (RITIS). RITIS is a secure data platform that integrates existing operational data from various transportation agencies and is available dating back to January 1, 2016. Speed information were obtained in 15-minute intervals for each individual segment and were aggregated over each year of the study period in order to calculate mean, 15th percentile, 50th percentile, 85th percentile speeds, as well as the standard deviation of speed for each of the segments included in the analysis. Since the RITIS data are available starting in 2016, the same speed metrics are assumed for each of the three years of the before-period (2014-2016).

During a comprehensive review of the after-period speed data, a significant inflection point was observed from various site-specific speed profiles. After consultation with MDOT and INRIX, it was found that starting June 2019, there were increases of 5 mph or more in average speeds due to changes in the vehicle fleet from which the speed data were sampled. A significant reduction in the share of heavy vehicles (relative to passenger vehicles) was identified as the cause of this discrepancy. Consequently, to allow for a more appropriate comparison between the pre- and post-speed limit increase periods, speed data for 2019 was aggregated only through May of 2019. The aggregated speed data were then merged with the roadway and crash dataset.

To better understand the nature of these increases, particularly the relationship between speed and safety, a series of random effects negative binomial models were estimated. The random effects modeling framework accounts for any correlation among crash count observations across different years. The natural log of segment length is defined as an offset which introduces an implicit assumption that the crash count increases proportionately with the segment length.

Separate random effects negative binomial models were estimated for crashes at various injury severity levels. Due to the lower frequency of fatal crashes (K), these are aggregated with serious injury (A) crashes. Similarly, minor (B) and possible (C) injury aggregated, while PDO crashes are evaluated separately due to their relatively higher frequency.

3. Findings

Overall, crashes were shown to decrease by 1.9% overall at the control sites. These decreases were more pronounced among B/C level injuries (7.5%) and K/A injuries (5.8%). In contrast, crashes of all types increased by approximately 5.0% at those sites where the speed limits were increased.

In terms of relationship between speed and crash frequency, the results show that both the mean speeds, as well as the standard deviation of speeds were strong predictors of crash frequency across all severity levels. A 1-mph increase in mean speed was associated with a 1.8% reduction in total crashes and these decreases ranged from 0.2% to 2.4% across the various severity levels. On the other hand, the relationship between speed variance and crash frequency was positive. Crashes of higher severity were found to be more sensitive to speed variability with a 1-mph increase in standard deviation in speeds resulting in a 15% increase in KA crashes and 11% and 6.7% increase in BC and PDO crashes, respectively. Total crashes increased by 7% when standard deviation in speeds is increased by 1-mph.

The model results were controlled for several roadway geometric and traffic characteristics. As expected, the crashes were found to increase with traffic volume. The effects were found to be relatively inelastic, with a 1% increase in volume associated with a 0.59% increase in total crashes, KA crashes, and PDO crashes, and a 0.81% increase in BC crashes. The percentage of trucks in the traffic stream was found to have a negative but weak relationship with crash frequency. In general, segments on curves were found to have 12%-39% higher crash frequency compared to the tangent sections. Crashes were significantly lower on segments with wider medians and shoulders.

4. Conclusions

Recent speed limit increases have been associated with significant increases in fatal crashes, though impacts on total crashes, as well as the general relationship between speed and safety remain under researched. This study provides important insights as to the speed-safety relationship based on data from speed limit increases from 70 mph to 75 mph that occurred on nearly 614 miles of rural freeways in Michigan.

From a big picture perspective, the results show that the 5-mph speed limit increase resulted in persistent increases in traffic crashes across all levels of injury severity. These increases were consistently around 5% across all severity levels after controlling for the effects of other important variables. Notably, the mean speed and variability in speed were both strong determinants of crash frequencies on these roadways. Higher mean speeds were associated with lower crash frequencies, though it is unclear the degree to which this is due to driver behavior versus general differences in traffic characteristics across sites. Continuing on this point, greater variability in speeds on a given segment were associated with higher crash frequencies across all severity levels. Several site-specific characteristics, including traffic volume, traffic composition, shoulder and median widths, and the presence of cable median barriers, also tended to affect the frequency of crashes.

The results from this study provide valuable information to support policy decisions and future research related to posted speed limits.

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