Relationship of Traffic Fatality Rates to Maximum State Speed Limits

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ABSTRACT

Objectives: The objective of this study was to examine the safety effects of increases in U.S. state maximum speed limits during the period 1993-2013.

Methods: Poisson regression was used to model state-by-state annual traffic fatality rates per mile of travel as a function of time, the unemployment rate, the percentage of the driving age population that was younger than 25, per capita alcohol consumption, and the maximum posted speed limit on any road in the state. Separate analyses were conducted for all roads, interstates and freeways, and all other roads.

Results: A 5 mph increase in the maximum state speed limit was associated with an 8% increase in fatality rates on interstates and freeways and a 4% increase on other roads. In total, there were an estimated 33,000 more traffic fatalities during the years 1995-2013 than would have been expected if maximum speed limits had not increased. In 2013 alone, there were approximately 1,900 additional deaths — 500 on interstates/freeways and 1,400 on other roads.

Conclusions: There is a definite trend of increased fatality risk when speed limits are raised. As roadway sections with higher speed limits have become more ubiquitous, the increase in fatality risk has extended beyond these roadways. The increase in risk has been so great that it has now largely offset the beneficial effects of some other traffic safety strategies. State policymakers should keep this trade-off in mind when considering proposals to raise speed limits.

Keywords: Driver Behavior; Safety; Vehicles

INTRODUCTION

"Speed kills" has been the theme of a number of traffic safety campaigns, including the 2014 World Day of Remembrance for Road Traffic Victims (United Nations Road Safety Collaboration, 2014). The laws of physics dictate that the energy of a collision increases exponentially with the speed of the colliding objects. So it is generally agreed that the severity of a motor vehicle collision increases at higher speeds. Joksch (1993) concluded that the risk of driver fatality in a crash is approximately proportional to the fourth power of the change in speed. This relationship was extended to nonfatal injuries by Elvik (2009). He concluded that the risk of serious injury is approximately proportional to the third power of the change in speed. Thus it is reasonable to expect that higher speed limits and higher speeds on roads lead to more deaths and serious injuries.

Ever since the invention of the motor vehicle, drivers have been expected to limit their speed to what is "reasonable and prudent" considering traffic, road, and weather conditions. Sometimes called the *basic rule* or the *reasonable man* requirement, this expectation still exists. However, as traffic volume and vehicle capabilities increased, governments saw the need to establish numerical speed limits on certain roadways. For example, the 1861 Locomotive Act made it illegal in the United Kingdom "to drive any Locomotive along any Turnpike Road or public Highway at a greater Speed than Ten Miles an Hour, or through any City, Town, or Village at a greater Speed than Five Miles an Hour" (Great Britain, 1861).

In the United States, speed limits traditionally have been the province of the states, counties, and cities. A maximum speed limit of 12 miles per hour was enacted in Connecticut in 1901 (Miller, 1950). As improvements in motor vehicle design led to higher and higher potential speeds, most other states also established numerical speed limits. During the 1930s, the speed capability of the average new automobile rose from 55 to 84 mph (DeSilva, 1942). As a temporary measure to conserve fuel and rubber during World War II, the U.S. federal government established a nationwide maximum speed limit of 35 mph.

By the 1960s, most states had statutory maximum speed limits of 70 or 75 mph. The federal government again became involved in setting speed limits as a response to the 1970s oil embargo. In 1974, Congress established the National Maximum Speed Limit (NMSL) of 55 mph as part of the Emergency Highway Energy Conservation Act (87 Stat. 1046). Although the intention was to conserve oil supplies by increasing engine efficiency, the NMSL had an even greater effect on highway fatalities (Johnson et al., 1981; National Safety Council, 1979). A study by the Transportation Research Board (1984) concluded that the NMSL was responsible for 3,000-5,000 fewer deaths in 1974 and 2,000-4,000 fewer deaths in 1983. As a result, the NMSL was extended past its original 1-year target.

In 1987, Congress relaxed the NMSL, allowing states to increase speed limits to 65 mph on rural interstates. Thirty-eight states raised their speed limits on rural interstates in 1987, followed by three more states in 1988. Studies done at the time estimated a 15%-19% increase in deaths associated with the relaxation of the NMSL (Baum et al., 1991; Garber and Graham, 1990). However, a later study by Lave and Elias (1994) concluded that the relaxation of the NMSL actually reduced fatality rates by 3%-5%. Their assertion was that the higher speed limits attracted drivers away from other, more dangerous roads, so the increased deaths on rural interstates were offset by reduced deaths on other roads.

Congress repealed the NMSL in December 1995, and many states took the opportunity to raise speed limits on both rural interstates and other roads previously posted at 55 mph. Thirty-two states raised interstate speed limits by the end of 1996, followed by three more states in 1997. Evaluations of the effect of the NMSL repeal on fatality rates found increases of 9-17% (Balkin and Ord, 2001; Farmer et al., 1999; National Highway Traffic Safety Administration (NHTSA), 1998).

Proponents of higher speed limits often cite data showing that many drivers already exceed the speed limit. They argue that drivers have the best sense of what speed is safe, and an increase in the posted limit merely recognizes this fact. This implies that an increase in the speed limit should have little or no effect on actual vehicle speeds. However, a number of researchers have shown that speeding drivers increase their speeds even more when the limits are raised (Casey and Lund, 1992; Joscelyn et al., 1970; Parker, 1992; Retting and Greene, 1997).

States have continued to raise their maximum speed limits since 1997, although at a slower pace. By the end of 2015, the maximum speed limit was 75 mph in 10 states, 80 mph in 6 states, and 85 mph in 1 state (Insurance Institute for Highway Safety, 2015). On the other hand, traffic fatality rates have been declining since 1997, so it is not obvious that the increased speed limits have made roads less safe. An analysis of the speed limit increases over time should take into account the many other factors that may have affected traffic fatality rates. The objective of this study was to examine the safety effects of all increases in maximum speed limits during the period 1993-2013. Unlike earlier studies, this study attempts to estimate the effects of various levels of speed limit increases.

METHOD

Data on all traffic fatalities in the United States during the years 1975-2013 were extracted from the Fatality Analysis Reporting System, a census of fatal crashes maintained by NHTSA. Data on vehicle miles of travel (VMT) for the same time period were obtained from the *Highway Statistics* series of the Federal Highway Administration (FHWA, 2015). These data were used to calculate the traffic fatality rate per billion VMT during each of the years 1975-2013 (Figure 1). The U.S. traffic fatality rate was relatively constant during 1975-1980, dropped steeply during 1981-1983, leveled off again during 1984-1987, and dropped steeply again during 1988-1992. The traffic fatality rate declined more gradually during 1993-2013, except for a noticeable dip concurrent with the 2007-2009 economic recession.

Both the fatality and VMT databases were categorized by state and type of roadway (rural interstates and freeways, other rural roads, urban interstates and freeways, other urban roads). Annual traffic fatality rates in each state were modeled as a function of time, the maximum posted speed limit on any road in the state, and a number of covariates. Suppose D_{ij} represents the number of traffic deaths, V_{ij} represents the vehicle miles traveled, and s_{ij} represents the maximum speed limit in state i during time period j. Assuming D_{ij} was a Poisson random variable with mean $V_{ij}\ \lambda_{ij}$, a statistical model was formulated as $\log \lambda_{ij} = \alpha + \beta_1\ (j) + \beta_2\ (s_{ij}) + \beta_3$ (covariates). So $100\ (\exp(\beta_2) - 1)$ represented the percentage change in the expected fatality rate for each one unit increase in the maximum speed limit. Estimates of α, β_1, β_2, and β_3 were obtained using the GENMOD procedure in SAS (SAS Institute Inc., 2011). A generalized estimating equation was used to incorporate the correlation among different time periods for the same state. The correlations between measurements taken over time were assumed to be the same for every state, and measurements taken on different states were assumed to be uncorrelated (i.e., an exchangeable correlation structure).

The covariates considered in the statistical model were time (i.e., years since a starting point), changes in the annual state unemployment rate, the percentage of the driving age population younger than 25, the percentage of the driving age population 65 and older, the percentage of annual VMT that occurred on rural roads, the state seat belt use rate, and the per capita alcohol consumption (in liters). Unlike the other covariates, unemployment may not have an immediate effect on traffic fatality rates. In order to account for the possibility of a lagged effect, the year-to-year change in the unemployment rate was used rather than the actual unemployment rate. Estimates of the annual unemployment rate for each state were obtained from the U.S. Bureau of Labor Statistics (2016). Annual estimates of each state population by age were obtained from the U.S. Bureau of the Census (2016). Estimates of per capita alcohol consumption were obtained from the National Institute on Alcohol Abuse and Alcoholism (Haughwout et al., 2015). Finally, the estimated percentages of front seat vehicle occupants using seat belts were obtained from NHTSA (Chen, 2015).

It was expected that fatality rates would be negatively correlated with time, changes in unemployment, and the seat belt use rate. Alcohol consumption, the percentage of the driving age population younger than 25 or 65 and older, and the percentage of VMT on rural roads were expected to be positively correlated with fatality rates. As some of the covariates do not have data for earlier years, the analyses cover the period 1993-2013. In 1993, the maximum speed limit was 65 mph (on rural interstates) for all states except Connecticut, Delaware, the District of Columbia (DC), Hawaii, Maryland, New Jersey, New York, Pennsylvania, and Rhode Island. In 2013, the maximum speed limit was 55 mph in DC, 60 mph in Hawaii, 65 mph in 13 states, 70 mph in 20 states, 75 mph in 13 states, 80 mph in 2 states, and 85 mph in Texas.

Fatality rates varied widely over the years for some of the smaller states, possibly due to low exposure, so the analysis was further restricted to the 41 states with at least 10 billion VMT in each year. This eliminated Alaska, Delaware, DC, Hawaii, Montana, North Dakota, Rhode Island, South Dakota, Vermont, and Wyoming (Figure 2).

Table 1 lists the changes in maximum speed limits during 1993-2013 for the 41 included states. Five states raised their maximum speed limits from 55 to 65 mph during these years. Thirty-one states raised their maximum speed limits to at least 70 mph. Maximum speed limits remained constant at 65 mph for Illinois, Massachusetts, New Hampshire, Oregon, and Wisconsin.

RESULTS

Results of the statistical model for fatalities on all roads are summarized in Table 2. Most effects were in the expected directions. There was a general decline in fatality rates over time. Fatality rates declined even further when the unemployment rate went up. Fatality rates were higher when alcohol consumption was up and when there was a higher proportion of young drivers. The effects of older drivers, rural mileage, and belt use were not statistically significant. Finally, fatality rates were 0.7% higher for each 1 mph increase in the maximum speed limit (or 3.6% higher for each 5 mph increase).

The effects of older drivers, rural mileage, and belt use were not statistically significant, possibly because they were confounded with other variables in the model. For example, the correlation between belt use and time was 0.88 or higher for 38 of the 41 states. The percentage of the driving population age 65 and older did not vary much within each state; the change during the 20 year time period was at most 4 percentage points (e.g., from 15% to 19%). The analysis was repeated without the non-significant covariates, resulting in the estimates for the other effects being slightly stronger. Fatality rates were 0.9% higher for each 1 mph increase in the maximum speed limit (or 4.3% higher for each 5 mph increase).

When fatality rates were restricted to interstates and freeways, the roads for which speed limits were highest, the effect of maximum speed limit was stronger (Table 3). Fatality rates were about 1.6% higher for each 1 mph increase in the maximum speed limit (or 8.3% higher for each 5 mph increase).

The effect on roads other than interstates and freeways was weaker, but still in the same direction (Table 4). Fatality rates on these other roads were about 0.8% higher for each 1 mph increase in the maximum state speed limit (or 4.0% higher for each 5 mph increase).

Finally, the statistical model for all roads was used to estimate the number of deaths that would have been expected in each year if there had been no changes in the maximum speed limits. These expected deaths are plotted in Figure 3 along with the actual number of deaths from each year.

The actual and expected deaths were the same in 1994 because there were no changes that year in maximum state speed limits. However, the trends began to diverge in 1995 and 1996 as states responded to the repeal of the NMSL. In total, there were an estimated 33,000 more traffic fatalities during the years 1995-2013 than would have been expected if maximum speed limits had not increased. In 2013 alone there were approximately 1,900 additional deaths — 500 on interstates/freeways and 1,400 on other roads.

DISCUSSION

The increases in maximum speed limits since 1995 were associated with 1,900 more deaths in 2013 than otherwise would have been expected. This accounted for 6% of the 32,894 traffic fatalities in that year. In comparison, it is estimated that frontal airbags saved 2,388 lives in 2013 — a 7% reduction (NHTSA, 2015). So the increases in speed limits essentially have negated the safety benefits gained from airbags. Traffic fatality rates have continued to decline due to such factors as increased seat belt use and vehicle design improvements (Farmer and Lund, 2015; Glassbrenner, 2012). However, the push for higher and higher speed limits is slowing progress toward the goal of zero deaths now being touted by many communities (City of Los Angeles, 2015; City of New York, 2014).

This analysis confirms the findings of other researchers that higher speed limits are associated with increased fatality rates on the roads for which speed limits were raised (Friedman et al., 2009; Kockelman, 2006; Patterson et al., 2002). On interstates and freeways, a 5 mph increase in the posted speed limit was associated with an 8% increase in fatality rates, and a 10 mph increase in the speed limit was associated with a 17% increase in fatality rates.

Furthermore, there was no associated reduction in fatality rates on roads other than interstates and freeways. In fact, the speed limit increases also were associated with an increased risk on these other roads. This contradicts the conclusion by Lave and Elias (1994) that higher speed limits encourage drivers to abandon often undivided open-access roads for the safer limited-access roads. Although the proportion of travel on limited-access roads increased from 29% in 1993 to 32% in 2013, limited-access roads also accounted for a larger proportion of the U.S. roadway system — 1.6% in 2013 versus 1.4% in 1993 (FHWA, 2015). The increases in maximum speed limits since 1995 were associated with 500 additional deaths in 2013 on interstates and freeways and 1,400 deaths on other roads. Unlike the speed limit increases in the 1980s and 1990s, many of the more recent changes also have raised speed limits on some open-access roads. So, although the speed limits on open-access roads may not be as high as those on limited-access roads, the increased speeds have led to more deaths.

There also is evidence against the theory that speeds are unaffected by increases in the posted limit. Increases in the speed limit tend to produce increases in both the average speed and the proportion of vehicles at higher speeds. For example, Retting and Greene (1997) reported that the percentage of drivers exceeding 75 mph more than doubled on Houston freeways in 1996 after the speed limit was raised from 55 to 70 mph. More recently, a focus group of drivers in Seattle reported that they typically drove 4-8 mph above the limit on lower speed roads and 8-15 mph above the limit on freeways (Richard et al., 2013). They said that they feel safer "going with the flow of traffic."

This belief in "going with the flow" is the basis for the argument that speed limit increases reduce the variability of vehicle speeds, thus reducing the chances of vehicle-to-vehicle conflicts. However, not every vehicle can go with the flow. Vehicles may need to slow when turning or merging. Also, many crashes are single-vehicle crashes, for which differences in vehicle speeds have little effect.

It is common for state agencies to conduct cost-benefit analyses before recommending higher speed limits on any given class of roads. One of the factors crucial to such analyses is an estimate of the expected reduction in travel time for a typical driver. Gates et al. (2015) predicted that proposed speed limit increases in Michigan would reduce travel times and their associated costs by 5.5% for passenger vehicles and 5.7% for heavy trucks. However, Ellison and Greaves (2015) showed that the typical driver saves only 2 minutes per week by exceeding the speed limit. Redelmeier and Bayoumi (2010) concluded that any savings in travel time with increased speed is more than offset by lost time in life expectancy due to the potential of a crash.

Limitations

These analyses do not account for raised speed limits on lower speed roads or the extension of higher speed limits to a greater number of roads. For example, Massachusetts, New Hampshire, and Wisconsin extended 65 mph speed limits to urban interstates in 1996, but they did not go even higher on rural interstates. Similarly, some states initially posted their maximum speed limit on only certain sections of highway, then gradually extended the number of sections to which it applied. In other words, there were some years for which the maximum speed limit did not change, but the number of maximum-speed road sections increased. Ignoring these additional changes likely led to an underestimate of the lives lost due to speed limit increases.

There were a number of relevant state-specific factors not accounted for in these analyses. So, although in general higher speed limits were associated with higher fatality rates, the effect may not have been consistent across all states. Among the safety-related factors that may have differed by state are roadway improvements, public safety campaigns, and driving regulations (Goodwin et al., 2015; Peng et al., 2012). For example, rumble strips and roundabouts have been shown to reduce the rate of severe crashes (Griffith, 1999; Persaud et al., 2001), and graduated driver licensing has been shown to reduce the number of crashes involving young drivers (McCartt et al., 2010; Williams et al., 2015).

Another factor that may produce state-by-state variability in the effects of speed limit increases could be differences in the level of speed enforcement. States typically promise to tighten enforcement after increasing speed limits. Aggressive enforcement has been shown to reduce speeding behavior (Vaa, 1997). Positioning enforcement vehicles so as to surprise drivers leads to more prolonged speed reductions (Dowling and Holloman, 2008). Campaigns that raise public awareness of enforcement efforts can result in an enhanced deterrent effect (Neuman et al., 2009), but the severity of sanctions seems to have little effect on speeding behavior. While drivers will slow down in order to lower their insurance costs, they do not lower their speeds when speeding fines are increased (Elvik, 2007; Stigson et al., 2014).

Conclusion

There is a definite trend of increased fatality risk when speed limits are raised. As roadway sections with higher speed limits have become more ubiquitous, the increase in fatality risk has extended beyond these roadways. The increase in risk has been so great that it has now largely offset the beneficial effects of some other traffic safety strategies. State policymakers should keep this trade-off in mind when considering proposals to raise speed limits.

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Table 1. Changes in maximum speed limits, 1993-2013.

	Maximum speed limit increased to				
Year*	65 mph	70 mph	75 mph	80 mph	85 mph
1995	MD, NY, PA				
1996		AL, AR, CA, FL, GA, KS, MI, MS, MO, NC, TX, WA	AZ, CO, ID, NE, NV, NM, OK, UT		
1997		LA, MN, WV			
1998	NJ	TN			
1999	CT	SC	TX		
2005		IN, IA		TX	
2007		KY			
2008				UT	
2010		VA			
2011		OH	KS, LA		TX
2012			ME		

*Year of change if effective date was prior to October 1; otherwise the next year was used

Table 2. Poisson regression of state-by-state fatality rates, 1993-2013, all roads.

Parameter	Estimate	Effect (%)	Lower CL	Upper CL	p-value
Intercept	-5.0030	-99.3	-99.7	-98.3	<.0001
Time	-0.0248	-2.5	-2.8	-2.1	<.0001
Change in unemployment rate	-0.0128	-1.3	-1.8	-0.7	<.0001
Percent younger than 25	0.0211	2.1	0.2	4.1	0.0291
Percent age 65 and older	-0.0176	-1.7	-4.2	0.8	0.1766
Percent rural VMT	0.0012	0.1	-0.1	0.4	0.3363
Percent using seat belts	-0.0013	-0.1	-0.3	0.1	0.1704
Alcohol consumption (liters)	0.0528	5.4	1.9	9.0	0.0021
Maximum speed limit (mph)	0.0071	0.7	0.3	1.2	0.0013

Table 3. Poisson regression of state-by-state fatality rates, 1993-2013, interstates and freeways.

Parameter	Estimate	Effect (%)	Lower CL	Upper CL	p-value
Intercept	-7.6141	-100.0	-100.0	-99.8	<.0001
Time	-0.0350	-3.4	-4.3	-2.6	<.0001
Change in unemployment rate	-0.0147	-1.5	-2.3	-0.6	0.0005
Percent younger than 25	0.0590	6.1	1.1	11.2	0.0151
Alcohol consumption (liters)	0.0970	10.2	2.1	18.9	0.0122
Maximum speed limit (mph)	0.0160	1.6	0.9	2.3	<.0001

Table 4. Poisson regression of state-by-state fatality rates, 1993-2013, roads other than interstates/freeways.

Parameter	Estimate	Effect (%)	Lower CL	Upper CL	p-value
Intercept	-5.2650	-99.5	-99.7	-99.1	<.0001
Time	-0.0252	-2.5	-2.7	-2.3	<.0001
Change in unemployment rate	-0.0102	-1.0	-1.5	-0.6	<.0001
Percent younger than 25	0.0280	2.8	1.1	4.6	0.0014
Alcohol consumption (liters)	0.0437	4.5	1.4	7.6	0.0038
Maximum speed limit (mph)	0.0079	0.8	0.3	1.3	0.0029

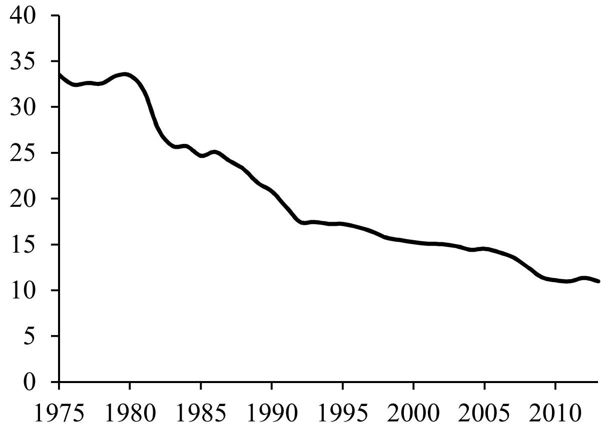

Fig. 1. U.S. traffic fatalities per billion vehicle miles traveled, 1975-2013.

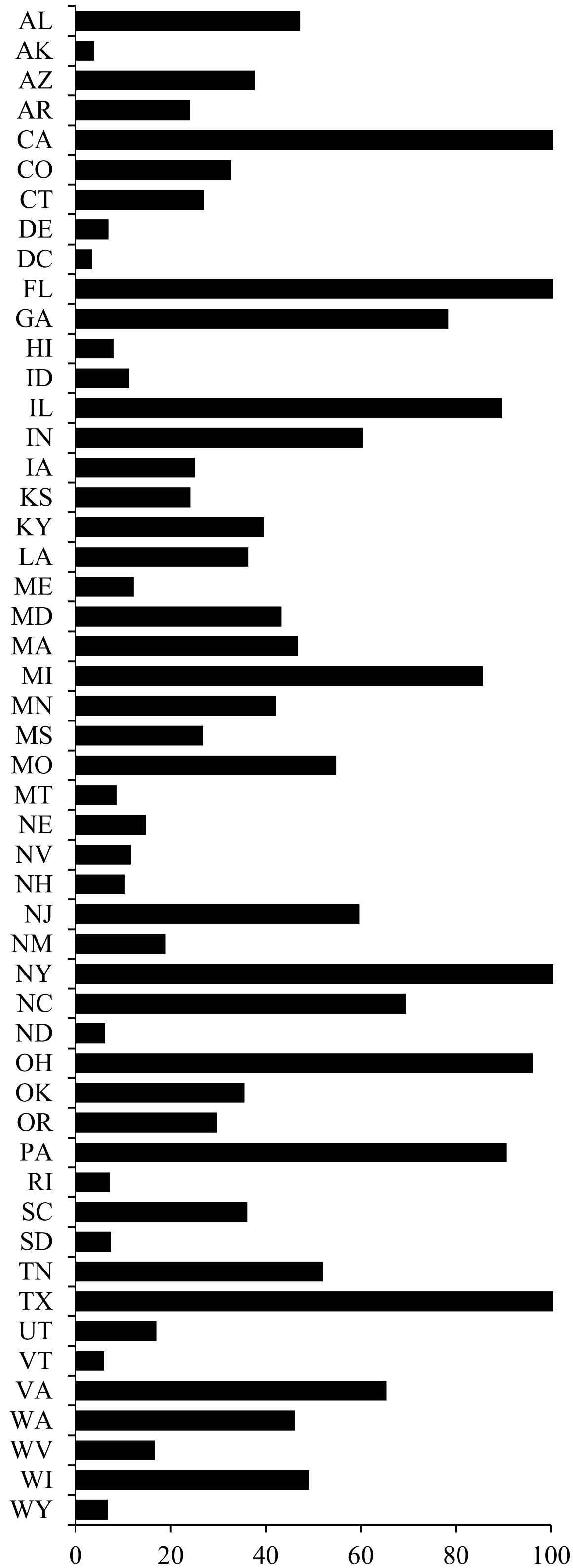

Fig 2. Billions of vehicle miles traveled in 1993.

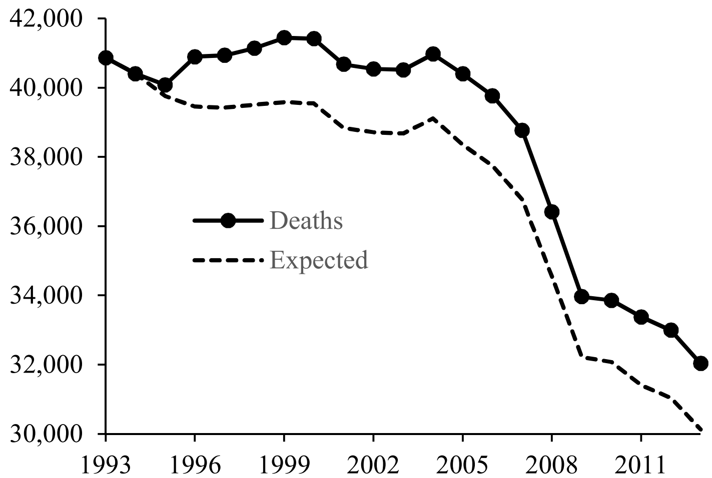

Fig 3. Traffic fatalities on all roads in the 41 study states, 1993-2013, and expected deaths if maximum speed limits had not increased.