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Evaluating the Effectiveness of State Toward Zero Deaths Program

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Since 2001 approximately 30 U.S. states have adopted programs to reduce traffic fatalities to zero with names such as Vision Zero, Target Zero, or Toward Zero Deaths (TZD). TZD is now being promoted as a national strategy by a coalition of transportation and safety groups. Successful TZD programs have five characteristics: 1) an ambitious goal of eliminating traffic fatalities and serious injuries; 2) high levels of inter-agency cooperation in pursuit of the TZD goal among state departments of transportation, public safety, health, and other relevant agencies; 3) a comprehensive strategy addressing all 4 E's – engineering, enforcement, education, and EMS elements of traffic safety; 4) a performance-based, data-driven system of targeting resources and strategies where they will have the greatest impact in reducing traffic fatalities; and 5) policy leadership from relevant entities, including the Governor, the state legislature, and the heads of state agencies. While many of the state TZD programs are relatively new and emerging, four state programs have been around long enough to have enough years of crash data to evaluate the impacts of the programs – Minnesota, Idaho, Utah and Washington. Statistical tests on these four programs support the conclusion that implementing TZD programs accelerates the reduction of fatality rates. The acceleration rate varies from state to state, taking time for a new program to gain its full effect. Although each state has different degrees of temporal effect of its TZD program, the average effect is more and more apparent over time.

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Technical Report

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INTRODUCTION

Since 2001, approximately 30 U.S. states have adopted a mission, vision, or goal to reduce fatal traffic crashes to zero. Additionally some states have aggressive formal programs try to reach these goals. These efforts, which operate under different titles, such as Vision Zero, Target Zero, or Toward Zero Deaths, are now being promoted as a national strategy by a coalition of transportation and safety groups under the banner of Towards Zero Deaths (TZD). These strategies draw upon evidence-based countermeasures to reduce fatalities using a range of engineering, education, enforcement and emergency medical approaches. TZD strategies use design, technology, behavioral and policy approaches to achieve significant reductions in traffic fatalities and serious injuries and continuously evaluate performance data to adjust these techniques based on the data.

This paper commends the national trend of states adopting some form of a zero death mission, vision, or goals. It highlights and examines some common characteristics of noteworthy states in the U.S. and attempts to evaluate the effectiveness of these efforts. The authors also make recommendations related to future evaluation of these programs and recommendations to assure the success of TZD programs and the national effort to expand to all states.

HISTORY OF TZD

Toward Zero Deaths (TZD) efforts trace their roots to Vision Zero, a fatality reduction program launched by Sweden in 1997. The program does not attempt to eliminate crashes, but rather those that lead to fatalities or serious injuries. In developing the program, the issue was framed as an ethical one with zero deaths being the only morally acceptable number.

Johansson (*1*) provides an overview of Vision Zero's operating strategy which assumes that designers of the road network are responsible for the safety of the network, so long as users follow relevant laws and the rules of the road. When fatalities do still occur or when the rules are not followed for a number of reasons, the burden is placed back on the engineers to prevent them. Vision Zero recognizes that human error or driver behavior as the primary cause of crashes, much like in the U.S., but Vision Zero believes that the solutions lie in better engineering. Johansson puts fourth two examples – seat belt reminders and alcohol interlocks – which are framed as examples of re-engineering vehicles to alter driver behavior. He argues that there is an increasing public demand for the voluntary use of interlocks, generating "proven sober" transport options. In the U.S. context, these may be considered policy solutions.

Vision Zero embraces a different roadway design strategy, attempting to "manage kinetic energy" in crash situations rather than try to provide wider roadways which are traditionally perceived to be safer (*1*). Understanding the vehicle speeds at which pedestrians no longer sustain injuries but rather fatalities, Vision Zero "separates" vulnerable road uses (e.g. pedestrians and bicycles) and "integrates" compatible road users (e.g. vehicles of comparable weight) (*1*). The management of kinetic energy drives Vision Zero to slow vehicles when in proximity to vulnerable road uses, change intersection geometry though the use of roundabouts, and provide roadside barriers. Early TZD programs in the U.S. drew inspiration from Vision Zero and its assertion that zero fatalities is the only acceptable number. Washington State and Minnesota were the first two states to adopt the zero fatality goal in 2000 and 2003, respectively.

The development of integrated highway safety plans was changed with the introduction of the Strategic Highway Safety Plan (SHSP) by the American Association of State Highway and Transportation Officials (AASHTO), first published in 1998. Later revised in 2005 (*2*), the SHSP focuses on 22 emphasis areas and when paired with the National Cooperative Highway Research Program's *NCHRP Report 500* series (*3*) and *NCHRP Report 501* (*4*), provides comprehensive information on increasing highway safety. *NCHRP Report 622* (*5*) provides a comparison of behavioral countermeasures. When the 2005 legislation *Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users* (SAFETEA-LU) was passed, each state was required to develop a state-specific data-driven SHSP. This injected a comprehensive statistical approach into some pre-existing plans, such as *Target Zero*, which had previously lacked it.

As states published SHSPs, language indicating the long-term goal of zero fatalities appeared in many documents. However, the seriousness of the commitment to the zero fatality goal is difficult to quantify. In some cases, the mission, vision, or goal or zero deaths is mentioned only once or twice in a SHSP, while in other cases it appears regularly and clearly informs aggressive, collaborative safety programs. Based off a survey of all SHSPs in March, 2012, the Center for Excellence in Rural Safety (CERS) identified over 30 states which make some mention of zero deaths or a comparable objective. Additionally, a number of states use the "Toward Zero Deaths" name outside of their SHSP in some kind of non-highway state program. These states have also been included in CERS' count (Figure 1). This count is not static, as states are constantly updating, revising, and adopting zero death language in official plans.

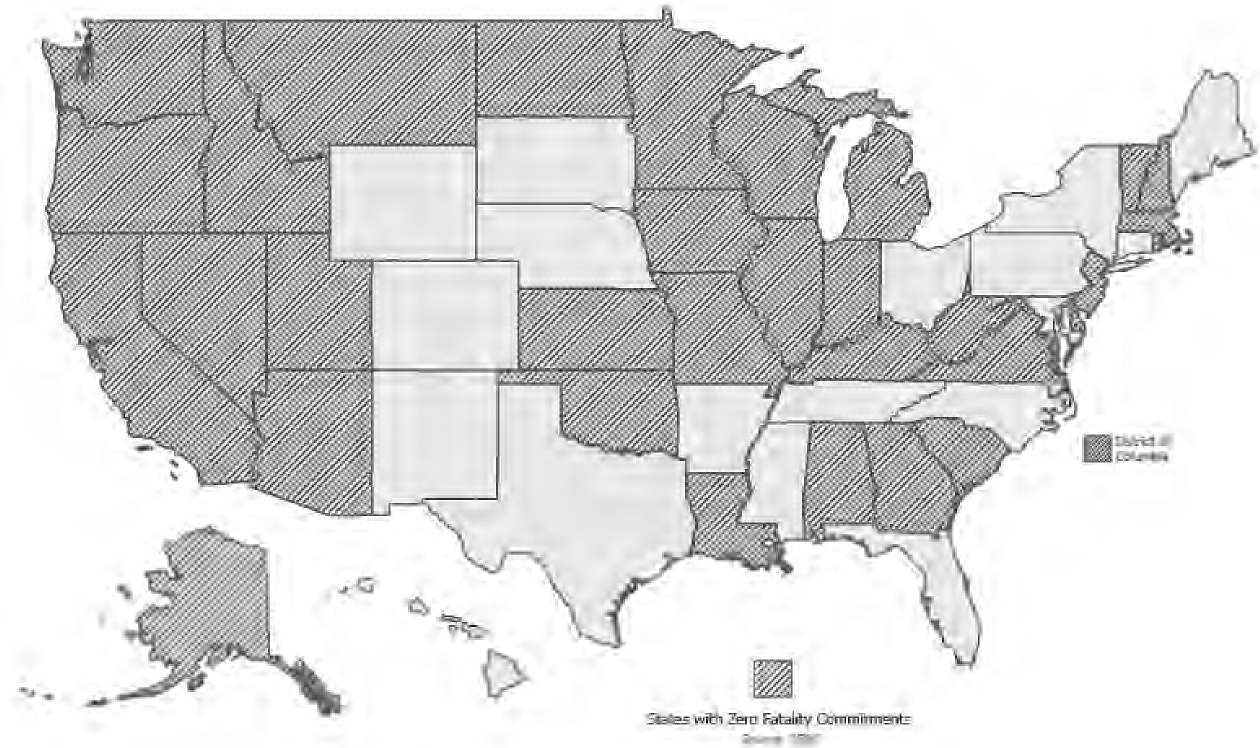


Figure 1: States with Zero Fatality Language as of March 2012

In step with the SHSPs, many states or groups of states have established comprehensive TZD programs. The branding of the program varies by state, including Target Zero in Washington State or Zero Fatalities in Utah, Nevada, and Arizona. The zero fatality objective is also articulated in these states' SHSPs and in some cases the SHSP bears the name *Toward Zero Deaths.* Presently, a steering committee made up of representatives from AASHTO, the Governors Highway Safety Association (GHSA), and other organizations is producing a national strategy for TZD.

SHSPs have been highly successful and can create a framework for TZD efforts. Produced through collaboration and taking a comprehensive view of highway safety, SHSPs lay the foundation for successful TZD efforts. In some cases, TZD programs are a way to operationalize and implement a state's SHSP. The two efforts are similar, though TZD efforts can go beyond the federal mandates for SHSPs.

In a national highway safety context where zero deaths language is relatively ubiquitous, the challenge is to both outline a working definition of a TZD state and to analyze the decrease in fatalities in such states. This paper attempts both.

ELEMENTS OF SUCCESSFUL TZD PROGRAMS

The first key characteristic of a TZD effort is the ambitious mission, vision, or goal of eliminating fatalities and serious injuries. Higher, intermediate goals are important and are present in many states, but an overarching objective of zero deaths injects a degree of urgency and focus into safety efforts. It is crucial that this zero death language be made explicit, though whether it is a mission, vision, or goal depends on the state. Some states' SHSPs contain language with a mission or goal of all motorists "arriving safely" at their destinations. However this language, while appropriate and positive, is not sufficiently strong enough to be considered by this paper as embodying a zero death or serious injury mission, vision, or goal. In establishing the goal of zero fatalities and serious injuries, TZD programs establish a directive for all participating agencies and private partners to follow.

This is due in part to the fact that full TZD programs change the nature of decision-making in their state. In their defense of Vision Zero, Rosencrantz et al. state a series of trade-offs and compromises precede objective- and goal-setting in economic issues. Arguably, the same may be said of the political realm. However, in issues related to enforcement or health and safety where only zero deaths should be acceptable they argue the decision-making process is reversed. In these fields goal-setting proceeds trade-offs and comprises. The Vision Zero goal is unique in that it applies the second approach to traffic safety that is generally addressed with the first method, even if the goal cannot be fully achieved (*6*). TZD efforts therefore alter their state's decision making process by establishing goals, ultimate or interim, en route to zero deaths, and then these programs internally debate the relative merits of their countermeasure strategies. It should be noted that all SHSPs use a data-driven approach to countermeasure selection. TZD efforts stand apart in that they use the same approach with explicitly stated objective of eliminating deaths and serious injuries.

In an international comparison of nations which set fatality reduction goals, Wong and Sze (*7*) find that well-informed goal setting has a positive effect on safety. Early research by Elvik (*8*) in Europe establishes that setting targets can have positive effects on safety. Updating research by Wong et al. (*9*), Allsop et al. (*10*) find that road fatalities were reduced by an overall 10.4% in nine countries three years after setting their targets.

Elvik (*11*) indicates that realistic but challenging goals are necessary. However, when too ambitious, a goal can become a "spiritual substitute or philosophy," according to Wong and Sze (*7*), rather than an object which drives organizational change. TZD programs must therefore balance the long-term zero death vision with other aggressive interim goals. Some states have a stated year by which they will achieve zero fatalities (e.g. Washington State), while others do not specify an end date. Minnesota, while lacking a final success date, does have interim goals. Sweden's program, like Minnesota, has no official end date and therefore "it will never be too late to achieve the goal" (*6*).

The second key component of a TZD effort is collaboration. TZD efforts exhibit high levels of inter-agency cooperation in pursuit of their goal, generally occurring among the state Departments of Transportation (DOT), Public Safety, Health, and other relevant agencies. SHSP development is primarily the responsibility of the state DOT, with other state-wide collaboration. Being a data-driven approach to safety, SHSPs often focus on the fact that primary contributors to fatalities and serious injuries are behavioral and therefore lie outside the engineering expertise of the DOT. For example, North Dakota's SHSP lists seven areas of emphasis including alcohol impaired driving, seat belt use, younger and older drivers, aggressive driving, lane departures, Emergency Medical Services (EMS), and intersection safety (*12*). The first four priorities are overwhelmingly behavioral. Similarly, the first two priorities in Illinois' SHSP are impaired driving and driver behavior (*13*). Therefore, the challenge in dramatically affecting fatalities and serious injuries is to galvanize all the relevant agencies in support of a mutual goal. Minnesota's SHSP (*14*) reflects this mentality, visually depicting TZD as an umbrella covering the SHSP and the participating agencies. Since the adoption of TZD in Minnesota, a collaborative approach to safety has developed among the Minnesota DOT (MnDOT), Minnesota Department of Health (MDH), the Minnesota Department of Public Safety (MnDPS), and other partners.

Thirdly, TZD efforts are comprehensive and address engineering enforcement, education, and EMS elements of traffic safety simultaneously. This "4-E" approach to safety was included in SAFETEA-LU in 2005 and is a required element of SHSPs. Marketing and communication materials are central parts of TZD education program and are sometimes shared by multiple states.

Fourth, TZD states are particularly effective at using performance-based, data-driven methods to target resources where they will have the greatest impact in reducing traffic fatalities. This performance orientation affects the choice of countermeasure in any given context. This is also one of the key strengths of all SHSPs. In Washington State, the first iteration of *Target Zero*, now the state's SHSP, lacked this data-driven approach. Originally published in 2000, it first articulated the TZD concept in the United States but was not organized around data-driven principles. After SAFETEA-LU, *Target Zero* was fundamentally re-developed and incorporated these elements.

While SHSPs have generated a state-wide data-driven approach to countermeasure deployment, TZD programs often take the data driven approach beyond the requirements of SAFETEA-LU. Minnesota's commitment to TZD has led MnDOT to restructure its funding methodology. The agency now uses a data-driven approach to direct federal funds to roads where fatal or serious injury crashes occur. This includes eligible state, county, and local roads. The data-driven approach also leads to continuous planning and evaluation. Many states are presently updating their SHSPs and adjusting the focus areas based on the changing nature of crashes in their state. This requires continuous evaluation and adjustment of strategies to have the greatest impact.

Finally, the fifth element of TZD programs is clear policy leadership from relevant entities, including the Governor, the state legislature, and the heads of state agencies. The success of a TZD program is contingent on commitments from elected officials who are able to provide legislation supporting enforcement efforts, the second of the 4-E's. For the collaborative approach to be the most effective, state leadership must provide the relevant agencies with the political support and financial resources to accomplish the TZD goal. Seat belt enforcement, helmet use, and reducing Driving While Intoxicated (DWI) recidivism heavily depend on enabling legislation. The legislature and Governor must be proactive partners in roadway safety.

States exhibiting these five characteristics are considered TZD states and a handful of such states, including Idaho, Minnesota, Utah, and Washington used as the treatment group in the quantitative analysis of TZD programs. These states were chosen because they adopted the zero death goal relatively early (before 2006) and clearly exhibit the majority of the above five criteria. In some cases, the degree of collaboration and policy support could not be fully substantiated. This subject is addressed in the findings portion of this paper.

EVALUATION

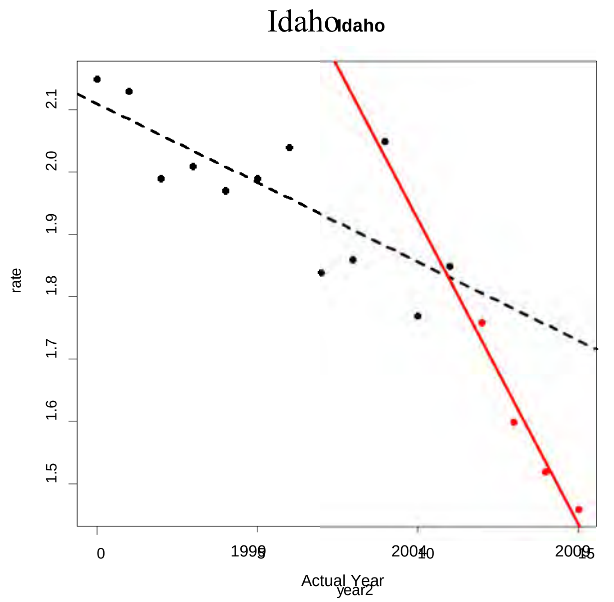
For the purposes of this initial, broad assessment of TZD efforts, fatality rates were used to compare each state with national trends to account for different amount of vehicle miles travelled.

The traffic fatality data of each state is a logic choice for quantitatively assessing the effectiveness of a TZD or zero deaths effort. To account for the different traffic exposures measured by 100 million vehicle miles traveled (MVMT), the fatality rate per 100 MVMT was used as the performance measure. Sixteen year traffic fatality data from 1994 to 2009 were obtained from the Fatality Analysis Reporting System (FARS) managed by the National Highway Traffic Safety Administration (NHTSA) (*15*). Idaho, Minnesota, Utah, and Washington started their respective programs in 2005, 2003, 2006, and 2000. They were considered in this study as the TZD states meeting the five-point criteria with at least three year crash data after implementing the program. Other states meet the 5-point criteria but have later start dates. For the purpose of evaluation, a new dummy variable TZD was created to represent any year with a TZD program. Another new continuous variable is TZD-year which starts at 1 and represents the *n*th year since a TZD program was implemented. For example, Minnesota started to deploy its TZD program in 2003. The value of TZD is set to zero between 1994 and 2002 and one between 2003 and 2009. TZD-year begins to count from 1 in 2003 to 7 in 2009. It is anticipated that two questions will be answered in this evaluation:

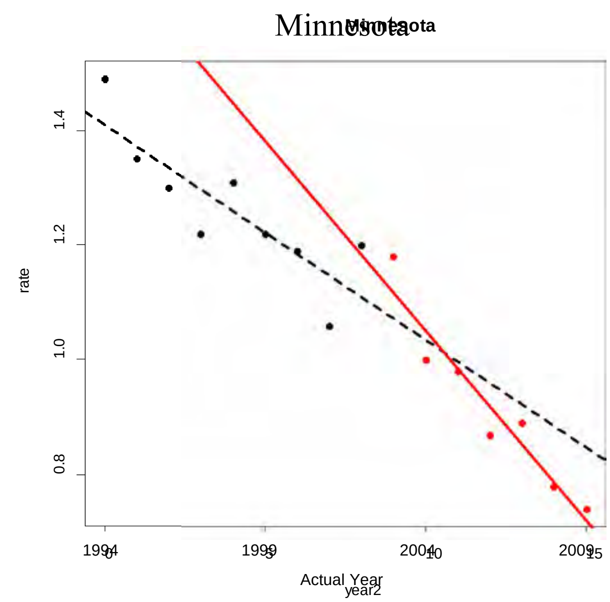
1. Will fatality rate be significantly reduced after implementing a TZD effort?
2. Will the effect of a TZD effort change over time?

Exploratory Data Analysis

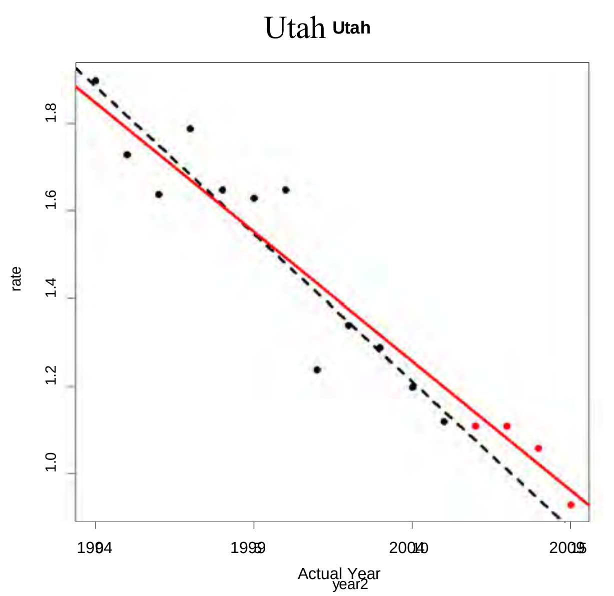
In the exploratory data analysis, fatality rates for each of the four states were plotted and fitted via two linear regression lines for before (dashed line) and after (solid line) a TZD program, respectively. In Figure 2, the Y-axis is the fatality rate, the X-axis is the year ranging from 1994 to 2009, and the slope of the straight line indicates how fast the fatality rate decreases over the years. The regression equations for before and after are included below the plot in the panel. Figure 2 illustrates a marked difference before and after implementing the TZD program in Idaho and Minnesota where an accelerated fatality reduction was observed. A slightly larger reduction rate was also observed in Washington. In Utah, the fatality rate continues to decrease over time but the reduction rate is slightly smaller than before. The visual inspection shows an overall reduction in fatality rates after implementing the program with Idaho achieving the largest reduction and Utah the smallest.



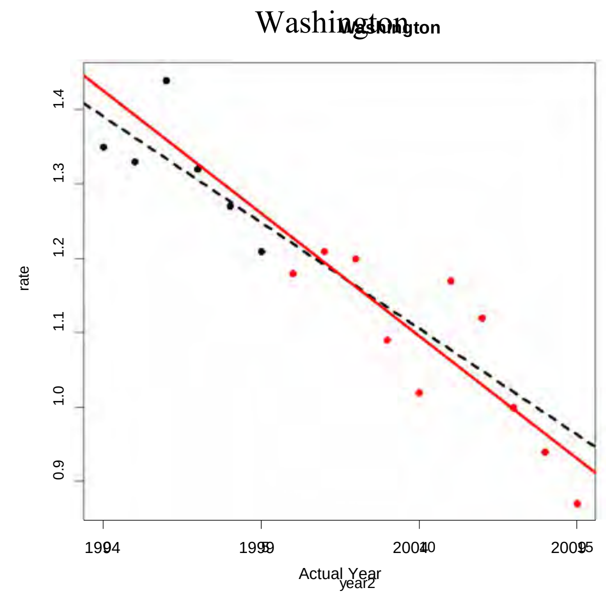
Before: Fatality rate=2.109-0.025Year
After: Fatality rate=2.908-0.098Year



Before: Fatality rate=1.410-0.037Year
After: Fatality rate=1.713-0.066Year



Before: Fatality rate=1.885-0.067Year
After: Fatality rate=1.849-0.059Year



Before: Fatality rate=1.391-0.029Year
After: Fatality rate=1.426-0.033Year

Figure 2: Fatality Rate Changes Before-and-after the TZD Program

A different comparison was made between the states with TZD programs (treatment) and those without TZD programs (comparison) by year. In Figure 3, the average trend of the fatality rate decreases over time for both groups, but a greater reduction can be recognized in the years with TZD programs. In fact, the downward trend in the states without TZD programs is primarily caused by the sharp declination starting in 2005 (last five data points in the comparison plot), which may be caused by the increased federal funding, additional efforts to change driver behavior and other safety improvements. The reduction may also indicate the role played by SHSPs since 2005 after SAFETEA-LU was passed. According to the linear regression output, the years with a TZD program have the reduction rate of 0.0447 while the years without a TZD program have the reduction rate of 0.0312. This yields the following results:

- State years with TZD programs: fatality rate = -0.0447 Year + 1.2942 ($R^2 = 0.8409$)
- State years without TZD programs: fatality rate = -0.0312 Year + 1.8385 ($R^2 = 0.902$)

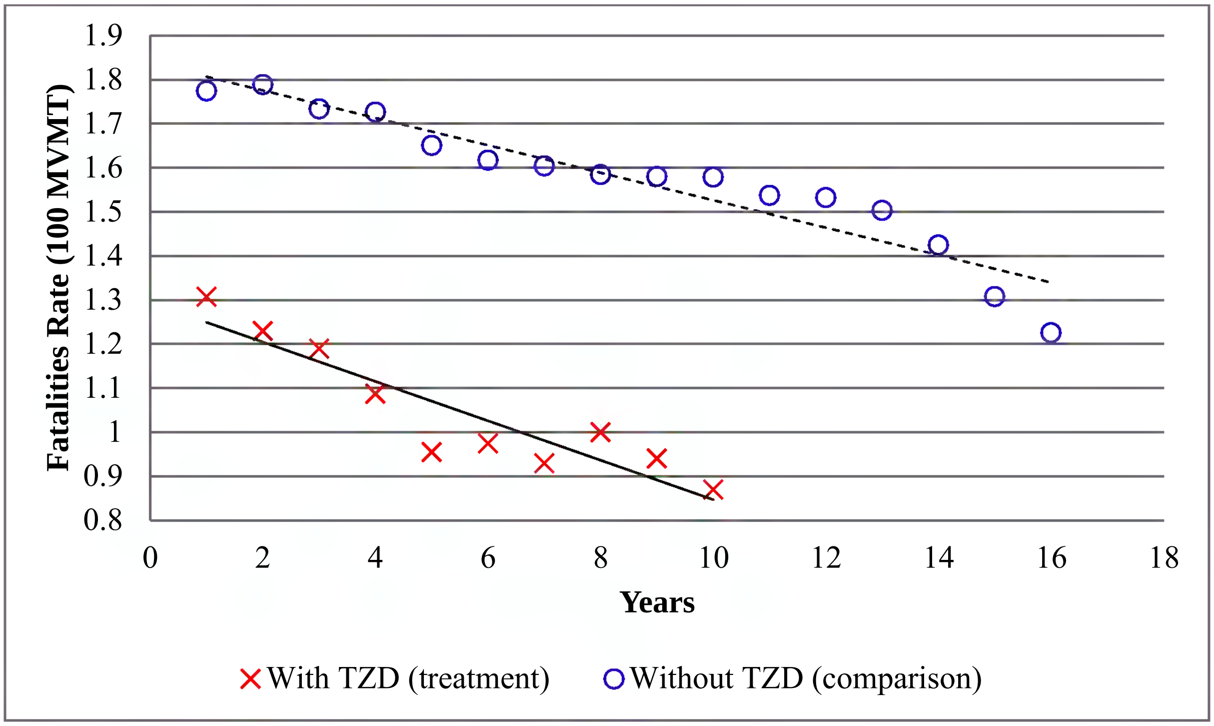


Figure 3: Fatality Rate Changes with and without the TZD Program

Two-factor ANOVA for TZD Effect

The states have substantial differences such as rural versus urban, traffic volume, miles of highway, etc. These disparities contribute to different number of traffic fatalities. To take the state variation into consideration, a two-factor analysis of variance (ANOVA) was designed. The fixed effects model is defined as:

$$\text{Fatality Rate}_{ijk} = \mu + \text{State}_i + \text{TZD}_j + \varepsilon_{ijk} \quad (1)$$

where i=1, 51, representing 51 states including District of Columbia and j =1,2, representing the treatment factor (i.e. with or without TZD), and ε_{ijk}'s are independent and normally distributed with mean 0 and variance σ^2.

The model results are displayed in Table 1. Due to limited space, the coefficient estimates of other states are omitted. The TZD factor is statistically significant at 5% level of significance and the coefficient value is -0.3495, suggesting an average reduction of 0.3495 fatalities per 100 MVMT.

Table 1: ANOVA with TZD effect

STATE	Estimate	Standard Error	DF	t Value	Pr>|t|
Intercept	1.9269	0.05173	764	37.25	<.0001
Idaho	0.03487	0.07448	764	0.47	0.6398
Minnesota	-0.6627	0.07714	764	-8.59	<.0001
Utah	-0.4401	0.07448	764	-5.91	<.0001
Washington	-0.5384	0.08108	764	-6.64	<.0001
TZD	-0.3495	0.05593	764	-6.25	<.0001

The regression model is expressed in Equation 2.

Fatality rate = 1.9269+… +…+0.0349 Idaho …-0.6627 Minnesota +…-0.4401 Utah-0.5384Washington -0.3495(TZD=1) (2)

Temporal Effect of TZD

Though implementing a TZD program appears to reduce the fatality rate, the effect may vary by time and by state. A statistical model was developed to test the state factor, the TZD trend over time, as well as their interaction. In this analysis of covariance (ANCOVA) design, the fatality rates from the four TZD states were compared with all the years when a TZD program was in operation. The model results in Table 2 show that TZD-year and two interaction variables (e.g. Idaho and TZD-year, Minnesota and TZD-year) are statistically significant at the 5% level of significance. There are two important findings in Table 2: First, TZD programs reduce the fatality rate and a program's effect increases at a rate of 0.03297 per year; and second, the temporal effect of TZD programs varies among states. Ranked from high to low, the temporal effects of the TZD programs were the highest in Idaho, followed by Minnesota, Washington, and probably Utah because it is not statistically significant at 5% level of significance. In other words, for the year 2009, this represents a reduction of 15, 37, 9, and 19 traffic fatalities in Idaho, Minnesota, Utah, and Washington, respectively.

Table 2: Temporal Effect of TZD and State Interaction

Effect	State	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		1.2613	0.03809	17	33.12	<.0001
State	Idaho	0.5687	0.07819	17	7.27	<.0001
State	Minnesota	-0.07705	0.06059	17	-1.27	0.2206
State	Utah	-0.06133	0.07819	17	-0.78	0.4436
State	Washington	0	.	.	.	.
TZD-year		-0.03297	0.006138	17	-5.37	<.0001
TZD-year *State	Idaho	-0.06503	0.02568	17	-2.53	0.0215
TZD-year *State	Minnesota	-0.0331	0.01219	17	-2.71	0.0147
TZD-year *State	Utah	-0.02603	0.02568	17	-1.01	0.3249
TZD-year *State	Washington	0	.	.	.	.

All the statistical tests support that implementing TZD programs accelerates the reduction of fatality rates. The acceleration rate however varies from state to state. It takes time for a new program to gain its full effect, as can be found in the analysis. Although each state has different degrees of temporal effect of its TZD program, the average effect is more and more apparent over time.

CONCLUSIONS AND FUTURE RESEARCH

By combining and targeting countermeasures, TZD strategies may be a particularly important approach in reducing rural road fatalities. Rural fatalities are about twice those in urban areas in proportion to population as well as vehicles miles traveled. While better engineering and design of rural roadways is an important element, it is not possible or cost effective to address all rural roads and intersections with expensive engineering solutions. The TZD approach encourages state agencies to work collaboratively with local police, fire, health, emergency response, courts, schools and private businesses to tackle the behavioral and policy challenges with proven countermeasures such as targeted speed or DUI enforcement and use of information technology to improve crash outcomes in remote rural areas.

The future success of TZD efforts within states will depend on policy-driven countermeasures, e.g. primary seat belt laws, graduated drivers licenses for teens, motorcycle helmet laws, automated speed enforcement, in-vehicle DUI enforcement. These countermeasures have been proven to be effective but face political challenges from organized opposition, even though public opinion shows high level of support for these countermeasures (*16*, *17*). Similarly, state TZD efforts have recognized the importance of the fourth "E" – emergency medical response and trauma services. New information technologies such as CrashHelp, a smart phone application used to increase communication between EMS providers and trauma centers, offer promise for reducing traffic deaths in rural areas where distance and time delays can contribute to more crash fatalities.

A more rigorous quantitative evaluation of TZD may be improved through an empirical Bayes (EB) before-and-after study (*18*). The EB method can mitigate the impact of the regression-to-mean effect which may bias the results and overestimate the benefits of a treatment. The EB before-and-after study requires the selection of reference group that have similar characteristics as the treatment state. The selection of similar states will require a clear definition and extensive comparison which can be conducted in the future research plan.

A qualitative analysis of TZD programs in the U.S. is particularly difficult because it involves an outside organization attempting to study the inner workings of a number of state agencies. The publically available SHSP or other state documents do not necessarily fully illustrate a state's internal level of functioning or its drive to achieve zero deaths. More information is also needed about policy leadership from the Governor and legislature.

While challenging, TZD designation could be accomplished through certification process wherein states would apply for TZD certification. This is not unlike the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification process which has a number of different levels of certification. States that can clearly show evidence of all five TZD criteria would be considered TZD states, while states with three or four elements would be considered developing programs. States with one to two of the elements would be considered emerging programs. The data-driven nature of SHSPs and the inclusion of 4-E language in SHSPs mean that states with any kind of zero death language can be considered emerging or developing, though in this system the net number of TZD states would fall substantially from the more than thirty which make some mention of a zero death mission, vision, or goals in their SHSPs.

As an added benefit, this recommendation places the impetus on states to establish that they exemplify strong levels of intra-agency partnerships, and that the zero death vision – in tandem with aggressive interim goals – actually drives safety strategy. In such a designation system, a state would not be considered a TZD state unless it takes steps to receive this certification. This is crucial, since a pervasive statewide acceptance of the zero death vision is necessary for success. Like LEED, TZD designation could be used to set a state apart as a leader in highway safety.

Additionally, Congress could incentivize such a designation by allowing DOTs to "flex" a slightly larger percentage of funds for other safety issues such as education, enforcement, or EMS. At the present time, the 2012 legislation *Moving Ahead for Progress in the 21st Century Act* (MAP-21) seriously restricts the ability to implement this recommendation, though future transportation bills could include this type of incentive. Similar incentives could be extended to other participating agencies for an increased level of flexibility in their funding mechanisms. This is consistent with experience of countries such as Norway where Elvik (*11*) finds that, in addition to concentrating on a few key objectives, support from the political realm and a series of incentives are vital if the country is to meet a series of ambitious goals.

This evaluation of TZD programs in the United States defined TZD using a list of five criteria, including a zero death goal, inter-agency collaboration, a "4-E"approach to safety, data driven methods, and policy and legislative support. The TZD programs reduced the fatality rates for the four states examined under this definition, and they increased in effectiveness by a rate of 0.03297 traffic fatalities per 100 MVMT per year, equivalent to the reduction of 15, 37, 9, and 19 traffic fatalities in Idaho, Minnesota, Utah, and Washington in 2009, respectively. Fatality rates decreased faster in states with TZD programs than in states without TZD programs.

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