Transportation Research Synthesis

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School Zone Speed Limits (SZSLs): Effectiveness of SZSLs in reducing vehicle speeds, crash severity and crash frequency

Prepared by SEH

The effort for this Transportation Research Synthesis (TRS) is to provide a summary of current research on the effectiveness of school zone speed limits (SZSLs) in reducing vehicle speeds and the severity and frequency of crashes, particularly for vulnerable roadway users. It also provides a summary of current state statutes and guidance on SZSLs and additional resources on countermeasures for traffic calming and safety.

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by the Minnesota Department of Transportation (MnDOT). This TRS does not represent the conclusions of either the authors or MnDOT.

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16. Abstract (Limit: 250 words)

Minnesota statute provides for a wide range of school zone speed limits (SZSLs) from which local authorities may select. This Transportation Research Synthesis summarizes the current research regarding setting SZSLs, effective methods and procedures for setting school zone speed limits and known spillover or other unintended consequences for setting improper school zone speed limits to provide guidance on SZSL best practices.

The majority of states use a statute to define a SZSL, with over half of these states having a statutory SZSL set at 15, 20 or 25 mph. Many allow jurisdictions to lower SZSLs further based on an engineering and traffic study. Minnesota statute allows for a larger range than any other state.

Based on available research, SZSLs consistently reduce mean and 85th percentile speeds, however the extent of the reductions and statistical significance varies. In many cases, a SZSL resulted in lower compliance with speed limits, however, lower overall speeds and tightening and leftward shift of speed distributions indicate overall safety benefits.

Crash histories through school zones overwhelmingly found reductions in crashes, in particular, reductions in fatal and serious injury crashes involving vulnerable roadway users.

The speed differential between the approach speed limit and the SZSL has an impact on compliance and safety, with a recommended differential of 5 to 10 mph and speed buffer zones on high-speed roadways. The layering of additional countermeasures such as flashing beacons and geometric changes to the roadway are recommended as best practices to achieve lower speeds in school zones. No unintended consequences on vehicle speeds nor user safety were identified.

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Technical Advisory Panel

Chelsea Moore-Ritchie, Sr. Transportation Planner
SEH

Dave Cowan, Safe Routes to School Coordinator
MnDOT

Derek Leuer, State Traffic Safety Engineer
MnDOT

Heather Kienitz, Consultant Project Manager/Sr. Traffic Engineer
SEH

Jason Radde, Sr. Engineer
MnDOT

Ken Johnson, Assistant State Traffic Engineer
MnDOT

Leif Halverson, Project Coordinator
MnDOT

Mark Wagner, OTE Project Manager
MnDOT

Nathan Drews, OTE Safety Section
MnDOT

Tom Sohrweide, Sr. Traffic Engineer
SEH

Effectiveness of School Zone Speed Limits (SZSLs) in reducing vehicle speeds, crash severity, and crash frequency

Executive Summary

Communities implement School Zone Speed Limits (SZSLs) in locations near a school to reduce the speeds of motor vehicle drivers and improve the safety and environment for students walking, bicycling, and rolling to school. Often SZSLs are installed at the request of parents and community members as a means of traffic calming to improve safety for students. There is debate as to the degree of effectiveness of SZSLs as a stand-alone treatment for calming traffic and improving safety. There is also debate about what speed limits have the best safety and compliance outcomes within school zones. The current law in Minnesota allows local authorities to establish a school zone speed limit anywhere between 15 mph and up to the approaching roadway speed limit (but no greater than 30 mph below the approach speed limit), leaving a wide range of SZSLs from which local authorities may select.

This Transportation Research Synthesis (TRS) is a technical document that summarizes a compilation of relevant research findings and policies regarding SZSLs. Following is a list of the research objectives for this document.

<u>Research Objectives:</u>

1. What is the current research regarding setting school zone speed limits?
2. Has research found effective methods and procedures for setting effective school zone speed limits?
3. Are there known spillover or other unintended consequences for setting improper school zone speed limits?

This TRS reviewed publications from national organizations such as the National Highway Cooperative Research Program (NCHRP), Transportation Research Board (TRB), Institute of Transportation Engineers (ITE), Safe Routes to School National Partnership, and National Center for Safe Routes to School.

This information will assist MnDOT in updating *A Guide to Establishing Speed Limits in School Zones* (the Guide), which was last updated in 2012 and does not account for several modern traffic engineering elements and best practices. The Guide will establish current practices and integrate speed management, routing for walking, bicycling, and rolling to school, as well as other methods and guidance for establishing SZSLs in the state. Ultimately, the Guide will provide local officials with technical guidance to establish the appropriate speed limit within school zones as well as provide options to achieve higher rates of compliance.

Summary of Findings: School Zone Speed Limits

Speed Setting Methods

Traditional traffic engineering methods of using 85th percentile speed to set speed limits are coming into question based on evidence of unintended consequences of higher operating speeds and an undesirable cycle of speed escalation[1]. Smart system methods, such as USLIMITS2[2], stop short of providing speed setting guidance within school zones. The Safe System approach was adopted by the United States Department of Transportation (USDOT) in 2022 as the leading approach to setting speed limits in coordination with additional countermeasures to improve compliance and safety, particularly for the most vulnerable roadway users.

Policies by State

The majority of states (36) use a statute to define a SZSL, with more than half of these states having a statutory SZSL set at 15, 20 or 25 mph. Many allow jurisdictions to lower SZSLs further based on an engineering and traffic study. Minnesota statute allows for a larger range in SZSLs than any other state.

Speed Reduction

SZSLs are largely found to result in reductions in mean and 85th percentile vehicle speeds, however the extent of the reductions and statistical significance varies. In many cases, a SZSL resulted in lower compliance with speed limits, however, lower overall speeds and tightening and leftward shift of speed distributions indicate overall safety benefits. Other than lower compliance, no negative impacts on vehicle speeds through school zones were identified.

Crash Reduction

Studies of multi-year crash histories through school zones and residential zones overwhelmingly found reductions in crashes, and in particular, reductions in fatal and serious injury crashes involving vulnerable roadway users. This suggests that SZSLs can have a positive impact on safety in school zones. No negative impacts on user safety through school zones were identified.

Additional Areas of Emphasis

The speed differential between the approach speed limit and the SZSL has an impact on compliance and safety, with a recommended speed differential of 5 to 10 mph and speed buffer zones recommended on high-speed roadways. The layering of additional countermeasures such as flashing beacons and geometric changes are recommended as best practices for traffic calming in school zones.

Conclusion

While properly set SZSLs on their own may have a positive, yet modest, impact on safety within school zones, it is widely understood that redundancy is the key to effective traffic calming through school zones. For the largest effect on speed reduction and to maximize school zone safety, the use of SZSLs should coincide with additional speed management countermeasures such as dynamic warnings and signage and geometric changes to the roadway such as curb extensions, median islands, and traffic circles. Additional research is needed to determine the effectiveness SZSLs have as a standalone treatment on high-speed roadways, which are characterized as roadways with speed limits of 40-plus mph for this research.

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[1] Unintended Consequences of the 85th Percentile Speed. *Vison Zero Case Study of Portland, Oregon.*

[2] The Federal Highway Administration's USLIMITS2 is a web-based tool designed to help practitioners set reasonable, safe, and consistent speed limits for specific segments of roads.

Background

Speed limits in the US are set by state and local governments. The Uniform Vehicle Code (UVC) includes a basic speed statute requiring motorists to operate at a reasonable speed for conditions. Statutory Speed Limits, set by state legislatures, provide default speed limits by roadway type or location (e.g., interstates, rural highways, urban, work zones and school zones). The UVC also recommends states establish speed zones based on an engineering and traffic investigation. The roadway authority including the state department of transportation, county or municipality sets speed limits based on engineering and traffic investigations, DOT procedures, and/or adopted local policies/guidance.

The following section provides information on the following topics:

- General methodology for establishing speed limits
- Statutory SZSLs and DOT guidance by state
- Guiding documents for SZSLs in Minnesota

Speed Setting Methods

A 2012 Federal Highway Administration (FHWA) report titled *Methods and Practices for Setting Speed Limits*[3] cites four methods for setting speed limits: engineering, expert systems, optimization, and Safe System approach.

Engineering Method:

Historically, the engineering method, often using the 85th percentile operating speed, has been the primary tool used by engineers for setting speed limits on roadways. Current research, however, from the National Transportation Safety Board (NTSB) and other sources[4] indicate that the use of 85th percentile speeds has led to unintended consequences of higher operating speeds and an undesirable cycle of speed escalation and reduced safety. To address these concerns the expert system, optimization, and Safe System approaches have emerged to bring consistency and best practices to the setting of speed limits.

Expert System:

The expert system approach uses tools such as USLIMITS2 and NCHRP 966 to assist local communities and agencies in setting appropriate and objective speed limits. These programs recommend speed limits in speed zones considered credible and enforceable while taking pedestrians and bicyclists into consideration. They stop short, however, of providing guidance on setting speed limits in school zones and work zones.

[3] FHWA-SA-12-004

[4] Unintended Consequences of the 85th Percentile Speed. *Vison Zero Case Study of Portland, Oregon.*

Optimization Method:

The optimum speed limit is considered the speed limit that yields the minimum total societal cost, which includes vehicle operation costs, crash costs, travel-time costs, and other social costs. This method of setting speed limits is rarely used due to the difficulty of quantifying key variables.

Safe System Approach:

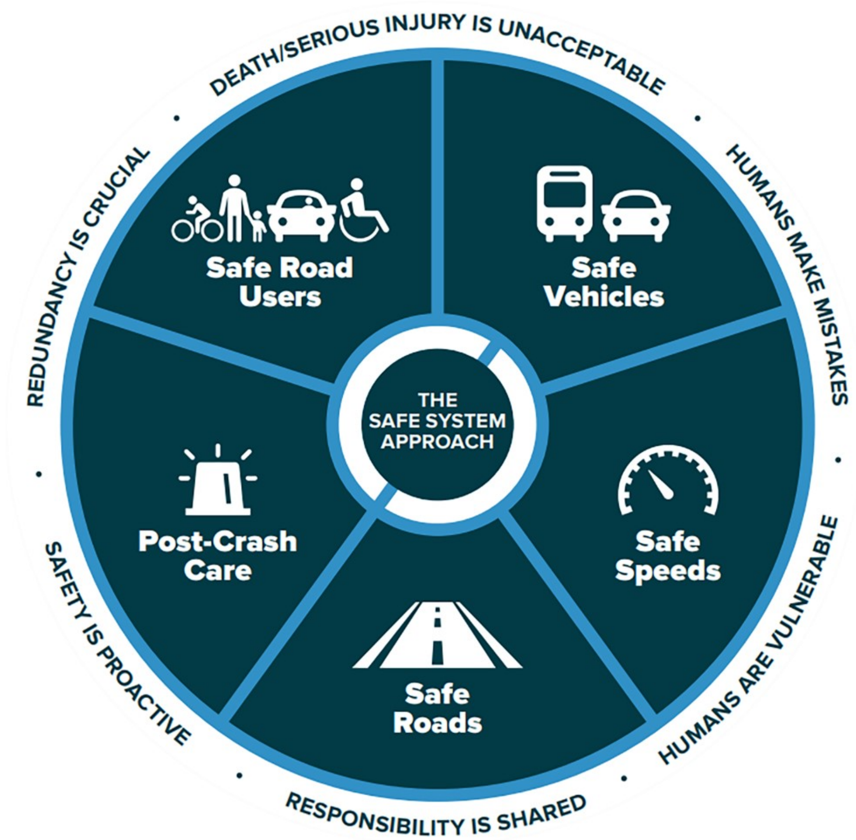
Instead, there is a growing trend to use the Safe System approach in setting speed limits. The Safe System approach, or injury minimization, is based on the tolerance of the human body to injury during a crash. A pedestrian hit by a driver at 25 mph is nearly twice as likely to die compared to someone hit at 20 mph [5].

In January 2022, USDOT officially adopted the Safe System approach in an update to its *National Roadway Safety Strategy* [6]. USDOT recognizes that one of the primary causes of fatal crashes is motor vehicle speeding. The Safe System approach encourages layers of elements to achieve safer roadways and slower speeds, including combinations of road design, multi-modal facility implementation, speed limit setting, education, enforcement, and other strategies.

[5] Tefft (2013), *Impact Speed and a Pedestrian's Risk of Severe Injury or Death*

[6] *ITE Journa*l (May 2022), National Roadway Safety Strategy: USDOT adopts the Safe System approach (pp. 23-27)

Figure 1. The Safe System approach principles and elements (Source: FHWA)



Policies by State

To better understand methods for setting SZSLs, a policy summary was completed to document how states regulate or provide guidance on appropriate speed limits in school zones. Tables 1 and 2 summarize the findings. Of the 50 states and the District of Columbia, the majority (36) use a statute to define either a static SZSL, a range, or a minimum SZSL. Over half have a statutory SZSL set at 15, 20 or 25 mph. Many allow jurisdictions to lower them further based on an engineering and traffic study.

Minnesota statute allows SZSLs to be set anywhere between 15 mph and that of the approach roadway speed limit, with a maximum speed differential of 30 mph. The results show that Minnesota is unique in the size of the SZSL range within state statute. Other notable variations in state statutes and DOT guidance include:

- Kansas Manual on Uniform Traffic Control Devices (MUTCD) defines a 45 mph SZSL on rural roads
- Michigan statute excludes schools from having school zones if no children arrive by walking or biking
- North Dakota statute allows local authorities to reduce speed to 15 mph in a SZSL without requiring an engineering and traffic study
- Texas DOT guidance defines a max speed differential between approach speed and a SZSL of 15 mph, except for on 55 mph-plus roadways, where the speed differential can go up to 20 mph [7]

A complete summary of state statutes and guidance can be found in Appendix A.

[7] Texas guidance largely based on findings from Fitzpatrick et al., 2009

Table 1. Summary of SZSLs for all 50 states and the District of Columbia

SZSL	Number of states
Statutory Minimum (i.e., >= 20 mph)	8
Statutory Range (i.e., 15-25 mph)	3
Static Statutory Speed (i.e., 20 mph)	16
Statutory Speed, adjustments allowed with study (i.e., 20 mph or 15 mph with an engineering and traffic study)	9
DOT Defined Speed or Range	6
No Statute or Guidance	9
Total states (and D.C.)	**51**

Table 2. Summary of state SZSLs and whether they are defined by state statute or by state DOT guidance.

State defined SZSL(s)	Number of states	Statute defined	DOT defined
15 MPH	9	9	0
20 MPH	9	9	0
25 MPH	4	4	0
15+ MPH	3	3	0
20+ MPH	3	3	0
25+ MPH	1	1	0
15-20 MPH	2	2	0
15-25 MPH	1	1	0
15-40+ MPH (Minnesota)	1	1	0
25-45 MPH	1	0	1
10 MPH below posted	1	1	0
0 to 10 MPH below posted	2	0	2
0 to 20 MPH below posted	1	1	0
10 MPH below posted, no lower than 25 MPH	1	0	1
15 MPH below 85th to 35 MPH	1	0	1
15 MPH to 10 MPH below 85th	1	0	1
25 MPH typical; 15 MPH in residential areas	1	1	0
No guidance defined	9		
Total states (and D.C.)	**51**		

Guiding Documents

Minnesota Statutes and the Minnesota *Manual on Uniform Traffic Control Devices* (MN MUTCD) Definitions

Current Minnesota School Zone and School Speed Limit Policies:

- School Zone (defined by the Minnesota MUTCD): "a designated roadway segment approaching, adjacent to, and beyond school buildings or grounds, or along which school-related activities occur (1A.13) [8]."
- Statute 69.14.5a: The school speed limit shall not be lower than 15 mph and shall not be more than 30 mph below the established speed limit on an affected street or highway.
- Statute 169.14.5a: Local authorities may establish a school speed limit within a school zone of a public or nonpublic school based on an engineering and traffic study as prescribed by the commissioner.

These statutes and policies provide agencies and engineers with a large range of SZSLs to choose from with limited guidance for assigning appropriate SZSLs based on roadway characteristics and goals of the school zone. This can pose several challenges to integrate consistent and effective SZSLs as they relate to creating safer roadways and slower motor vehicle speeds in areas with school-aged children walking, bicycling, and rolling to school.

MN *Traffic Engineering Manual* (TEM)

The purpose of the TEM is to establish uniform guidelines and procedures, primarily for use by MnDOT personnel. Counties, cities, and local units of government will also find this manual useful when striving for uniformity in traffic engineering throughout Minnesota. The information must be combined with engineering judgment and balanced with social, economic, environmental, and political factors to yield appropriate traffic engineering solutions.

The TEM provides information and guidance for the setting of speed limits. This includes discussion of the Principles of Speed Zoning, Investigation Procedures and Conditions Justifying Variations from the 85th Percentile Speed.

Minnesota's Statewide Speed Limit Vision Project

Within Minnesota, the Statewide Speed Limit Vision Project was developed to provide an approach for cities, counties, and other public groups to set speed limits with all roadway users in mind. The project emphasizes the understanding that a speed limit should recognize context, users, and function and has three core values:

1. Speed limits are affected by community context, land use, and road design.
2. Speed limits are governed by voluntary compliance through education and accepted social norms.
3. Speed limits are established through consistent technical evaluation and applied equitably across all communities.

[8] *Minnesota Manual on Uniform Traffic Control Devices* (MN MUTCD)

Statewide Multimodal Transportation Plan

The Minnesota Statewide Multimodal Transportation Plan (SMTP)[9] is a transportation policy plan that is updated every five years. The SMTP outlines a 20-year plan based on Minnesota's vision to improve the health of all transportation users, the environment, and the state's economy. The plan evaluates all transportation systems, including those not on a state highway network. MnDOT routinely updates this plan so it can incorporate how changes in population, economy, environment, technology, safety, and behavior impact the way transportation occurs in the state.

The upcoming 2022 SMTP will focus on six topics: aging infrastructure, climate change, economy and employment, equity, safety, and transportation options. Regarding the safety topic, the plan emphasizes the priority for Minnesota to further safe transportation options for users and the community. The identified strategies will increase participation and support for the Toward Zero Deaths initiative that aims to eliminate fatal and serious injury crashes on all Minnesota roadways. One of several strategies in the plan outlines the need to implement complete streets approaches to the design of transportation systems. Through holistic, multi-modal and equitable design, the complete street model may reduce the speed and volume of motor vehicle traffic by using traffic calming methods and supporting facilities that encourage other transportation modes.

NACTO City Limits

Several agencies and associations have begun to develop and integrate systematic approaches to setting speed limits that look beyond historical, traditional approaches. For example, the National Association of City Transportation Officials (NACTO) developed City Limits[10], which outlines how to use a Safe System approach to set speed limits in urban settings since these are the most challenging environments for determining speed limits and include the highest proportion of pedestrian and bicyclist fatalities. These methods are outlined for cities to consider rather than applying the traditional traffic engineering method of percentile-based speed limits.

Safe Routes to School

While there is a federally funded Safe Routes to School (SRTS) program, MnDOT offers a state funded program for communities (MnSRTS). The MnSRTS Strategic Plan outlines a vision to improve equity and safety for youth and supports them to "safely, confidently, and conveniently walk, bike, and roll to school and in daily life[11]." The MnSRTS Strategic Plan includes six goals to progress toward this vision over five years:

1. Build Local Partners' Capacity to Implement SRTS
2. Coordinate SRTS Implementation Statewide
3. Increase Awareness of SRTS
4. Develop Process, Policy, and Design Guidance that Supports SRTS

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[9] https://minnesotago.org/learn-about-plans/statewide-multimodal-transportation-plan

[10] City Limits (2020-summer), *Setting Safe Speed Limits on Urban Streets*. National Association of City Transportation Officials. https://nacto.org/wp-content/uploads/2020/07/NACTO_CityLimits_Spreads.pdf

[11] http://www.dot.state.mn.us/mnsaferoutes/assets/downloads/mn-srts-strategic-plan-2020.pdf

5. Measure Progress, Evaluate Impacts, and Continually Improve the Program
6. Innovate in Program Development and Implementation

These goals are rooted in the National SRTS program that is structured around a multidisciplined approach to creating a safer and more accessible environment for students as well as a more inviting, accessible, and inclusive community. This approach is referred to as the 6 E's: evaluation, education, encouragement, equity, engagement and engineering.

The National Center for Safe Routes to School[12] emphasizes that one of the biggest barriers in creating a safe route for students walking, bicycling, and rolling to school is motor vehicle travel speed. Slower motor vehicle travel speeds shorten the stopping sight distance and reduce the chance for a pedestrian fatality or serious injury crash. The SRTS program cautions against over-reliance on SZSL signs since it may lead to noncompliance and unsafe roadways. Therefore, most state SRTS programs recommend supplementing SZSL signs or traffic control with roadway design improvements, enforcement, or other methods to attract drivers' attention (e.g., flashers/dynamic signs) to effectively calm traffic and influence motorist behaviors within school zones.

Literature Review of SZSLs Effectiveness

The following literature review was conducted to understand what before-and-after studies state about the effectiveness of school zone speed limits as a stand-alone treatment for calming traffic and improving safety, particularly for vulnerable roadway users such as students. Spillover effects (such as impacts on other roadways or outside enforced SZSL hours), unintended consequences (such as increases in driver speeds or crash history), and additional countermeasures were also noted as part of the research.

The review aimed to identify studies that used a high-level of methodological rigor to isolate the change in speed from a SZSL independent of other countermeasures and used a high enough sample size to determine statistical significance. A total of 12 US and international studies were found that provided before-and-after evaluations of SZSLs or residential speed zone implementation. Of these, ten studies investigated the effects of SZSLs or residential speed zones on driver speeds, four investigated the effects on safety. A total of five studies were identified that considered the use or effectiveness of speed differentials or buffers between the approaching speed limit and the SZSL. The methodological rigor of these studies varied, with some studies using low sample sizes or using non-traditional methodology such as the driving simulator study out of China (Zhao et al. 2015).

Fewer before-and-after studies with a high level of methodological rigor were identified than was anticipated. It is likely that most studies on the effectiveness of SZSLs are done at the local level by city engineers to evaluate individual school zones and remain unpublished due to small sample sizes.

The following summarizes the findings of the available, published studies as of July 2022 while Appendix B provides additional information on the methodology and results for each study.

[12] http://guide.saferoutesinfo.org/engineering/slowing_down_traffic.cfm

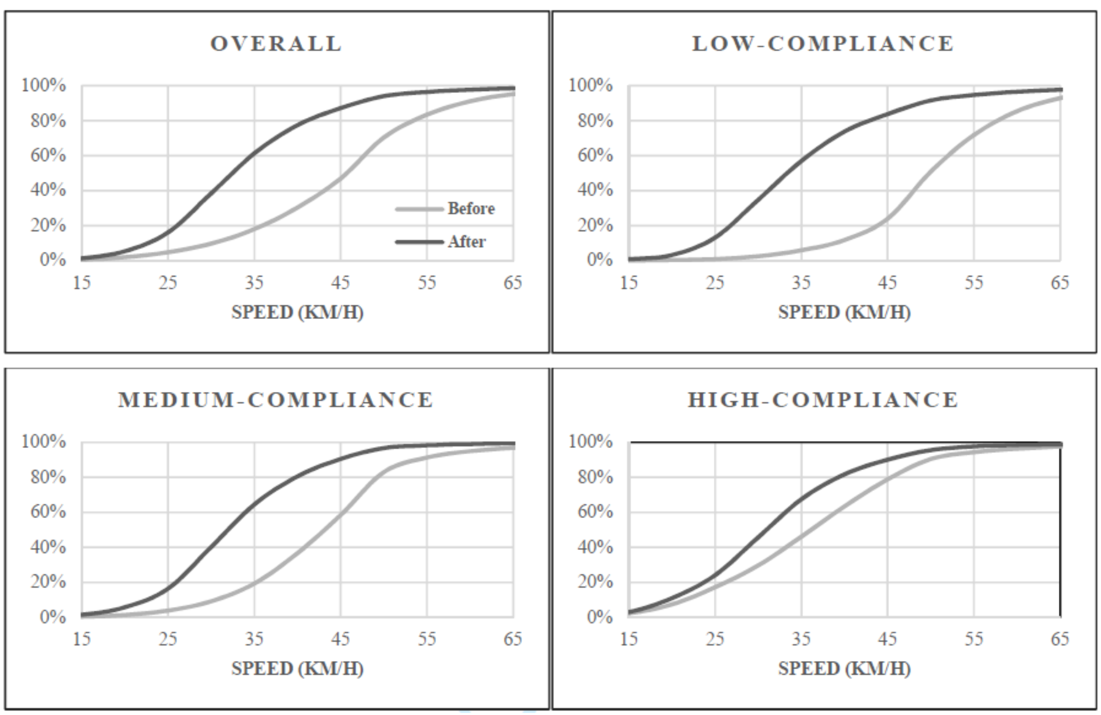
Speed Reduction

Research demonstrates that the risk of severe injury or death for pedestrians involved in an auto crash increases as speeds increase. Thus the ability to achieve speed reductions with SZSLs is of importance to practitioners, officials and school communities.

A total of nine US and International studies provided before-and-after evaluations of SZSLs. All of the studies that looked at SZSLs found reductions in mean and/or 85th percentile speeds when compared to before or inactive SZ periods, but the extent, statistical significance and shift of the distribution varied by study. Though the statistical significance of the findings varied, none of the studies reported findings of an increase in driver speeds.

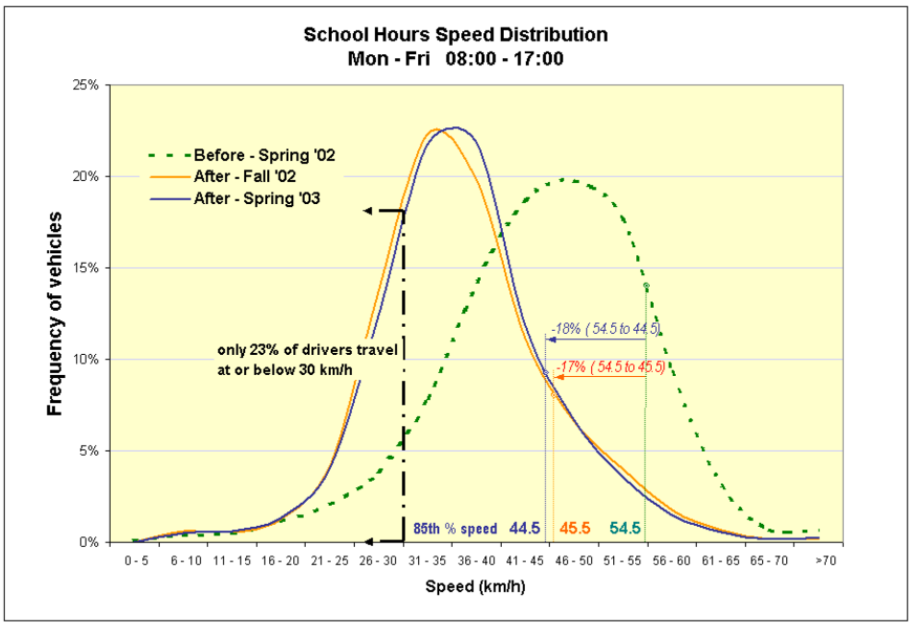
The most scientifically robust study was completed in 2018 by Sun et al. and published in the Canadian Journal of Civil Engineering. It conducted a longitudinal analysis of 43 school zones in the City of Edmonton, within which no other significant changes were made upon treatment and comparison sites except the posting of a SZSL. Each SZ consisted of a 30 km/h (19 mph) SZSL, reduced from a 50 km/h (31 mph) approach speed limit. Their findings include a 12.2 km/h (7.5 mph) reduction in mean and a 11.6 km/h (7.2 mph) reduction in 85th percentile speeds through school zones. Also noted was the shift to the left of the cumulative speed distributions and the decrease in speed variance, which typically implies an improvement in traffic safety. Figure 2 shows the cumulative speed distributions for all locations, as well as those in low, medium and high compliance locations based on initial compliance rates. This shift was more prominent in the low-compliance locations and for vehicles traveling at higher speeds.

Figure 2. Cumulative Speed Distributions Profiles - before and after 30km/h SZSL implementation (Sun et al. 2018)



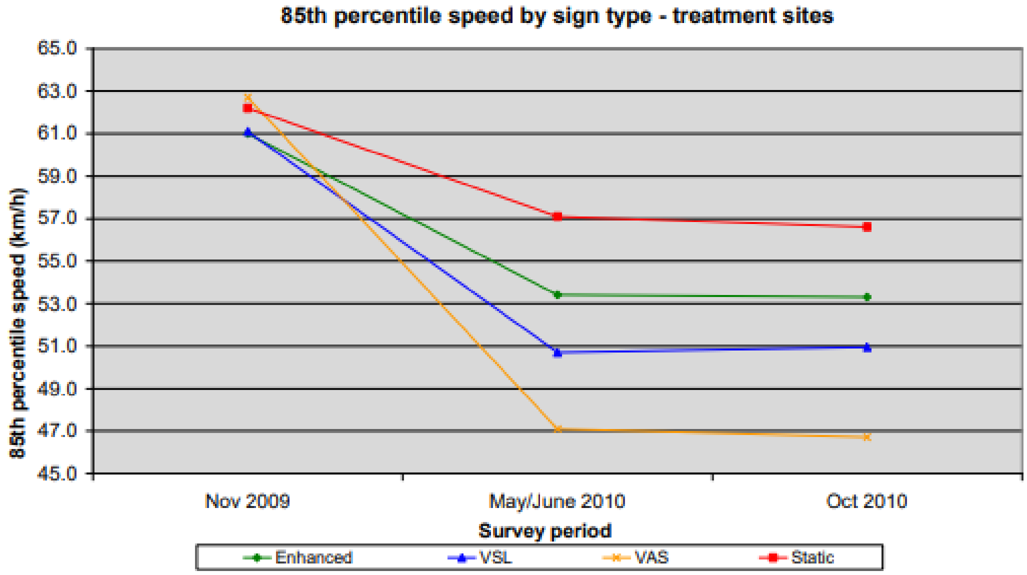
Another notable study was presented at the 2003 Transportation Association of Canada's Annual Conference and Exhibition (Lazic 2003). It was conducted by city engineers as a before-and-after evaluation of 15 school zones throughout the City of Saskatoon in Saskatchewan, Canada. Results of the study show an overall shift to the left and tightening of speed distributions during school hours (8am to 5pm) when speed limits were reduced from 50 km/h (31 mph) to 30 km/h (18.6 mph). Eight months after the installation of the school zones, the mean speed was reduced by 11 km/h (6.8 mph) and 85th percentile speed was reduced by 10 km/h (6.2 mph). The study also noted a lower level of driver compliance with the 30 km/h speed limit, but that despite the less than satisfactory compliance, the achieved reduction in speed of 10 km/h (6.2 mph) still likely represents an improvement to child pedestrian safety during the school hours in terms of increased reaction time and driver's general awareness of school zones. Figure 3 shows the tightening and sustained shift in averaged speed distribution after the installation of the 30 km/h school zone.

Figure 3. Average speed distribution during school hours (Lazic 2003)



Other studies that found reductions in mean and 85th percentile speeds include a 2010 study out of Queensland, Australia (Singh 2011) that looked at the impact of static and other signage types on the mean and 85th percentile speeds on 40 km/h (25 mph) multilane school zones. Data was collected at eight school zones and eight control sites for a total of two school locations for each signage type during the before period, six months after installation and 11 months after installation. Results of the study showed that the use of static SZSL signs saw a 7-9 km/h reduction in mean speeds and a 5 km/h reduction in 85th percentile speeds and results were sustained after 10 months. Additional findings showed that vehicle activated signs (VAS) performed best recording the lowest and largest reductions in mean (13 km/h reduction) and 85th percentile speeds (16 km/h reduction).

Figure 4. 85th percentile speed by sign type at treatment sites in Queensland, Australia

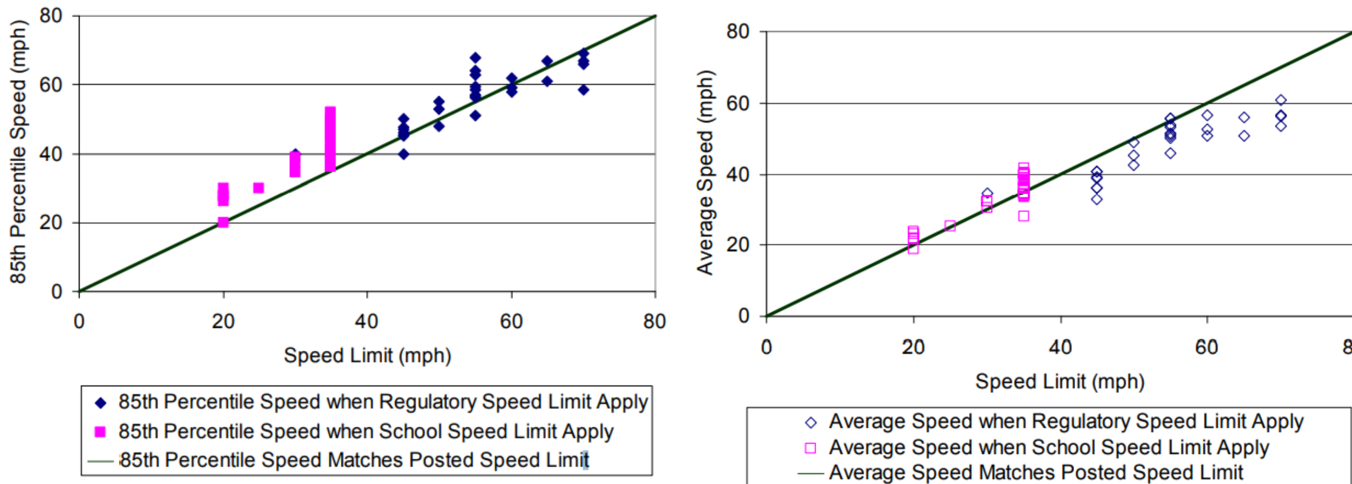


Another study out of Canada (Tay 2009) observed speed changes at 20 school zones or playground zones after the zone speed limit was changed from 50 km/h to 30 km/h. The study concluded that the mean speed and 85th percentile speed were significantly lower after the implementation for the school or playground zone. The mean speed on four-lane roads was found to be higher than the mean speed on two-lane roads, however, this difference was not statistically significant. Another finding from the study was the impact on fencing, with speed limit violation rate significantly higher in zones without fencing than in zones with chain-link fencing.

In 2020 the Nebraska DOT published findings from speed data at 18 school zones which compared active (flashing beacon) vs. inactive school zones. The study considered roadway design and context, including other features such as school visibility, presence of fencing, types of traffic control devices, school zone length, loading areas, and on-street parking. Results show statistically significant reductions in driver speeds when school zones were active (i.e., flashing beacons). When flashing lights were active, drivers slowed their speeds by 5-7 mph and less than 4% of the drivers exceeded 35 mph. The study, however, does not provide a direct comparison between school zones with flashing beacons and school zones with static signage.

Fitzpatrick et al. 2009 is a frequently cited study that formed the basis for Texas DOT guidance. The study analyzed data at 24 school zones for findings on speed-distance relationships, speed-time relationships, influences of various site characteristics on speeds, and special characteristics of school zones with buffer zones. The study found statistically significant reductions in mean speed when the school zones were active and that the school speed limit variable dominated all other variables in the regression analysis to evaluate which variable effect operating speeds in an active school zone. The study also noted relatively low compliance rates for school zones compared to regulatory speed limits. No information was provided on the shift in the distribution curve. As this study also includes the use of flashing beacons there is not a direct comparison for the use of static SZSL signs.

Figure 5. 85th and mean speeds when school speed limits applied (flashing beacons)



(a) 85th Percentile Speed **(b) Average Speed**

The most notable findings from Fitzpatrick et al. 2009 were regarding the use of speed differentials, buffers and other site characteristics and are summarized in the “Additional areas of emphasis” section of this report.

Four additional studies reported inconclusive or no statistically significant findings with regards to SZSLs and speed reductions, most of which had low sample sizes and did not control for confounding variables. The first was a driving simulator study out of China (Zhao et al. 2015) that concluded that the effectiveness of school zones in changing speed varied greatly depending on road geometric conditions. An evaluation of four school zones in Atlanta by Young and Dixon in 2003 found that school zone signage had no general impact on reducing vehicular speeds. While not a direct comparison, a study completed for the Mississippi DOT (Strawderman and Zhang 2013) that looked at sign saturation at four school zones found that drivers have higher compliance on 4-lane roads compared to 2-lane roads and in areas with high sign saturation.

A study in Switzerland (Lindenmann 2005) of residential speed zones completed a speed study and cost/benefit analysis to better understand the safety benefits of the reduced speed limits in residential areas from 50 to 30 km/h. While the study does not evaluate school zones, its overall findings can still highlight trends in 50 to 30 km/h speed reductions. Of the 11 zones in large and medium size towns and 20 zones in small towns and village that collected before-and-after speed data, they found a considerable deterioration in compliance to the zone speed limit, but an overall decrease in 85th and 50th percentile speed of 6 to 7 km/h. Traffic engineering and structural countermeasures (i.e., speed bumps and street narrowing) were associated with a positive effect of the structural measure. By contrast, there was practically no reduction or only a minimal speed reduction in zones without structural traffic calming measures. Despite the low compliance for the speed limit changes as a standalone countermeasure, the crash history and cost benefit analysis described in the following section indicate a sustained increase in road safety.

The conclusion drawn from these studies indicates that, particularly for SZSLs or residential speed zones in the 15-25 mph on 25-35 mph roadways range, the decrease in compliance does not correlate with a decrease in safety. The overall effect of lowering speeds, particularly 85^{th} percentiles, and the tightening and leftward shift of speed distributions indicated safety benefits despite lower compliance to speed limits. Additionally, traffic engineering and structural countermeasures paired with SZSLs or residential speed zones result in a greater level of speed reduction and thus improvements in safety. While this report does not complete a full evaluation of additional countermeasures, Table 3 provides additional resources for further review.

Crash Reduction

In the past two decades, four applicable studies in Canada, Europe and Australia have evaluated the effect of SZSLs and 20 mph residential speed zones on safety through the analysis of multi-year crash histories. Two of these studies evaluated crash histories on residential speed zones and two looked specifically at school zones. All studies found a reduction in the overall crash rates, the fatal and severe crash rates and the crash rates for vulnerable roadway users, indicating safety improvements of SZSLs and/or residential speed zones.

Sun et al. 2018 – 30 km/h SZSL

Once again, the Canadian study by Sun et al. in 2018 conducted the most extensive analysis of safety effects of school zone speed limits. The before-and-after study of crash histories evaluated 216 school zones and 622 control sites throughout the City of Edmonton. Within school zones, the speed limit was reduced from a 50km/h (30 mph) SZSL to 30 km/h (20 mph) when the SZSLs were implemented and active. To establish statistical significance, the study conducted a Full Bayes Analysis of 366 injury and fatal crashes over a five-year period from 2011 to 2016. Results from the study implied a statistically significant reduction in expected collision frequency of 45.3% in fatal/injury crashes and 55.3% in fatal/injury for vulnerable roadway users. No significant spatial or temporal spillover effects were found. The study concluded that there is “strong evidence that reducing speed limits to 30 km/h in school zones can bring significant safety benefits by reducing vehicular speeds and fatal/injury crashes.”

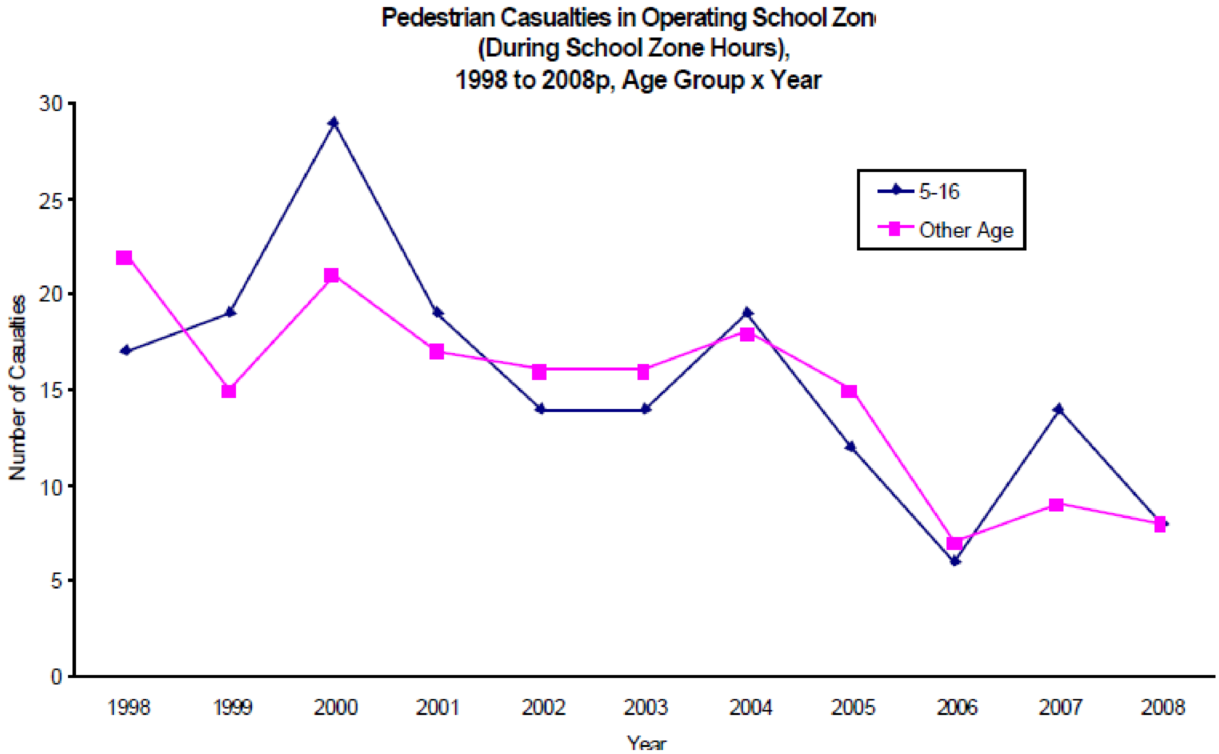
Graham and Sparkes 2010 – 40 km/h SZSL

Another study that looked at large scale implementation of SZSLs was a 2010 study out of Australia that analyzed crash data before and after a state-wide 40 km/h (25 mph) SZSL was implemented in New South Whales (Sydney). An analysis studied pedestrian casualty history (1998-2008) for 5–16-year-old children in school zones before and after a 40 km/h statutory SZSL was implemented in New South Whales. The incidence of speed involvement in crashes in school zones was also investigated, as well as the types of crash occurring in school zones during active School Zone Times.

The data analysis from the study suggests that pedestrian casualties amongst the 5 to 16 year-old age group decreased in school zones at a greater rate than at other locations. Compared with the pre period (1998 to 2000), the average annual pedestrian casualties in the selected school zones decreased by 45% during post period (2004 to 2008). This was a larger reduction in casualties for this age group than was found at sites outside school zones sites or operational times (only 35% reduction).

An interesting finding from this study was that, “contrary to popular misconceptions, crashes associated with sudden slowing of vehicles and congestion did not increase but actually decreased from the pre to the post periods." They do, however, note a couple compounding factors with this study, including the adoption of certain countermeasures during the after period such as the use of digital speed camera at a hand full of schools (starting in 2002) and progressive rollout of flashing beacon signage starting in late 2006.

Figure 6. Change in pedestrian casualties in operating school zones after implementation of a 40 km/h (25 mph) school zone speed limit in 2004 in NSW Australia (Graham and Sparkes 2010)



Lindemann 2005 – 30 km/h residential zone

As noted in the previous section, Lindenmann 2005 conducted an analysis of 30 km/h (20 mph) residential speed zones throughout Switzerland to understand their effects of residential speed zones on speeding behavior and crash history. Within a few years of the speed zones being implemented, the study found a considerable reduction in overall crashes of about 15 percent, a 27 percent decline in accident severity and a higher accident reduction in rural areas compared to urban areas (45 and 15 percent respectively). The accident distributions illustrates that the area-based 30 km/h measure is often not uniquely suitable as the sole measure for achieving a reduction in accident occurrence, particularly in the case of local accident black spots at intersections.

Figure 7. Classification of accident occurrence in 30 km/h residential zones in Switzerland (Lindenmann 2005)

Table 2. Classification of accident occurrence.

All 30 km/h zones		Accidents: V speed limit (50 km/h)		Accidents: N speed limit (30 km/h)		Accidents: X^2-test	Accident victims: V speed limit (50 km/h)	Accident victims: N speed limit (30 km/h)	Accident victims: X^2-test
Case III	22 zones	193	65 percent	139	67 percent	s	33	26	r
Case II	5 zones	70	21 percent	43	21 percent	s	16	8	s
Case I	3 zones	37	12 percent	22	12 percent	r	5	0	-

Note: s = significant (95 percent); r = random.

Grundy et al. 2009 – 20 mph residential zone

An observational study in London in 2009 (Grundy et al. 2009) quantified the effect of the introduction of 20 mph (30 km/h) traffic speed zones on road collisions, injuries, and fatalities in the city, adjusted for the underlying downward trend in traffic casualties. The study analyzed 901,166 injuries and 6231 deaths from 1986-2006. While not specific to school zones, the London study found that 20 mph speed zones were associated with a reduction in casualties and collisions (~40%). The observed reductions were largest for the youngest children (0-5 and 6-11). The numbers of killed or seriously injured children were reduced by half and injuries to pedestrians were reduced by a little under a third. Similar to Li and Graham (2016), Grundy et al. 2009 noted a smaller crash reduction for bicyclist than for pedestrians. Spillover analysis also noted a small reduction in speeds outside the 20 mph zones and that casualties inside the 20 mph zones were not being displaced to nearby roads.

Research Gaps

Notably missing from the research are published large scale US studies evaluating the before-and-after effects of school zone speed limits on safety and the effect of SZSLs on roadways with approach speeds of 40 mph or more. Overall the amount of published US research on SZSL implementation was limited and it is suspected that local agencies may not be reporting or documenting before and after evaluations of SZSL implementation. The majority of studies cited in this literature search were conducted outside the US and the initial speed limits of the facilities studied generally were equivalent to 31mph or less. The Fitzpatrick et al study was the only robust US Study and included a selection of seven schools on higher speed roadways.

In addition to additional research on the effects of SZSLs on higher speed facilities, another area of research gap is the distinction of outcomes for implementation of SZSLs accommodated by geometric modifications.

Additional areas of emphasis

Speed differential and buffers

The difference between the approach speed and the SZSL was another major finding from the research. Multiple studies cited the importance of a lower speed differential for compliance with a 5-10 mph differential recommended and > 15 mph differential discouraged (Fitzpatrick et al. 2009, NE DOT 2020, 1990, Saibel et al. 1999).

Rahman et al. 2009 evaluated the impact of speed buffers on safety in school zones located on high-speed roadways. Their research concluded that a two-step speed reduction significantly reduced crash risk in school zones compared to initial conditions.

Fitzpatrick et al. 2009 analyzed at the effects of buffers on speed compliance through school zones on seven high-speed roadways (greater than 55 mph). These schools used the TxDOT treatment called a “buffer zone” which assists in stepping down the speed for a highway segment with an 85th percentile speed or posted speed limit great than 55 mph. The school buffer zone permits motorists to travel at the higher posted speeds through both zones (buffer and school zones) when the school speed limits are not in effect. All the studied buffer zone sites had a compliance rate of at least 80 percent when the buffer speed limit was active. Additionally, it was recommended that school speed limits should not be greater than 15 mph below the 85th percentile speed or posted speed. Appendix C provides the TxDOT signage guidance in the TMUTCD for school zone buffers.

Countermeasures

As noted in the USDOT's National Roadway Safety Strategy, "achieving safe speeds requires a multi-faceted approach that leverages roadway design and other infrastructure interventions, speed limit setting, education, and enforcement.[13]" The layering of additional traffic engineering and structural countermeasures are recommended as best practices for traffic calming in school zones. While the scope of this document does not go into specific research on effectiveness of additional speed reduction countermeasures, there are a variety of sources available summarizing current research and best practices.

Table 3 summarizes some of the additional research with regard to traffic calming countermeasures in school zones. Additionally, MnDOT is in the process of evaluating the effectiveness of Rectangular Rapid Flashing Beacons (RRFBs) as a countermeasure for traffic calming in school zones and other roadways. RRFBs and flashing beacons are often cited for their effectiveness in school zones (Nebraska DOT 2020, Zhao et al. 2016). Law enforcement have noted the effectiveness of these dynamic warnings to clarify the question of how and when to enforce the statutes language of "when children are present."

As described in the previous section on SRTS, the multidisciplinary approach of the 6 E's provides direction for engineers, practitioners and school communities as they seek to implement countermeasures: evaluation, education, encouragement, equity, engagement and engineering. The 6 E's emphasize the need for and greater likelihood of success when a variety of strategies work together to achieve a common goal.

[13] National Roadway Safety Strategy: USDOT adopts the Safe System approach. *ITE Journal.* May 2022. Pages 23-29.

Table 3. Additional resources and studies on traffic calming countermeasures

Publication	Year	Summary of Source
MnDOT Safe Routes to School Website	--	Resource for facility design and other state guidance
NCHRP Synthesis 535: Pedestrian Safety Relative to Traffic-Speed Management	2019	Documents known strategies and countermeasures in confined, urban cities for pedestrian safety.
Minnesota's Best Practices for Pedestrian and Bicycle Safety	2021	Provides information on a mix of treatments that have been used widely across the state and are considered proven strategies, along with emerging treatments that are considered experimental.
MnDOT Speed Safety Cameras TRS	2022	Literature review of before-and-after evaluations of Speed Safety Cameras and their effectiveness at improving safety and speed compliance
Dakota County School Travel Safety Assessment	2021	Recommends improvements and prioritized improvements based on safety benefits relative to cost of the treatment.
FHWA Safe Transportation for Every Pedestrian (STEP)	--	A guide to help agencies select pedestrian crash countermeasures at uncontrolled intersections.
FHWA Traffic Calming ePrimer Toolbox	--	Free, online resource that provides descriptions, applicability, key effects and issues, and design considerations for traffic calming measures.
Attitudes and Concerns of Drivers with Respect to School Zone Safety and Speed Compliance: Results of an Opinion Survey of Drivers (Ash & Saito 2007)	2012	Utah survey of 762 drivers to understand opinions about current school zone traffic control devices
New Jersey School Zone Design Guide	2014	Provides information on engineering measures and treatments with the goal to enhance pedestrian and bicycle accommodations near schools.
Methods and Practices for Setting Speed Limits (FHWA-SA-12-004)	2004	Includes best practices for where to begin speed zone, typical signing to inform school zone speed limit, and advance warning assembly recommendations
Evaluation of Dynamic Speed Display Signs (Ullman and Rose, 2005)	2005	Analysis of effectiveness of dynamic speed display signs in permanent locations, including two school zone sites evaluations

Mississippi DOT: Driver Speed Limit Compliance in School Zones: Assessing the Impact of Sign Saturation	2013	Researches the impacts of increasing school zone saturation on driver compliance behavior to help agency officials to make informed decisions on the benefits of adding school zone signage in Mississippi
Evaluation of Four Recent Traffic Safety Initiatives, Volume IV: Increasing Speed Limit Compliance in Reduced-Speed School Zones (Ash & Saito, 2012)	2012	Effective methods for increasing speed compliance in reduced-speed school zones including a review of methodology for increasing speed compliance in school zones.
Simplified Methodology for the Evaluation of Pedestrian Safety in School Zones (Medina et al., 2010)	2010	Four urban school areas located in the city of Mayaguez, Puerto Rico
Enhancing traffic safety at school zones by operation and engineering countermeasures: A microscopic simulation approach (Rahman et al. 2009)	2019	Evaluate of different safety countermeasures using microsimulation
Speed Reduction in the Zone (Virginia Safe Routes to School 2016)	2016	Overview of education, engineering, encouragement, enforcement and evaluation strategies for school zone best practices
Managing Speed at School and Playground Zones (Kattan et al. 2011)	2011	Investigated the speed compliance, mean speed and 85th percentile speed at selected school and playground zones in the City of Calgary in Alberta

Conclusion

Based on the available research, SZSLs (in the range of 15-25 mph on a 25-35 mph roadway) can have a positive impact on the safety of children walking and biking to school. The study found that, particularly in 25-35 mph roadways, the implementation of a SZSL led to an overall reduction in vehicle speeds and total crashes as well as sizable reductions in fatal and severe crashes. In addition, no unintended consequences[14] were identified with the implementation of SZSLs as a standalone speed-reduction countermeasure.

It was also found that:

- Minimizing the speed differential between the approach speed limit and a SZSL (5 to 10 mph is ideal) and speed buffers on high-speed roadways can impact the effectiveness of SZSLs for reducing speeds and improving safety.

[14] Unintended consequences would have consisted of findings that decreased user safety, such as findings such as an increase in driver speeds, the widening of speed distributions, or an increase in crash history.

- It is common for states to use the 15-25 mph statutory speed limit within school zones without the requirement for an engineering and traffic study.
- While the use of SZSLs as a standalone safety countermeasure may have a positive impact on user safety within moderate to low-speed school zones, it is widely understood that redundancy in countermeasures is the key to effective traffic calming and safety improvements. For the best results, the use of SZSLs should coincide with additional speed-management countermeasures (such as geometric changes to the roadway and dynamic warnings) to maximize school zone safety.

Identified gaps in the research include a lack of robust before-and-after studies within the US as well as data for roadways with speeds of 40-plus mph approaching school zones. Due to the limited amount of research in this area, no conclusions were provided on the effectiveness and safety of SZSLs as a standalone treatment on high-speed roadways.

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Appendix A: Summary of state statutes and guidance

Appendix A. School Zone Speed Limits and Safety

Establishing School Zone Speed Limits - Summary of State Policies and Statutes

Objectives

1. What is the current research regarding setting school zone speed limits?
2. Has research found effective methods and procedures for setting effective school zone speed limits?
3. Are there known spillover or other unintended consequences for setting improper school zone speed limits?

(A) AASHTO Survey

https://traffic.transportation.org/surveys/

Key States

State	Low Range (MPH)	High Range (MPH)	Statutory Speed Status: Minimum	Statutory Speed Status: Range	Statutory Speed Status: Specific	Statutory Speed Status: Specific (Adjustable)	Statutory Speed Status: No Statute	DOT Defined Speed	Mandatory at all schools or just when schools apply?	Statute Language	Methodology for Establishing Speed Limit	Engineering Study Required?	Sources (Links)
Alabama							X		N/A	No State law for school zone speed limits; decisions made by counties/local municipalities	Decisions made by counties/local municipalities	Unclear	https://www.dot.state.al.us/publications/Design/pdf/TrafficSafetyOp/SpeedManagementManual.pdf
Alaska							X		N/A	No state school zone speed statute		Unclear	
Arizona	15	15			X					**Statute Defined - 15 MPH** 28-701 1. Fifteen miles per hour approaching a school crossing.	Statute Defined	No	https://www.azleg.gov/ars/28/00701.htm
Arkansas	25	25			X					AR Code § 27-51-212 (2020) (a) No person shall operate a motor vehicle in excess of twenty-five (25) miles per hour when passing a school building or school zone during school hours when children are present and outside the building.	Statute Defined	No	https://law.justia.com/codes/arkansas/2020/title-27/subtitle-4/chapter-51/subchapter-2/section-27-51-212/
California	15	25				X			If criteria are met	**Div. 11 Chap 7 Article 1 (22358.4)** **CA Statute - 25 miles, 20 or 15 based on E&T** 25 MPH but could be reduced to 20 MPH or 15 MPH under local authority on the basis of an E&TS **(A) A 15 miles per hour prima facie limit**	**Statue defined, modification based on E&T study** "A local authority may determine upon the basis of an E&TS that the prima facie speed limit of 25	If altering	https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/ca-mutcd/rev6/camutcd2014-part1-rev6.pdf https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/2020-california-manual-for-setting-speed-limits-a11y.pdf https://leginfo.legislature.ca.gov/faces/codes_displaySectio
Colorado	15		X						Based on E&T Study: Local governments can apply for a DOT study, or local jurisdictions may conduct their	**No less than 20 MPH on a highway or arterial road, no less than 15mph on non arterial/local streets** C.R.S. 42-4-1102 (5) Whenever the department of transportation or local authorities, within their respective jurisdictions, determine upon the basis of	- 20 mph min on a state highway or other arterial street as defined in subsection - 15 mph min on any other road or street - based on a traffic	Yes	(1) https://www.codot.gov/safety/traffic-safety/assets/documents/school_safety_evaluation_2008.pdf (2) https://www.codot.gov/library/Brochures/Establishing_Realistic_Speed_Limits_Brochure.pdf

Connecticut	10 below							X	N/A		Traffic Investigation Report by OSTA, not more that 10mph speed reduction	Yes	https://portal.ct.gov/-/media/DOT/documents/dstc/Guidelines-for-Establishing-Speed-Limits-in-the-State-of-Connecticut-102021.pdf https://portal.ct.gov/-/media/DOT/documents/dstc/SpeedLimitsFAQpdf.pdf
Delaware	20	20				X				**Statute defined 20 MPH - can be reduced by Local Authorities** § 4169. Specific speed limits (3) 20 miles per hour at all school zones where 20 mph regulatory signs are posted and state the time periods or conditions during which the speed limit is in effect;	Statute Defined or Engineering Study	If altering	https://delcode.delaware.gov/title21/c041/sc08/index.html
Florida	15	20		X						**15 MPH to 20 MPH except by local regulation or outside an urbanized area** § 316.1895 (5) A school zone speed limit may not be less than 15 miles per hour except by local regulation. No school zone speed limit shall be more than 20 miles per hour in an	Engineering study	Yes	https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/traffic/speedzone/2019-01-28_speed-zoning-manual_august-2018.pdf?sfvrsn=ac20bad7_0
Georgia	20 below		X							**No state defined school speed limit, up to local authority with a traffic study** **§ 40-6-183 - Alteration of speed limits by local authorities** a) Whenever the governing authority of an incorporated municipality or county, in its respective jurisdiction, determines on the	Engineering study	Yes	https://law.justia.com/codes/georgia/2020/title-40/chapter-6/article-9/section-40-6-183/
Hawaii							X			No state speed limits, up to Director of Transportation and the Counties		Unclear	https://hidot.hawaii.gov/highways/files/2013/07/Pedest-Tbox-Toolbox_8-Children-and-School-Zones.pdf
Idaho							X			**No state defined school speed limit, up to State and/or local authorities based on an engineering study**	Engineering study	Yes	https://legislature.idaho.gov/statutesrules/idstat/title49/t49ch6/sect49-658/ https://itd.idaho.gov//wp-content/uploads/2017/08/school-safety4.pdf
Illinois	20	20				X				**IL Statute =< 20 MPH during defined 'School Day'** 11-605 On a school day when school children are present and so close thereto that a potential hazard exists because of the close proximity of the motorized traffic, no person shall drive a motor	**Modifications based on E&T** Sec. 11-602. Alteration of limits by Department. Whenever the Department determines, upon the basis of an engineering and	If altering	https://www.ilga.gov/legislation/ilcs/fulltext.asp?DocName=062500050K11-605
Indiana	20		X							**>=20MPH up to Local Authorities** § 9-21-5-6 (d) Except as provided in this subsection, a local authority may not alter a speed limit on a highway or extension of a highway in the state highway system. A city or town may establish speed limits on	Engineering Study	Yes	https://law.justia.com/codes/indiana/2012/title9/article21/chapter5

Iowa	25	25			X					**Iowa Statute - 25 MPH** 321.285.2a(2) Twenty-five miles per hour in any residence or school district	Statute defined	No	https://iowadot.gov/traffic/manuals/pdf/speedlimitbrochure.pdf https://www.legis.iowa.gov/docs/code/2020/321.285.pdf https://www.legis.iowa.gov/docs/code/321.1.pdf
Kansas	20		X *					* 45 MPH rural speed on roadways with 50+ MPH		>=20MPH, based on Engineering Study III. **Based on engineering and traffic investigations**, a local government may increase or decrease the above speed limits within its jurisdiction. However, the following limitations apply: (1) a speed limit in an urban	Engineering Study/ MUTCD defined for Rural highways (45 MPH on 50+ MPH roadways)	Yes	https://www.ksdot.org/bureaus/burtrafficeng/sztoolbox/school_zone_program.asp https://kutc.ku.edu/sites/kutc.ku.edu/files/docs/ltap-news/LVR%20guide%202017_interactive.pdf http://www.kslegislature.org/li_2020/b2019_20/statute/008_000_0000_chapter/008_015_0000_article/008_015_0060_section/008_015_0060_k/
Kentucky							X			No state school speed limit, II. With the approval of the Secretary of Transportation, a local government may establish speed limits for the highways or streets within its jurisdiction.	Unclear	Unclear	https://apps.legislature.ky.gov/law/statutes/statute.aspx?id=51582 https://apps.legislature.ky.gov/law/statutes/statute.aspx?id=6372
Louisiana							X			No State school speed limit, engineering study	Engineering Study	Yes	http://wwwapps.dotd.la.gov/administration/dotdaz/definition.aspx?termID=140
Maine	15	15			X					**Statute 15 MPH** §2074. Rates of speed A. Fifteen miles per hour when traveling in a school zone:	Statute Defined	No	http://www.mainelegislature.org/legis/statutes/29-a/title29-asec2074.html
Maryland							X		If criteria are met and local authority establish School Zone	**No State School Zone Speed, based on Engineering Study of local authorities or State Highway Administration** § 21-803.1. School zones. (a) Establishment.- (1) Subject to subsection (f) of this section, within a half-mile radius of any school, the	Engineering Study	Yes	https://law.justia.com/codes/maryland/2010/transportation/title-21/subtitle-8/21-803-1 https://roads.maryland.gov/mdotsha/pages/index.aspx?PageId=814#:~:text=The%20Maryland%20Annotated%20Code%20(TR,should%20be%20a%20school%20zone.
Massachusetts	20	20			X				If criteria are met	MGL c. 90 § 18B provides cities and towns the ability to establish safety zones at a speed limit of 20 mph in accordance with the MassDOT Procedures for Speed Zoning.	MUTCD defined	No	https://www.mass.gov/doc/massachusetts-amendments-to-the-mutcd/download https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section17 https://www.mass.gov/doc/procedures-for-speed-zoning-on-state-and-municipal-roadways/download https://www.mass.gov/doc/speed-limit-and-advisory-speed-
Michigan	25		X						Did not specify	Michigan Vehicle Code Act 300 - 257.627a Cannot be decreased by more than 20 MPH; no less than 25 MPH (min speed limit in school zone)		Unclear	https://mdotcf.state.mi.us/public/tands/Details_Web/mmutcdcompleteinteractive.pdf http://www.legislature.mi.gov/(S(ljlyb1inivmx0x2psxzwcyn3))/mileg.aspx?page=GetObject&objectname=mcl-257-627a

Minnesota	15	40		X						**MN Statute - Varies** 169.14.5a.(a) The school speed limit shall not be lower than 15 miles per hour and shall not be more than 30 miles per hour below the established speed limit on an affected street or highway.	**Basis of an engineering and traffic investigation** MN Statute 169.14.5a.(a) Local authorities may establish a school speed limit within a school zone of a public or nonpublic	Yes	https://www.dot.state.mn.us/trafficeng/publ/mutcd/ https://www.revisor.mn.gov/statutes/cite/169.14
Mississippi	10 below							X	N/A	**DOT policy no less than 10 mph below, school zones speeds based on engineering study** III. Based on engineering and traffic investigations, local governments may adopt speed limits on limited portions of highways	Engineering Study	Yes	https://sos.ms.gov/ACProposed/00012958b.pdf
Missouri	25	10 below						X	Application required	**State MUTCD - 10 MPH below posted, >=25MPH** -the school speed limit shall be 10 MPH below the posted speed limit. In no case shall a school speed limit of less than 25 MPH be allowed	School speed limit shall be 10 MPH below the posted speed limit. In no case shall a school speed limit of less than 25 MPH be allowed.	Yes	https://epg.modot.org/index.php/903.18_Signing_for_School_Areas
Montana	15		X							**>=15mph, Engineering Study** 61-8-310. (d) decreases the limit in a school zone or in an area near a senior citizen center, as defined in 23-5-112, or a designated crosswalk that is close to a school or a senior citizen center to not less than 15	Engineering Study	Yes	https://leg.mt.gov/bills/mca/title_0610/chapter_0080/part_0030/section_0100/0610-0080-0030-0100.html
Nebraska							X			No state school speed limit, engineering study I. Based on engineering and traffic investigations, the State or local governments may increase or decrease the above statutory speed limits.	Engineering Study	Yes	https://dot.nebraska.gov/media/113686/school_zone_final_report_06-15-2020.pdf
Nevada	15	15			X					**15MPH school Zone, 25 MPH school crossing zone** NRS 484B.363 1. A person shall not drive a motor vehicle at a speed in excess of 15 miles per hour in an area designated as a school zone 2. A person shall not drive a motor	Statute Defined	No	https://files.clarkcountynv.gov/clarknv/Public%20Works/Traffic%20Safety%20Info/School%20Zones.181003.pdf
New Hampshire	10 below	10 below			X					**10 MPH below Usual Speed Limit, if altering local government needs engineering study** NH ST § 265:60(II) (a) In a posted school zone, at a speed of 10 miles per hour below the usual posted limit from 45 minutes prior to each school	Statute Defined	If altering	https://www.gencourt.state.nh.us/rsa/html/XXI/265/265-mrg.htm
New Jersey	25	25				X				**25 MPH, variable through an Engineering and traffic investigation/by local ordinance** **NJ Statute 39:4-98 25 MPH** a.Twenty-five miles per hour, when passing through a school zone during	SRTS Design Guide Pg 9(13 of pdf) However, not all school speed limit zones are 25 mph. **Local authorities, with reference to roadways under their**	If altering	https://www.state.nj.us/transportation/community/srts/pdf/schoolzonedesignguide2014.pdf https://law.justia.com/codes/new-jersey/2013/title-39/section-39-1-1/ https://law.justia.com/codes/new-jersey/2013/title-

New Mexico	15	15			X					**15 MPH** § 66-7-301 (1) fifteen miles per hour on all highways when passing a school while children are going to or leaving school and when the school zone is properly posted;	Statute Defined	No	https://www.nmlegis.gov/sessions/02%20Regular/FinalVersions/HB095.html
New York	10 below 85th	10 below 85th						X	N/A	NY MUTCD - Varies The numerical value of a school speed limit should be approximately 10 MPH below the normally prevailing 85th percentile speed on the highway, or at approximately the actual 85th	NY MUTCD 2011 Supplement: In order for a school speed limit to be established, all of the following conditions shall be met:	Yes, or where a reduced school speed limit is specified for such areas by statute	https://www.dot.ny.gov/divisions/operating/oom/transportation-systems/repository/B-2011Supplement-adopted.pdf https://www.dot.ny.gov/about-nysdot/faq/posting-speed-limit-within-a-school-zone
North Carolina	20		X							NC ST § 20-141.1. Speed limits in school zones. The Board of Transportation or local authorities within their respective jurisdictions may, by ordinance, set speed limits lower than those designated in G.S. 20-141 for areas adjacent to or near a	Engineering Study	Yes	https://www.ncleg.gov/enactedlegislation/statutes/pdf/bysection/chapter_20/gs_20-141.1.pdf
North Dakota	15	20		X						**ND Statute 20 MPH or less if posted by local authorities** Statute 39-09-02.1b Twenty miles [32.19 kilometers] an hour when passing a school during school recess or while children are going to or leaving school during opening or closing	Statute defined	Unclear	https://www.ndlegis.gov/cencode/t39c09.pdf
Ohio	20	20			X				Local authority request	**Statute 20 MPH** Section 4511.21 (1)(a) Twenty miles per hour in school zones during school recess and while children are going to or leaving school during the opening or closing hours, and when twenty miles per hour school speed	Statute Defined	No	https://codes.ohio.gov/ohio-revised-code/section-4511.21 https://www.dot.state.oh.us/roadway/omutcd/Documents/2012%20OMUTCD_%20-%20App.%20B.pdf
Oklahoma	25	25				X				**25 MPH, variable with engineering study** 47 OK Stat § 47-11-801 (2021) 3. On any highway outside of a municipality in a properly marked school zone, twenty-five (25) miles per hour, provided the zone is marked with appropriate warning signs placed in	Engineering study	If altering	https://law.justia.com/codes/oklahoma/2021/title-47/section-47-11-801/
Oregon	20	20			X					**20 MPH** OR Statute 811.111 Drives a vehicle in a school zone at a speed greater than 20 miles per hour if the school zone is: A segment of highway described in ORS 801.462 ("School zone") (1)(a) and: The school zone has a flashing light used	Statute defined	No	https://oregon.public.law/statutes/ors_801.462 https://oregon.public.law/statutes/ors_811.111 https://www.oregon.gov/odot/Engineering/Docs_TrafficEng/Guide_to_School_Area_Safety.pdf
Pennsylvania	15	15				X				Pa.C.S. 3365(b) School zones.--When passing through a school zone as defined and established under regulations of the department, no person shall drive a vehicle at a speed greater than 15 miles per hour. An official traffic-control device shall indicate the beginning and end of	Statute Defined	If altering	https://law.justia.com/codes/pennsylvania/2021/title-75/chapter-33/section-3365/ https://www.law.cornell.edu/regulations/pennsylvania/67-Pa-Code-SS-212-501#:~:text=special%20speed%20limitations).-,(1)%20To%20establish%20a%20school%20zone%2C%20local%20authorities%20shall,the%20school%20zone%20to%20

Rhode Island	20	20				X			Only when accompanied by posted warning signs	Chapter 31-14-2 Twenty miles per hour (20 mph) in the area within three hundred feet (300') of any school house grounds' entrances and exits during the daytime during the days when schools shall be open.	Statute Defined	If altering	https://law.justia.com/codes/rhode-island/2021/title-31/chapter-31-41-3/section-31-41-3-3/ https://law.justia.com/codes/rhode-island/2021/title-31/chapter-31-14/section-31-14-2/
South Carolina	25	45						X		DOT guidelines	Engineering Study	Yes	https://www.scdot.org/business/pdf/accessMgt/Traffic-Engineering-Guidelines/tg10.pdf
South Dakota	15	15			X					**SD Statute 15 MPH** 32-25-14. Speed limit in school zones- When passing a school during a school recess or while children are going to or leaving school during the opening or closing hours, the maximum lawful speed shall be fifteen miles per hour. A violation	Statute defined	No	https://sdlegislature.gov/Statutes/Codified_Laws/2054986
Tennessee	15		X							55-8-152. (d) (1) (A) Except as provided for certain counties in subdivision (d)(2), counties and municipalities are authorized to establish special speed limits upon any highway or public road of this state within their jurisdiction, except at school entrances and exits to and from controlled	Engineering study could raise speed limit past a minimum of 15 mph speed limit Guidance on Setting Speed Limits "In order to establish	Yes	https://law.justia.com/codes/tennessee/2010/title-55/chapter-8/55-8-152/
Texas	15 below 85th	35						X	N/A	**Not defined by statute** Texas Administrative Code Section 25.23, the Texas Department of Transportation established a maximum school speed limit policy of 35 mph. Procedures for establishing speed zones: It is not advisable to set a school speed limit above	Based on engineering and traffic investigation	Yes	http://onlinemanuals.txdot.gov/txdotmanuals/szn/szn.pdf
Utah	20	20			X					**UTAH STATUTE 41-6a-601 20MPH** (a) 20 miles per hour in a reduced speed school zone as defined in Section 41-6a-303;	Statute Defined	No	https://le.utah.gov/xcode/Title41/Chapter6A/41-6a-S303.html https://drive.google.com/file/d/1JyNnvMXo5LgvhvSltSOh5miCxD84PSdJ/view
Vermont							X		Not mandatory	**Statutory school zone speed limit not defined** Title 23 : Motor Vehicles Chapter 013 : Operation Of Vehicles Subchapter 001 : General Provisions (Cite as: 23 V.S.A. § 1003) § 1003. State speed zones	Engineering study and traffic investigation	Yes	https://legislature.vermont.gov/statutes/section/23/013/01003 https://localroads.vermont.gov/sites/localroads/files/files/resources/materials/Setting%20Speed%20Limits%20Guide%20Update%20August%202016.pdf https://www.vpr.org/vpr-news/2018-04-24/how-speed-limits-get-set-in-vermont
Virginia	25 typical; 15 in residential areas	25 typical; 15 in residential areas			X				Schools that apply	**Statute 15 or 25 MPH** § 46.2-873. The maximum speed limit shall be twenty-five miles per hour between portable signs, tilt-over signs, or fixed blinking signs placed in or along any highway and bearing the word "school" or "school crossing."	§ 46.2-873. D. The governing body of any city or town may, if the portion of the highway to be posted is within the limits of such city or town, **increase or decrease the**	If altering	https://www.virginiadot.org/business/resources/IIM/TE-183_School_Zone_Speed_Limits.pdf https://law.lis.virginia.gov/vacode/title46.2/chapter8/section46.2-873/ https://www.virginiadot.org/programs/resources/walkToSchool/2016/zino/2016_08_26_VDOT_LDL_Speed_Reduction_FINAL.pdf

Washington	20	20			X					**20 MPH** RCW 46.61.440 (1) Subject to RCW 46.61.400(1), and except in those instances where a lower maximum lawful speed is provided by this chapter or otherwise, it shall be unlawful for the operator of any vehicle to operate the same at a speed in excess of twenty miles	Statute Defined	No	https://app.leg.wa.gov/rcw/default.aspx?cite=46.61.440
Washington DC	15	15			X					**15 MPH** Ch 31 § 38–3101 (e)(1) School zones shall have a speed limit posted at 15 miles per hour and signs erected warning of the presence of children. For those school zones that have a traffic control device, signs shall be erected warning of the presence of these devices.	Statute Defined	No	https://code.dccouncil.us/us/dc/council/code/titles/38/chapters/31/
West Virginia	15	15			X					Chapter 17C, Article 6, Speed Restrictions (§17C-6-1. Speed limitations generally; penalty.) (1) Fifteen miles per hour in a school zone during school recess or while children are going to or leaving school during opening or closing hours.	Statute Defined	No	https://code.wvlegislature.gov/17C-6-1/
Wisconsin	15	15				X				**WI Statute - 15 MPH** 346.57(4)(a) Fifteen miles per hour when passing a schoolhouse at those times when children are going to or from school or are playing within the sidewalk area at or about the school. 346.57(4)(b) Fifteen miles per hour when	**Statute defined** WI Statute 349.11 All speed limit changes shall be based on a traffic engineering study, including modifications allowed under Statute.	No	https://docs.legis.wisconsin.gov/statutes/statutes/346/ix/57?view=section https://wisconsindot.gov/dtsdManuals/traffic-ops/manuals-and-standards/teops/13-05.pdf
Wyoming	20	20				X			Did not specify	WY Stat 31-5-301 (2021): (i) Twenty (20) miles per hour when passing a school building, the grounds thereof, within any other area or space in the vicinity of a school designated by an official traffic control device as a school zone with a reduced speed limit or a	Statute Defined	If altering	https://law.justia.com/codes/wyoming/2021/title-31/chapter-5/article-3/section-31-5-301/ https://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Traffic%20data/2016%20Speed%20Limits%20booklet.pdf

Appendix B: Literature Review Research matrix

Appendix B. School Zone Speed Limits and Safety

Before-and-after evaluations of SZSL changes

Objectives

1. What is the current research regarding setting school zone speed limits?
2. Has research found effective methods and procedures for setting effective school zone speed limits?
3. Are there known spillover or other unintended consequences for setting improper school zone speed limits?

Study	Country	Publication	Sample locations	Sample size	Methodology	SZSL change	Effects on driver speeds	Effects on safety	Speed limit differential/buffers	Complimentary countermeasures or other findings
Fitzpatrick et al. (2009)	US - Texas	TX DOT	24 school zones, 10 in rural settings, seven schools on high-speed roadways (> 55 mph)	2025 observations in a school zone and 679 in buffer zone	Observational studies at school facilities throughout the state to analyze the data for findings on speed-distance relationships, speed-time relationships, influences of various site characteristics on speeds, and special characteristics of school zones with buffer zones.		• Statistically significant reductions in mean speed when the school zones were active •The school speed limit variable dominated all other variables in the regression analysis to evaluate which variable affect operating speeds in an active school zone. • Relatively low compliance rates for school zones compared to regulatory speed limits. • As this study also includes the use of flashing beacons there is not a direct comparison for the use of state SZSL signs.		• Speed buffer zones recommended for high speed roads • Suggested that school speed limits should not be > 15 mph below the 85th percentile speed or posted speed	• The lowest speeds are associated with speed zones of the shortest lengths. Speeds are approximately 1mph higher for every 500 ft driven within a school zone • Lower speeds are associated with a higher number of access points, presence of a crosswalk, and presence of sidewalk .
Graham & Sparkes (2010)	Australia	Australian Road Safety Research Policing Education Conference - NSW Centre for Road Safety, Roads and Traffic Authority	820 school zones	1,594 casualties during School Zone Time , 22% pedestrians	Analysis of pedestrian casualty crash history (1998-2008) for 5-16yr olds in school zones before and after a 40 km/h statutory SZSL was implemented in New South Whales. The incidence of speed involvement in crashes in school zones was also investigated, as well as the types of crash occurring in school zones during SZT.	40 km/h school zones	N/A	• Crashes, especially pedestrian casualties, were significantly reduced. • Pedestrian casualties amongst the 5 to 16 year old age group decreased in school zones at a greater rate than at other locations. • Compared with the pre period (1998 to 2000), the average annual pedestrian casualties in the selected school zones decreased by 45% during post period (2004 to 2008). • For pedestrians aged 5 to 16 years there was a 46% decrease over the same period. • 46% reduction in pedestrian casualties aged 5 to 16 years in school zones during SZT was larger than the reduction in pedestrian casualties aged 5 to 16 years outside the sample school zones during SZT (only 35% reduction). • Crashes associated with sudden slowing of	N/A	Adoption of certain countermeasures during the after period such as the use of digital speed camera at a hand full of schools (starting in 2002) and progressive rollout of flashing beacon signage starting in late 2006.
Grundy et al. (2009)	UK - London	BMJ	20 mph speed zone in London	901,166 injuries and 6231 deaths from 1986-2006	Observational study to quantify the effect of the introduction of 20 mph (32 km an hour) traffic speed zones on road collisions, injuries, and fatalities in London, adjusted for the underlying downward trend in traffic casualties. Analyses was based on the patterns of change in annual collision counts within each road segment before and after introduction of the zone using conditional fixed effects Poisson models.	20 mph zone	N/A	• The introduction of the 20 mph zones was associated with a reduction in casualties and collisions of around 40%. • Casualties as a whole were reduced by 41.9% with slightly larger point estimates for the reductions in all casualties in children aged 0-15 and in the numbers killed or seriously injured. • The numbers of killed or seriously injured children were reduced by half and injuries to pedestrians were reduced by a little under a third • The observed reductions were largest for the youngest children (0-5 and 6-11) • There was a smaller reduction in casualties among cyclists	• Data on casualties in areas adjacent to 20 mph zones also showed evidence of small (generally single figure) percentage reductions after implementation of the zones. • Casualties inside 20 mph zones are not being displaced to nearby roads.	

Lazic (2003)	Canada - Saskatoon	2003 Annual Conference of the Transportation Association of Canada	15 school zones (8 elem. and 8 high schools)	Unknown sample size. Three sets of data collected in both directions, over the 24 hour period, for seven days. Arterial ADT approxim. 13,500 to 15,000 vehicles per day. Local ADT unknown.	Looked at change in speed distribution before, one month after and eight months after the installation of the 30 km/h SZSL. Reduced speed zones were in effect from 8:00 a.m. to 5:00 p.m., Monday to Friday.	lowered from 50 km/h (31 mph) to 30 km/h (18.6 mph) school zones	• Mean speed were reduced by 11 km/h (6.8 mph) and 85th percentile speeds were reduced by 10 km/h (6.2 mph). • Averaged speed distribution during school hours shows an overall shift to the left and tightening of speed distributions. • 85th percentile speed of 45 km/h is still considered to be excessive. • Despite the less than satisfactory compliance with the 30 km/h speed limit, the achieved reduction in speed of 10 km/h still represents an improvement to child pedestrian safety	Not studied	Not studied	• Street use and prevailing traffic conditions influence motorist's behaviour and speed compliance. • No significant change in speed was observed when school zones were inactive. • Average weekday traffic volume dropped by approximately 13%, suggesting that some drivers may be avoiding school zones and using alternate routes. • Prior to the start of the following 2002/2003 school year, a public education program was initiated
Lindenmann (2005)	Switzerland	ITE Journal	31 residential zones (11 zones in large and medium size towns and 20 zones in small towns and villages)		• Analyzed driver behavior and crash history in residential zones that had recorded driver behavior before the implementation of a 30 km/h speed zone. • On high-speed segments, additional countermeasures such as speed bumps, central islands, street narrowin and parking lanes on alterrnate sides were used as additional calming methods.	Lowered from 50 km/h (31 mph) to 30 km/h (18.6 mph) in residential zones	• Considerable deterioration in compliance to the zone speed limit (6 to 7 km/h reduction in 85th and 50th percentile speeds compared to 20 km/h change in speed limits) • Traffic engineering and structural countermeasures (i.e. speed bumps and street narrowing) were associated with a positive effect of the structural measure. By contrast, there was practically no reduction or only a minimal reduction in zones without structural traffic calming measures.	• Decreases in accident numbers in both urban and rural areas • The total before/after reduction over all zones was considerable, at about 15 percent. • Accident severity declined markedly, by about 27 percent. • The number of accident victims decreased by about 15 percent in urban areas and by 45 percent in rural areas. • The accident distributions clearly illustrates that the area-based 30 km/h measure often is not uniquely suitable as the sole measure for achieving a reduction in accident occurrence. Particularly in		• In zones with a variety of structural traffic calming measures, such as lateral and vertical offsets (speed bumps), central islands and street narrowing, an average reduction between 7 and 8 km/h in the medium (V50%) and higher (V85%) speeds was achieved. By contrast, there was practically no reduction or only a minimal reduction in zones without structural traffic calming measures.
Nebraska DOT Report (2020)	US - Nebraska	NE DOT	18 school zones	**Speed Analysis:** 378,506 vehicles observed **Collision Analysis:** 277 crashes (237 during off and 40 during on periods) during the five-year period.	**Study compared active school zones (flashing beacons) vs passive school zones (non-active becons) so it does not provide a direct comparison.** **Speed Analysis - Estimated linear regression model,** Drivers' speed data was collected at various schools which were categorized based on speed differentials (difference in speed limits between flashing ON or OFF) and school session time. 15 elementary and three middle schools, 378,506 vehicles observed, besides the number of lanes and crosswalks, other attributes were also considered including visibility of school, presence of fencing, types of traffic control devices present, school zone length, presence of loading areas, presence of on-street parking, etc. **Crash Analysis -** five-year crash data, crashes were identified based on spatial location within a school zone, only crashes reported on regular school days were identified for analysis, crash rates during the school zone lights off and on periods were examined.	Differentials of 35 to 25 mph, 40 to 25 mph, 30 to 25 mph, and 35 to 15 mph	**• Speed analysis compared school zone flashing beacons vs passive school zones (non-active becons) so it does not provide a direct comparison.** • All schools except one indicated a statistically significant difference in drivers' speed when the school zone became active.		• Greater speed differential results in less compliance =15 MPH speed differential should be rarely used and > 15 mph avoided. • A speed limit differential of 5 mph (Category 4) resulted in mean speeds reduced by 6.93 percent; a differential of 10 mph (Category 1) showed mean speeds reduced by 16.82 percent; a 15 mph differential (Category 2) gave a 22.4 percent reduction in mean speeds while a 20 mph differential (Category 3) brought about 18.8 percent slower speeds.	• Analysis compared school zone flashing beacons vs passive school zones (non-active becons) so it does not provide a direct comparison. • Flashing lights were effective in slowing vehicles (5-7 MPH slower, and less than 4% exceeded 35 MPH)

Singh (2011)	Australia - Queensland	National Road Safety Conference	16 trial and control school zones on multi-lane roadways 1 yr. trial, 4 sign types	Unknown sample size.	A year long trial at the start of the 2010 school year of school zones on **multilane roads** throughout the State to determine driver compliance with the reduced speed limit over a sustained period and if any particular type of sign was more effective. Data was collected at eight school zones and eight control sites for a total of two school locations for each signage type during the before period, six months after installation and 11 months after installation.	40 km/h SZSL	**• Static signs saw a 7-9 km/h reduction in Mean speeds and a 5 km/h reduction in 85th percentile speeds.** • Mean speeds at all sites were reduced after the installation of school zone and were sustained at most sites after 10 months. • 85th percentile speeds at all sites were reduced and sustained at most sites after 10 months			**• The sites where vehicle activated signs were installed performed the best, recording the lowest and largest reductions in mean and 85th percentile speeds.** • The percentage of vehicles travelling above 50 km/h (10 km/h above the posted speed limit) were considerably lower, but still constitute a large number of traffic - 10% for VAS, 15% for the VSL on the divided road, 22% for enhanced flashing lights and 30% for static signs only.
Strawderman and Zhang 2013	US - Mississip	MS DOT	4 school zones		Small sample size, Looked at the impact of sign saturation, so not a direct comparison. Many confounding variables that were not be controlled or eliminated in the experiment		• No statistically significant reductions for speed • Higher compliance on 4-lane roads compared to 2-lane roads and in areas with high sign saturation.			Increasing sign saturation gained more benefit in a 4-lane road setting.
Sun et al. (2018)	Canada - Edmonton	Canadian Journal of Civil Engineering	216 school zones/432 streets for safety effects 43 school zones for speed changes	**Collision Analysis:** 366 injury and fatal crashes over 5 years, inlcuding 78 VRU injuries. 99 in school zones, 267 at comparison sites **Speed Analysis:** 338,490 vehicles recorded	**Longitudinal analysis within which no other significant changes were made upon treatment and comparison sites except the speed limit reduction.** **Collision Analysis - Full Bayes Before-After Study** **216 school zones**, 432 streets, were selected as the treatment group for the collision analysis and 622 streets with similar road characteristics and 50 km/h speed limit selected as comparison group.Crash data from 2011 to 2016. Included only collisions occurring during the school operation time for both SZ and comparison sites. **Speed Analysis - Two-sample t-test with pooled variance (change in mean) and F-test (speed variation), 43 school zones -** Up to 1 wk of speed data per school, same years and seasons as crash history, during regular scchool operation times, clear weather conditions, only free-flow speed data, speed of 338,490 vehicles was recorded and included in the analysis, compliance rates were also calculated, schools classified into low, medium and high compliance for the before priod, F-test was conducted to test the change in speed variance.	Lowered from 50 km/h (31 mph) to 30 km/h (18.6 mph) school zones	**Statistically significant reductions in Mean** (-12.2 km/h, 7.5 mph) a**nd 85th percentile speeds** (11.6 km/h, 7.2 mph) • Speed cumulative distributions shifted to the left, indicating further reductions for all speed ranges. • largest reduction recorded for the low-compliance group of 15.3 km/h. • When comparing the speed reductions to the above collision reductions, it could be concluded that for each 1 km/h reduction in speed, a 4% reduction in fatal and injury collisions was observed, consistent with previous findings by Nilsson (Nilsson 2004). • Speed variance in school zones was observed to have decreased after the speed limit reductions, which typically implies an improvement in traffic safety. • 85th Percentile Speed (43 school zones overall) 52.9 km/h 41.3 km/h Standard Deviation (mean speed) 12.1 km/h 12.0 km/h	Result implied a **statistically significant reduction in expected collision frequency of 45.3% and 55.3% in fatal/injury and VRU fatal/injury collisions,respectively.** Results of this study provide strong evidence that reducing speed limits to 30 km/h in school zones can bring significant safety benefits by reducing vehicular speeds and fatal/injury crashes. • Spatial migration/spillover effects - Statistically insignificant effect • Temporal migration/spillover effects - statistically insignificant effect	Not studied	No other significant changes were made upon treatment and comparison sites except the speed limit reduction.
Tay (2009)	Canadan - Cal	ITE	20 spots around schools and playgrounds	1,580 observations at free-flow locations	Measurements taken at elementary/high and public/private schools as well as arterial, collector and local streets. Only zones with enough length co ensure that free-flow speed would be attained were chosen for measurement. Also, all measurements were taken during the offpeak period, under dry conditions and when the reduced speed limit of 30 km/hr. (18.8 mph) was in effect. Looked at Mean, standard deviation, exceeding speed limit, and exceeding threshold speed (>10km/h over SZSL). Standard T-test was used to determine statistical significance.	lowered from 50 km/h to 30 km/h school zones	• Mean speed and 85th percentile speed were significantly lower. • Mean speed on four-lane roads was higher than the mean speed on two-lane roads. However, this difference was not statistically significant.	Not studied	Not studied	The violation race was significantly higher in zones without fencing than in zones with chain-link fencing.
Young & Dixon (2003)	US - Atlanta		4 school zones		Small sample size		• No statistically significant reductions • School zone signage had no general impact on reducing vehicular speed.			

Zhao et al. (2015, 2016)	China	SpringerPlus	20 school zones	30 subjects and five scenarios	Used a fixed-base driver simulation	30 km/h from 50 km/h appraoch	• No statistically significant reductions • Effectiveness of school zones in changing speed varied greatly depending on road geometric conditions.			Results showed that traffic control devices such as the Flashing Beacon and School Crossing Ahead Warning Assembly, the Reduce Speed and School Crossing Warning Assembly, and the School Crossing Ahead Pavement Markings were recommended for school zones adjacent to a major multilane roadway, which is characterized by a median strip, high traffic volume, high-speed traffic and the presence of pedestrian crossing signals. The School Crossing Ahead Pavement Markings were recommended for school zones on a minor two-lane roadway, which is characterized by low traffic volume, low speed, and no pedestrian crossing signals.

Appendix C: Tx MUTCD school zone buffers for high-speed roadways

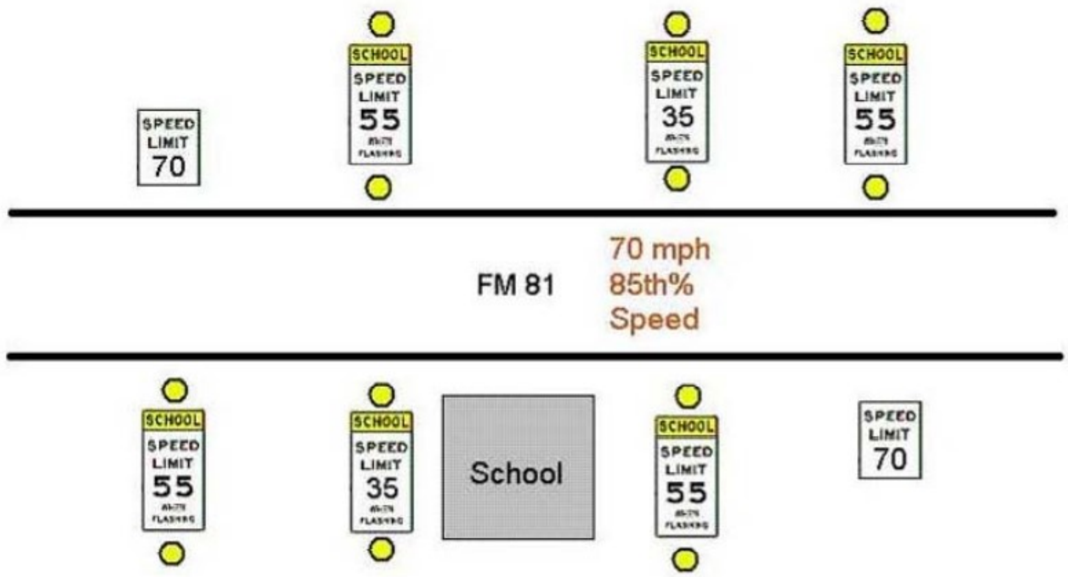

Figure 7-20. Typical Layout of School Speed Zone with Buffer Zone *(1)*.