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Application of a Rural Safety Policy Improvement Index (RSPII): Phase II

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Six legislatively-based safety improvement measures (LSIMs) were proposed for evaluation within a rural safety policy improvement index (RSPII) framework during Phase I of this project. This report documents the step-by-step application of the RSPII framework and its rural roadway crash fatality reduction results for these LSIMs. Several approaches to the framework application were completed for each LSIM and the results compared. It was estimated (based on the selection of one framework outcome for each LSIM) that rural roadway crash fatalities could be reduced by 209 from the primary enforcement of seat belt use, 299 from universal motorcycle helmet use, 322 from the regular application of sobriety checkpoints, 120 from graduated driver licensing program upgrades, 268 from the mandatory ignition interlock installation, and 699 from automated speed enforcement. These estimates cannot be summed, however, because the fatalities impacted by these LSIMs sometimes overlap. The assumptions and generalizations required to overcome challenges to the RSPII framework application will also have an impact on its results. Additional LSIM research is suggested and it is recommended that the estimates in this report be used as a starting point for rural roadway safety discussions and the completion of more accurate individual state RSPII framework applications.

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Executive Summary

The majority of crash fatalities in the United States occur along rural roadways. The factors that contribute to these crashes often include those related to one or more human behaviors or choices (e.g., seat belt use, driving while intoxicated, etc.). The enactment, application, and enforcement of legislatively-based safety improvement measures (LSIMs) is one component of the comprehensive roadway safety plans used to address this issue.

The primary objective of the research project described in this report was to apply a quantitatively-based rural safety policy improvement index (RSPII) framework to six LSIMs. The development of the framework and selection of the six "proven" LSIMs were completed during Phase I of this project. The report documenting these activities was published in 2009 (*3*). A step-by-step application of the RSPII framework to estimate the potential rural roadway crash fatality reduction impacts of the LSIMs is described in this report. The results produced by various approaches to the application are presented for each LSIM and the challenges to using the framework and implementing the LSIMs in rural areas are identified.

Chapter 2 of this report summarizes, in detail, the step-by-step application of the RSPII framework to six "proven" LSIMs. This framework follows the same general format as the process proposed in NCHRP Report 622 (*4*). The six framework steps include the research-based definition of the potential safety impact of an LSIM, determination of its applicable fatality target group, identification of states with an applicable LSIM "before" status, calculation of the rural portion of the fatality target group within the identified "before" states, application of the potential safety impact to the rural portion of the fatality target group, and the presentation of framework results. NCHRP Report 622, along with the results from an independent literature review, were also the origin of the six "proven" LSIMs selected for application in this phase of the RSPII project (*3*, *4*). The rural roadway crash fatality reduction impacts were estimated within the RSPII framework for the following LSIMs: primary enforcement of seat belt use, universal motorcycle helmet use, regular application of sobriety checkpoints, graduated driver licensing program upgrades, mandatory ignition interlock installation, and automated speed enforcement.

The six steps that define the RSPII framework were completed, sometimes using several different approaches or inputs, for each of the six LSIMs noted in the previous paragraph. These multiple applications of the RSPII framework for each LSIM were completed for various reasons. Typically, however, more than one approach or input was used to complete one or more of the framework steps in order to overcome and/or evaluate the impact of the challenges (See Chapter 3 of this report and the summary below) identified to its application. In addition, the inputs suggested for each step in NCHRP Report 622 were also applied for each LSIM (*4*). The basis and characteristics of the various rural roadway crash fatality reduction results estimated for each LSIM were compared and one outcome was selected as the most reasonable. The outcomes selected show that the LSIMs considered in this project have the potential to produce the following rural roadway crash fatality reductions:

- Primary enforcement of seat belt use – 209
- Universal motorcycle helmet use – 299

- Sobriety checkpoints – 322
- Graduate driver licensing program upgrades – 120
- Mandatory ignition interlocks – 268
- Automated speed enforcement – 699

It should be noted that the rural roadway crash fatality reduction estimates listed above need to be considered in the proper context. For example, the fatality target groups assumed for these LSIMs often overlap and their estimated reductions cannot be summed. In addition, these estimates are based on crash fatality data or approximations of crash fatality data from the Fatality Analysis Reporting System (FARS). More specific crash data are typically available within an individual state (e.g., actual crash reports) and when used in the RSPII framework should produce better results. This "in state" data may also better match the input needs of the RSPII framework. Finally, each application of the RSPII framework completed during this project required one or more assumptions and/or generalizations. The use of these assumptions and/or generalizations will inherently have an impact on the validity, accuracy, and/or robustness of the results produced. The challenges addressed by these assumptions/generalizations are discussed in Chapter 3 of this report and summarized below.

Chapter 3 of this report describes the challenges encountered during the application of the RSPII framework. In addition, the challenges related to the implementation of LSIMs in rural areas are also summarized. The challenges identified during the application of the RSPII framework were primarily related to gaps in the current state-of-knowledge about the rural roadway fatality impacts of the LSIMs considered. More specifically, Chapter 3 generally describes the difficulties encountered during the application of the RSPII framework and the potential impacts on its results due to the variability in LSIM research results, the lack of *rural* LSIM research, the variability and documentation of the safety measures considered in the research, the availability of data about particular fatality target groups, and the variability in the LSIMs applied. The assumptions or generalizations required to overcome each of these challenges are also described in this report and, as noted above, they need to be considered during any interpretation or use of the RSPII framework results. The implementation and enforcement of LSIMs in rural areas also have their own challenges. Overall, these challenges are connected to the inherently limited amount of resources (e.g., staffing, funding, etc.) in rural areas and the need to implement the LSIMs over a large sparsely populated area. All of the estimates completed during this project, however, are based on an assumption that the LSIM being evaluated would be properly implemented and enforced in the field (similar to the LSIMs considered within the framework application). This is the only approach that could potentially produce the safety improvements estimated by the RSPII framework.

The conclusions and recommendations of this project are summarized in the last chapter of this report. The conclusions summarize the application and results of the RSPII framework for each LSIM. The challenges to the application of the RSPII framework and the implementation of LSIMs in rural areas are also presented. The assumptions and generalizations that were used in the application of the RSPII framework formed the basis of most of the project recommendations. Overall, it was recommended that more LSIM research be completed and that it needed to be more comprehensive. Some of the more desirable characteristics of any future LSIM research were also noted. They include, but are not limited to, the incorporation of currently accepted crash data analysis methodologies, differentiation between rural and urban applications, and the evaluation of LSIMs using various well documented safety measures (e.g., fatality, injury, and crash data). Finally, it is recommended that the results of this research only be used to initiate further discussions about rural roadway safety and more detailed applications of the RSPII framework within each state (*4*). A website is also proposed that would include the critical details about the research used to apply the RSPII framework or the NCHRP Report 622 process (*4*). This website would also include a rating of the adequacy (based on well-defined criteria) of the safety impact results produced by these research projects.

Chapter 1. Introduction

More than half of the crash fatalities in the United States occur along rural roadways (*1*). In fact, the fatality crash rate along rural roadways is more than twice that calculated for urban roadways (*1*). Rural roadways also have more than the expected number of crashes with contributing factors related to passenger decisions or choices (e.g., seat belt use, alcohol use, and speeding).

A reduction in rural and urban roadway fatalities will require the implementation of a comprehensive set of safety improvement measures related to engineering, education, enforcement, and emergency services (*2*). The application of some of these measures sometimes requires the enactment and enforcement of transportation safety legislation or policy (e.g., primary seat belt laws). The potential rural roadway safety impact of these legislatively- or policy-based safety improvement measures (LSIMs) is the focus of this project. The expected reduction in rural roadway crash fatalities due to six LSIMs have been calculated state-by-state. These measures were chosen from a list of those defined as "proven" by researchers with an expertise in driver or vehicle occupant behavior and choices (*3*, *4*).

This research project was organized to investigate the feasibility and potential implementation of a rural safety policy improvement index (RSPII). An RSPII would be used to quantitatively estimate, state-by-state, the potential rural roadway safety impacts due to the enactment of and/or change to transportation safety policies or legislation. The activities completed to determine the feasibility of an RSPII were documented in the Phase I report of this project (*3*). It was concluded that the application of the RSPII was possible, but that improvements to the applicable research would result in updates to the process. This Phase II project report documents the application of the RSPII framework to six "proven" LSIMs. Challenges to the implementation of the RSPII framework and the rural application of LSIMs considered will also generally be discussed. In addition, conclusions and recommendations related to the application and improvement of the process and results described in this document are also provided.

PROBLEM ADDRESSED

The problem addressed by this project was described in its Phase I report (*3*). A brief summary of that description is repeated here. Overall, it is generally accepted that a number of LSIMs (when properly implemented and/or enforced) can have a positive impact on safety-related driver and/or passenger behaviors/choices. In fact, because of their significant potential for roadway safety improvement, the enactment or implementation of many LSIMs has been included as a goal within a number of state Department of Transportation (DOT) Strategic Highway Safety Plans (SHSPs). It is generally accepted, however, that a lack of progress related to LSIMs continues to result in motor vehicle crashes, injuries, and/or fatalities that could potentially have been avoided. It is hypothesized that the overrepresentation of certain crash characteristics along rural roadways (e.g., lack of seat belt use, alcohol use, and speeding) could also result in greater safety improvements along these types of roadways due to the enactment/enforcement of some LSIMs.

It has been proposed that a tool or methodology is needed to help quantify the potential rural roadway safety impacts that may result from the enactment/update and enforcement of LSIMs. This tool or methodology (referred to as the RSPII in this report) should allow the user to quantitatively determine and/or compare the potential rural roadway safety impacts (e.g., crash fatality reduction) of the implementation (or changes to) one or more LSIMs on a state-by-state basis. This report documents the application of the RSPII framework (proposed in Phase I of this project) to six LSIMs. The state-by-state results from the RSPII framework are also presented and for research purposes the impact of various inputs to the framework (for each LSIM) are considered and compared. A detailed description of the RSPII framework, along with the selection process used to choose the six LSIMs considered in this document, can be found in the Phase I project report (*3*).

PROJECT SCOPE AND OBJECTIVES

This research project included two phases. The scope of the first phase was limited to an investigation of the feasibility and pilot application of an RSPII. The results of these activities were presented in the Phase I project report (*3*). The feasibility of applying an RSPII was acknowledged and a framework for its application was developed. The Phase I project report also has more detail on these subjects (*3*). The second phase of the research project, documented in this report, was limited to the application of the RSPII framework to the six LSIMs selected during Phase I. These LSIMs included:

- Primary enforcement of seat belt use,
- Universal motorcycle helmet use,
- Regular application of sobriety checkpoints,
- Graduated driver licensing program upgrades,
- Mandatory ignition interlock installation, and
- Automated speed enforcement.

A number of the challenges related to the application of the RSPII framework and the implementation/enforcement of the measures above within rural areas are also discussed in this report.

The primary objectives of this research project were to investigate and develop, if feasible, a tool or methodology (i.e., the RSPII) to quantify the potential rural roadway safety impacts (e.g., crash fatality reduction) expected due to changes in one or more LSIMs on a state-by-state basis. As indicated in the Phase I project report, the specific tasks proposed for completion of these objectives were the following:

1. Review and describe relevant literature that summarizes, evaluates and quantifies the research and/or crash, injury, and/or fatality reduction capabilities of behavior-related LSIMs (e.g., primary seat belt laws)
2. Identify and summarize the results of existing LSIM-related (and possibly other) indices and/or processes

3. Identify those LSIMs that have supporting safety impact research results and/or the potential to influence rural roadway safety
4. Evaluate and determine the feasibility of an RSPII that might be applied throughout the United States and, if appropriate, complete the following:
   a. Develop a general framework for its application
   b. Discuss the challenges related to its implementation
   c. Complete a pilot application of the proposed implementation framework for one LSIM
5. If the RSPII is feasible, determine the rural roadway safety impacts of multiple LSIMs within the application framework developed (in addition, the challenges related to the individual application should also be identified and a response documented)
6. Document the results of all the tasks above in a manner that is useful to the general public, transportation safety personnel, non-governmental organizations, and legislative decision-makers and their staff

The Phase I project report summarized the project activities connected to the first four tasks listed above (*3*). The results of the research and index review, identification of potential LSIMs, feasibility determination, general framework development, and pilot application were described (*3*). This Phase II project report includes a discussion of the application of the RSPII framework for six LSIMs. The challenges to properly implementing the framework will also be described. In addition, some of the issues that must be overcome for the application of these six LSIMs in the field will be summarized. Finally, conclusions from the application of the RSPII will be described and recommendations related to its use and the rural application of the LSIMs offered. The organization of this Phase II project report is noted below.

REPORT ORGANIZATION

There are four chapters in this Phase II project report. Chapter 1 describes the problem addressed, scope, and objectives of the overall research project and its phases. The project tasks are also listed. Chapter 2 includes a summary of the RSPII framework steps from the Phase I project report and a detailed description of the results from each step for its application to all six LSIMs (listed previously). The alternatives assumed in the application of each step are noted and the framework estimates provided. One result for each LSIM application is then selected and summarized at the end of this chapter. Chapter 3 identifies and generally describes some of the challenges that must be overcome for the application of the RSPII and the implementation of LSIMs in rural areas. Chapter 4 includes a summary of the conclusions based on the Phase II project activities and recommendations that address the use and research needs to improve the RSPII framework.

Chapter 2. RSPII Implementation Framework Applications

During Phase I of this project it was determined that the potential rural roadway crash fatality impacts due to the enactment or update of six "proven" LSIMs should be estimated on a state-by-state basis. The six LSIMs considered include the enactment (and enforcement) of legislation related to the primary enforcement of seat belt use, universal motorcycle helmet use, the regular application of sobriety checkpoints, graduated driver licensing program upgrades, mandatory ignition interlock installation, and automated speed enforcement. The potential safety improvement impacts of these measures will be determined through the application of the RSPII implementation framework (See Figure 2.1). The development of this framework, along with the process used to select the six LSIMs being considered in this report, was documented in more detail within the Phase I report for this project (*3*). The step-by-step application of the RSPII framework for each of the six LSIMs is described within this chapter.

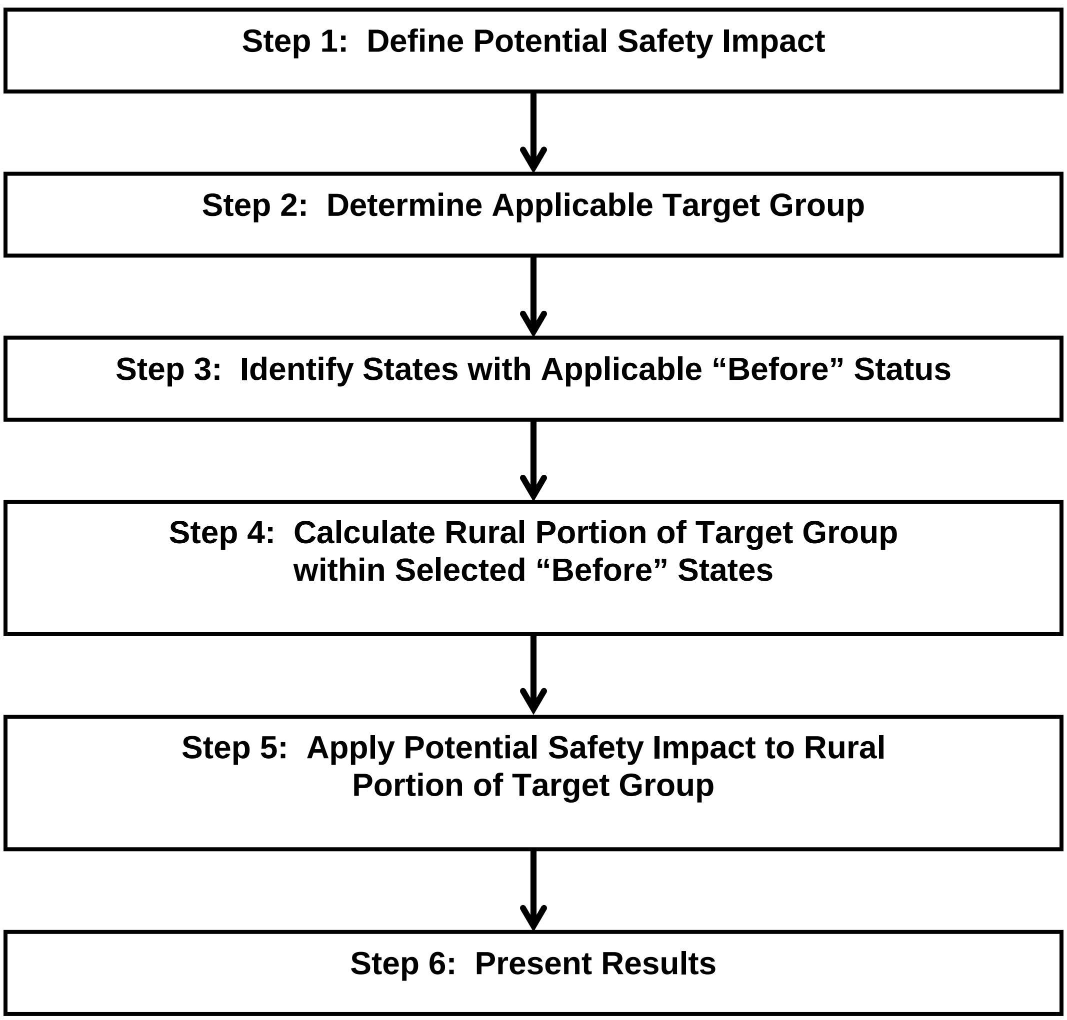

Figure 2.1. RSPII implementation framework.

STEP-BY-STEP APPLICATION METHODS AND RESULTS

The RSPII implementation framework (See Figure 2.1) that was developed during the first phase of this project included six steps:

1. Define the potential safety impact of the LSIM. The magnitude and type of impacts expected from the LSIM should be based on past research results.
2. Determine the target group of fatalities to which the expected safety impacts apply. The research used to identify the potential safety impacts should also be used to define the target group to which these impacts apply.
3. Identify the states that could benefit from the implementation, enactment, and/or update of a particular LSIM. The existing legislative situation within each state should be compared to what was believed to be the "before" situation used in the research.
4. Calculate the rural portion of the target group within each of the applicable states. The rural portion of the fatality target group was determined from the results of Step 2, the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS), and the FARS definition of fatal crashes by rural and urban roadway functional class. These calculations were done for the states identified in Step 3.
5. Apply the safety impacts (e.g., crash reduction expected from the implementation and enforcement of a primary seat belt law) from Step 1 to the rural portion of the fatality target group determined in Step 4.
6. Present the estimated safety improvements due to the enactment or improvement of the LSIM on a state-by-state basis.

The application of the six steps listed above is described for the six LSIMs previously noted and selected in Phase I of this project. More detail about the framework and the LSIM selection can be found in the Phase I report of this project (*3*).

There were several approaches used to complete one or more of the application framework steps for each LSIM. The "safety impact" (i.e., fatality reduction) proposed in NCHRP Report 622 was always applied, but multiple inputs and/or assumptions were typically considered for one or more of the steps in the framework for each LSIM (e.g., the size of the rural portion of the target group of fatalities might be calculated with various approaches). The results from these alternative approaches were also sometimes calculated to provide a measure of how sensitive the overall framework results might be to a change in one input. The application of the framework steps and the results from each alternative approach are described in this chapter. The chapter concludes with a suggestion by the project team of the alternative they believe is the most reasonable (with the current state-of-the-knowledge) to use as an estimate of the LSIM impact. Challenges to the application of the framework and the implementation (and enforcement) of the LSIMs in a rural environment are described in Chapter 3.

Primary Enforcement of Seat Belt Use

A primary seat belt law allows law enforcement officers to stop a vehicle when one or more of its occupants are not wearing a seat belt. A seat belt law with secondary enforcement only allows an officer to cite someone for not wearing their seat belt if the vehicle has been stopped for another offense. Primary seat belt enforcement laws vary from state to state and can apply to all passengers, front seat passengers, or only vehicle occupants of a certain age. Overall, however, the enactment and enforcement of primary seat belt legislation has generally been shown to have a larger safety impact than secondary enforcement. A number of states have recently implemented primary seat belt laws.

The roadway safety impact connected to the enactment and enforcement of primary seat belt laws has been the focus of many research projects (See the Phase I project report) (*3*). In fact, it is the most studied LSIM of the six being considered in this project. In addition, NHTSA has used software to estimate the lives saved by seat belts for many years. Therefore, the rural roadway safety impact of a primary seat belt law was estimated by the project team through two methods. First, the NHTSA BELTUSE software package was used to calculate lives saved. This software can estimate the reduction in motor vehicle crash fatalities if it is provided with the expected change in seat belt use (among occupants killed in motor vehicle crashes) due to an upgrade to a primary seat belt enforcement law. Similar software is not available for any of the other five LSIMs being considered in this report. The second method used to calculate the rural roadway safety impacts of a primary enforcement seat belt law was that proposed in NCHRP Report 622 (*4*). The potential safety impact and target group in that document for this LSIM was applied and the expected rural roadway fatality reduction calculated. The safety impact that was used was based on empirical observations of the magnitude of fatalities before and after the implementation of a primary enforcement seat belt law. The application of the RSPII framework to calculate the potential rural roadway safety impact of an upgrade to a primary enforcement seat belt law is described below.

Step 1: Define Potential Safety Impact

As indicated above, this application of the RSPII framework included two methods to quantify the expected change in rural roadway safety due to the introduction of a primary enforcement seat belt law. The potential safety impact used as input for these two methods is different. The potential safety impact suggested for use in NCHRP Report 622, based on the research results from projects focused on seat belt legislation upgrades, was a 7 to 8 percent reduction in fatalities (*4*). The potential for different safety improvement impacts in rural and urban areas due to the introduction of a primary enforcement seat belt law was not addressed. What little information is available on this issue is described in the Phase I report (*3*). The BELTUSE software, on the other hand, can be used to estimate the passenger vehicle crash fatalities that could be avoided due to a seat belt enforcement upgrade. One of the measures that the software uses to complete this estimate is a change in seat belt usage of occupants killed in crashes. NCHRP Report 601 indicates that more recent seat belt law upgrades (i.e., 1999 to 2004) have resulted in an average increase of 9.7 percent in seat belt usage by vehicle occupants killed in a crash (*5*).

Step 2: Determine Applicable Target Group

The applicable target group (e.g., rural roadway crashes, injuries, and/or fatalities) that needed to be defined for the two methods being used in this framework were also different. The measure documented in the research results on this subject can vary (e.g., seat belt usage in passenger cars, change in driver fatalities, etc.). As indicated, for each LSIM the framework will at least apply the suggestions from NCHRP Report 622 (*4*). The applicable target group proposed in NCHRP Report 622 for this LSIM was very specifically defined as those fatalities related to unbelted front seat passenger vehicle occupants that are 13 years old or older (*4*). This target group, restricted to seating position, belt use, and passenger age, is considered conservative by the authors of this report. In theory, the target group identified here should be the same as that used in the research to determine the potential safety impact indicated in Step 1 (i.e., a 7 to 8 percent reduction in fatalities). In other words it might also be more appropriately applied to a target group that includes all fatalities (this was not done, however, during this research project). The NHTSA BELTUSE software, on the other hand, uses the total number of passenger vehicle fatalities and seat belt usage, disaggregated by vehicle type and seating position, as the inputs needed to estimate the fatalities avoided due to an upgrade in seat belt enforcement legislation.

Step 3: Identify States with Applicable "Before" Status

The third step in the RSPII application framework is the identification of states that are expected to experience the majority of the potential safety impact identified in Step 1. The criteria used to define these states should, in theory, also be based on the research used to complete Steps 1 and 2. The implementation requirement, and the wide variety of primary seat belt laws, however, required a generalization of the criteria. For this project, it was decided that the states with an applicable "before" status were those without a non-age restricted primary enforcement seat belt law (as of mid-2008). In other words, those states with no seat belt law (i.e., New Hampshire) and primary seat belt laws that only applied to passengers of a particular age (e.g., 18 years old or younger) were included in our "before" state list. North Carolina (which has a primary seat belt law that applies only to front seat passengers), however, was not. In general, the research that has analyzed the impact of upgrades to a primary enforcement of seat belt law has not adjusted their results for these types of differences. Overall, in mid-2008 there were 24 states that met the "before" status criteria for this LSIM (in 2009 Arkansas, Florida, Minnesota, and Wisconsin enacted primary seat belt legislation) (*6*). These states are listed below):

- Arizona
- Arkansas
- Colorado
- Florida
- Idaho
- Kansas
- Massachusetts
- Minnesota
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- North Dakota
- Ohio
- Pennsylvania
- Rhode Island
- South Dakota
- Utah
- Vermont
- Virginia
- West Virginia
- Wisconsin
- Wyoming

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

The fourth step in the RSPII application framework includes the quantification of the rural portion of the target group(s) defined in Step 2. This research project used the NHTSA Fatality Analysis Reporting System (FARS) database to accomplish this task. The 2008 rural portion of the target groups and/or NHTSA BELTUSE software input were acquired from FARS for each of the states identified in Step 3. The total number of rural passenger vehicle fatalities and the percentage of restrained rural fatalities are shown in Table 2.1. In addition, the total number of unbelted rural front seat passenger vehicle fatalities (≥ 13 years old) for each of the states is listed. It should be noted that the difference between the rural total and unrestrained front seat (≥ 13 years old) fatalities is significant. This supports the conclusion that this target group (suggested in NCHRP Report 622) will likely produce relatively conservative results in comparison to using a target group that is not restricted to age or seating position (*4*).

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

The fifth step in the RSPII framework applies the safety impacts identified in Step 1 to the rural portion of the target groups defined in Step 4 (See Table 2.1). In this case, two methods were used to estimate this impact. First, a 7 percent reduction (See Step 1) was applied to the unbelted front-seat passenger vehicle fatalities (See Step 2) shown in Table 2.1. This approach indicates that the introduction of a primary seat belt law (in the states indicated) might reduce the total number of these fatalities by 209 (See Table 2.2). Second, a state-by-state estimate of the rural fatalities avoided due to the implementation of primary seat belt law was calculated using the NHTSA BELTUSE software (See Table 2.2). The software estimated that 407 rural fatalities could have been avoided if a primary seat belt law had been implemented in the states listed in Step 3. The difference in the two estimates shown in Table 2.2 is related to the variability in the approaches used and their target groups. The BELTUSE software focuses on the impact of changes in the seat belt usage of a hypothetical population consisting of vehicle passengers saved by seat belts and those restrained and unrestrained passengers that were killed. In addition, the number of rural unbelted front seat passenger vehicle fatalities (≥ 13 years old) in 2008 (for the states considered) was a little less than half of the total number of passenger vehicle crash fatalities that do occur (without the age and seating location restrictions). The choice of target group is one of the critical decisions made in the RSPII framework.

Step 6: Present Results

Two approaches were used to calculate the potential rural roadway crash fatality impact of an upgrade to a primary enforcement seat belt law. The magnitudes of the estimated rural fatalities avoided (from the NHTSA BELTUSE software) and reduced are shown in Table 2.2. It should be noted that the NHTSA BELTUSE software (and its calculation of fatalities avoided) is only applicable to this LSIM. A similar method, however, is available to calculate lives saved or fatalities avoided due to motorcycle helmet use, but a software application is not. The impact evaluation of the other LSIMs considered in this project is limited to the research results available on fatality, injury, or crash reductions. Therefore, the primary enforcement of seat belt use results that apply the NCHRP Report 622 approach was included in the summary at the end of this chapter. This particular approach and its results are consistent with the majority of those presented for the other LSIMs discussed in this chapter. It should be noted, however, that the research results may actually support the application of the percent reduction proposed in

NCHRP Report 622 to all rural roadway crash fatalities rather than an age and seating location restricted number of fatalities.

Table 2.1. Rural Roadway Fatalities in States with No Primary Seat Belt Law (2008)[1]

State	Total Rural Fatalities	Percent of Rural Fatalities Restrained	Unbelted Rural Front Seat Fatalities (≥ 13 Years Old)
Arizona	333	36.1	132
Arkansas	345	36.5	181
Colorado	240	45.5	108
Florida	757	37.3	409
Idaho	143	37.9	76
Kansas	241	34.4	138
Massachusetts	23	43.5	13
Minnesota	227	54.0	71
Missouri	499	31.6	302
Montana	155	27.6	96
Nebraska	160	41.5	79
Nevada	98	51.0	39
New Hampshire	93	26.9	62
North Dakota	67	19.0	46
Ohio	545	44.4	260
Pennsylvania	617	37.2	315
Rhode Island	11	50.0	5
South Dakota	86	29.6	51
Utah	129	60.2	40
Vermont	52	53.2	19
Virginia	402	38.4	215
West Virginia	209	39.7	98
Wisconsin	300	42.0	151
Wyoming	106	28.8	63

[1]All measures are for passenger vehicles only (i.e., cars, light trucks, and vans). In 2009 Arkansas, Florida, Minnesota, and Wisconsin enacted primary enforcement seat belt legislation.

Table 2.2. Estimated Rural Roadway Fatality Reduction due to a Primary Seat Belt Law (2008)

State[1]	BELTUSE Software Estimate of Rural Fatality Reduction[2]	Estimate of Unbelted Rural Front Seat Fatality (≥ 13 Years Old) Reduction[3]
Arizona	27	9
Arkansas	25	13
Colorado	17	8
Florida	53	29
Idaho	12	5
Kansas	17	10
Massachusetts	1	1
Minnesota	14	5
Missouri	36	21
Montana	12	7
Nebraska	11	6
Nevada	7	3
New Hampshire	7	4
North Dakota	6	3
Ohio	35	18
Pennsylvania	42	22
Rhode Island	1	0
South Dakota	6	4
Utah	8	3
Vermont	3	1
Virginia	27	15
West Virginia	15	7
Wisconsin	19	11
Wyoming	6	4
Total	407	209

[1]In 2009 Arkansas, Florida, Minnesota, and Wisconsin enacted primary enforcement seat belt legislation.
[2]Estimate of rural fatality reduction based on an application of the NHTSA BELTUSE software.
[3]Estimate of rural fatality reduction based on the application of a 7 percent decrease in unbelted fatality target group identified in Table 2.1.

Universal Motorcycle Helmet Use

The motorcycle helmet laws within the United States can generally be divided into three categories. Laws that require helmet use by all riders are considered universal helmet laws. Typically this type of law also requires the use of a United States DOT-certified helmet. The potential rural roadway safety impact of this type of law is discussed below. The second type of motorcycle helmet use law in the United States applies to only a portion of riders (e.g., riders less than 21 years old). These laws are considered partial helmet laws. Finally, there are also three states (Illinois, Iowa, and New Hampshire) that do not have any motorcycle helmet laws (*7*).

A number of studies have shown that the use of motorcycle helmets decreases the probability of a fatality and/or major injury during a crash (*8, 9*). Some of these studies were discussed in the Phase I report for this project (*3*). NHTSA has also developed a methodology, similar to that used for seat belts (see the previous discussion), that can estimate the number of lives saved with respect to helmet use. This approach is based on the life saving effectiveness of proper helmet use (*9*). This project, therefore, estimated the potential impact of universal helmet laws with two methods. The fatality reduction approach proposed in NCHRP Report 622 was applied and the NHTSA lives saved estimate was also completed (*4*). The application of the RSPII framework to estimate the impact of universal motorcycle helmet laws is described below.

Step 1: Define Potential Safety Impact

Research results related to the safety impacts of universal motorcycle helmet laws typically focus on fatality and serious injury reductions. However, the magnitude of reductions documented can vary widely. A summary document that described several research studies concluded that the reduction in motorcycle rider fatalities due to the enactment of a universal motorcycle helmet law should be expected to be between 20 and 40 percent (*8*). It is believed that the authors of NCHRP Report 622 utilized these findings when they proposed that the low-end of this range (i.e., a 20 percent reduction) be used to calculate the impact of this LSIM (*4*). This "conservative" percentage reduction is applied in the steps that follow. In addition, NHTSA uses research that has shown helmets to be 37 percent effective at preventing fatalities (*9*).

Step 2: Determine Applicable Target Group

The target group for this LSIM is motorcycle rider fatalities. This is the same target group identified in NCHRP Report 622 (*4*). It will be used in the application of the RSPII framework steps described below. However, similar to the approach proposed in NCHRP Report 622 for the primary enforcement seat belt law, the potential impact on those motorcycle rider fatalities without a helmet was also considered. In other words, the RSPII framework was also applied to a target group of unhelmeted motorcycle fatalities.

Step 3: Identify States with Applicable "Before" Status

As indicated previously, there are generally three categories of motorcycle helmet use laws in the United States. It was initially assumed that the states without any motorcycle helmet use law would potentially experience a greater fatality reduction (with the introduction of a universal helmet law) than those states with partial helmet laws. However, the Advocates for Highway and Auto Safety and the Emergency Nurses Association, because of the difficulty with the actual enforcement of partial helmet laws, generally consider the fatality reduction effectiveness of partial and no helmet law situations to be similar (*10, 11*). In addition, the research focused on motorcycle helmet laws appear to primarily focus on the difference in the safety impacts for states with and without universal helmet use laws (i.e., no distinction in the results are made for existing partial helmet use laws). It was concluded, therefore, that the applicable "before" states for this LSIM should include those that do not have a universal motorcycle helmet law (*7*). Overall, 30 states met this criteria. These states are listed below:

- Alaska
- Arizona
- Arkansas
- Colorado
- Connecticut
- Delaware
- Florida
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Maine
- Minnesota
- Montana
- New Hampshire
- New Mexico
- North Dakota
- Ohio
- Oklahoma
- Pennsylvania
- Rhode Island
- South Carolina
- South Dakota
- Texas
- Utah
- Wisconsin
- Wyoming

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

The fourth step in the RSPII framework requires an estimation of the rural portion of the target group(s) suggested in Step 2 for the states identified in Step 3. In Step 2 there were two target groups identified. These target groups included the total number of motorcyclist fatalities and the number of unhelmeted motorcyclist fatalities. The 2008 rural portion of these two target groups was obtained from the FARS database for the states listed in Step 3. This information is shown in Table 2.3

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

As indicated previously, two methods were used to estimate the potential fatality reduction impacts of a universal motorcycle helmet use law. The first method used the fatality reduction approach proposed in NCHRP Report 622. In this case, a 20 percent reduction was applied to the rural portion of both the target groups identified in Step 4 (See Table 2.3) for the states listed in Step 3. The results from these calculations are presented in Step 6.

The second method to determine the impact of a universal motorcycle helmet use law applied the lives saved approach developed by NHTSA. This method is used by NHTSA to calculate the overall safety impacts from helmet use. It estimates the number of riders who are saved due to wearing a helmet and applies research that has shown helmets to be 37 percent effective at preventing fatalities (9). The number of lives saved, therefore, can be calculated by multiplying potential motorcycle rider fatalities by the effectiveness of helmets:

$$\text{Lives Saved} = (\text{Potential Fatalities})*0.37$$

Table 2.3. Rural Roadway Fatalities in States without a Universal Motorcycle Helmet Law (2008)

State	Total Rural Fatalities	Rural Motorcyclist Fatalities	Rural Unhelmeted Motorcyclist Fatalities
Alaska	47	5	3
Arizona	473	53	21
Arkansas	443	39	20
Colorado	296	40	24
Connecticut	51	11	6
Delaware	73	12	5
Florida	1,113	170	80
Hawaii	58	13	8
Idaho	180	16	6
Illinois	433	57	43
Indiana	527	71	53
Iowa	343	35	29
Kansas	296	29	21
Kentucky	634	65	38
Maine	139	16	13
Minnesota	317	47	39
Montana	211	34	21
New Hampshire	128	27	17
New Mexico	265	20	19
North Dakota	92	9	7
Ohio	762	141	93
Oklahoma	524	55	39
Pennsylvania	828	122	58
Rhode Island	13	1	0
South Carolina	877	101	76
South Dakota	106	11	8
Texas	1,745	210	137
Utah	176	16	10
Wisconsin	413	62	47
Wyoming	137	18	10
Total	11,700	1,506	951

The number of potential motorcycle rider fatalities, as defined by NHTSA, includes motorcyclists who were killed while wearing a helmet and also those who were saved because they wore a helmet. However, the latter portion of this estimate is unknown. Therefore the number of potential fatalities is estimated by NHTSA by dividing the number of helmeted motorcyclist fatalities by the complement of helmet effectiveness (*9*):

$$\text{Potential Fatalities} = (\text{Helmeted Fatalities})/(1-0.37)$$

This equation for potential fatalities can then be inserted into the original equation for lives saved (*9*):

$$\text{Lives Saved} = (\text{Helmeted Fatalities})*0.37/(1-0.37)$$

As indicated, the lives saved calculation is an estimate of the number of motorcyclists who have been saved due to helmet use *(9).* For this study, however, an estimate of potential lives saved seemed more appropriate. NHTSA calculates this measure and it represents an estimate of the number of motorcyclists who could be saved if *every* motorcyclist wore a helmet. The input for potential lives saved, therefore, includes all motorcyclist fatalities and the results of the lives saved calculation. The sum of these two is then multiplied by the research-based helmet effectiveness as shown in the following equation:

$$\text{Potential Lives Saved} = (\text{Total Fatalities} + \text{Lives Saved})*0.37$$

An estimate of the fatality reduction in motorcycle riders can then be calculated by determining the difference between potential lives saved and lives saved. The results of this calculation are shown in Table 2.4. These estimates can also be calculated more simply with the following equation:

$$\text{Fatality Reduction} = (\text{Total Fatalities}*0.37) - (\text{Helmeted Fatalities}*0.37)$$

Step 6: Present Results

Table 2.4 contains the motorcyclist fatality reductions estimated (using the RSPII framework) for upgrades to universal motorcycle helmet laws. The first column in Table 2.4 is equivalent to a 20 percent reduction in the total number of 2008 rural roadway motorcyclist fatalities. This is the approach suggested NHCRP Report 622 (*4*). The second column in Table 2.4 is the output when a similar reduction is applied to the number of unhelmeted motorcyclist fatalities in 2008. The difference in the results of these two calculations is about 100 fatalities (See Table 2.4). The fatality reductions calculated with the NHTSA “lives saved” approach are shown in the third column of Table 2.4 (*9*). This approach generally assumes full compliance with the motorcycle helmet law and, not surprisingly, is larger than the other two estimates.

The 20 percent reduction in motorcyclist fatalities proposed in NCHRP Report 622 was applied to two different rural roadway motorcyclist fatality target groups (i.e., total and unhelmeted) in this RSPII framework exercise (*4*). The difference in the results shown in Table 2.4 is an outcome of the difference in these two target groups. The first approach, which considered total motorcyclist fatalities, is the target group proposed in NCHRP Report 622 (*4*). The research appears to support the use of this particular target group. A more conservative

Table 2.4. Estimated Rural Fatality Reductions due to a Universal Motorcycle Helmet Law (2008)

State	Total Fatality Reduction Method[1]	Unhelmeted Fatality Reduction Method[2]	Lives Saved Fatality Reduction Method[3]
Alaska	1	1	1
Arizona	11	4	8
Arkansas	8	4	7
Colorado	8	5	9
Connecticut	2	1	2
Delaware	2	1	2
Florida	34	16	30
Hawaii	3	2	3
Idaho	3	1	2
Illinois	11	9	16
Indiana	14	11	20
Iowa	7	6	11
Kansas	6	4	8
Kentucky	13	8	14
Maine	3	3	5
Minnesota	9	8	14
Montana	7	4	8
New Hampshire	5	3	6
New Mexico	4	4	7
North Dakota	2	1	3
Ohio	28	19	34
Oklahoma	11	8	14
Pennsylvania	24	12	21
Rhode Island	0	0	0
South Carolina	20	15	28
South Dakota	2	2	3
Texas	42	27	51
Utah	3	2	4
Wisconsin	12	9	17
Wyoming	4	2	4
Total	299	192	352

[1]Estimate of rural fatalities reduced based on a 20 percent decrease to the number of rural motorcyclist fatalities.
[2]A 20 percent reduction in unhelmeted rural motorcyclist fatalities for each state in 2008.
[3]Estimate of rural fatalities reduced based on the NHTSA's approach to calculating lives saved (*9*).

approach, however, would be the application of the 20 percent reduction in motorcyclist fatalities to those riders that were unhelmeted when they crashed. This approach is similar to that proposed by NCHRP Report 622 to estimate the fatality impacts due to an upgrade to a primary enforcement of seat belt law (see the previous section of this report (*4*)). The results from the approach that applied the NHTSA method for calculating motorcyclist lives saved are larger than those from the other two methods. These results are generally presented for informational purposes only (because the methodology exists to do the calculation). It follows a different methodology than that proposed in NCHRP Report 622 (*4*). The total fatality reduction from the first method, which uses the approach proposed in NCHRP Report 622, is included in the summary at the end of this chapter (*4*). This result is supported by the research and consistent with the approaches used for the majority of the LSIMs considered in this project.

Regular Application of Sobriety Checkpoints

The application of a sobriety checkpoint generally consists of police officers stopping vehicles on the roadway to test or evaluate drivers for intoxication. These efforts are location specific, focused, and more comprehensive than typical driver intoxication enforcement. At a sobriety checkpoint police officers will either stop every vehicle on the roadway or stop vehicles at regular intervals (e.g. every third vehicle). Sobriety tests of the driver that are stopped are then conducted. Sobriety checkpoints are often conducted during high risk drunk-driving periods (e.g., New Year's Eve). Most states allow the use of sobriety checkpoints, but their frequency of implementation varies greatly (*12*). It should be noted, however, that NHTSA recently completed a study that concluded sobriety checkpoints with low levels of staffing (similar to what might occur in a rural area) could be as effective as those in urban areas (*13*). An application of the RSPII framework to calculate the potential rural roadway safety impact of sobriety checkpoints is described below.

Step 1: Define Potential Safety Impact

Research projects that have focused on sobriety checkpoints generally indicate that their safety impacts can vary widely. For example, a Center for Disease Control and Prevention (CDC) study found a reduction of approximately 20 percent in alcohol-related fatal and non-fatal injury crashes due to sobriety checkpoints (*14*). However, a variety of other studies have suggested that the reduction in alcohol-related fatalities due to sobriety checkpoints can range from 8 to 71 percent (*15*). Most of the studies were completed in urban areas and the two studies that seemed to consider rural applications produced conflicting results (*15*). There is no conclusive evidence, therefore, that the safety improvement impact of sobriety checkpoints in rural areas are or should be expected to be different than those in urban areas.

It is proposed in NCHRP Report 622 that the 20 percent reduction from the CDC report be used to estimate the impact of sobriety checkpoints (*4*). It is also used in this application of the RSPII framework. It's generally acknowledged that sobriety checkpoints must be conducted regularly and be heavily publicized in order to be most effective. Therefore, during Step 4 of this RSPII framework application the project team assumption used to define the "regular application" of a sobriety checkpoint is summarized. It is also needs to be assumed that the application of a sobriety checkpoint would be well advertised.

Step 2: Determine Applicable Target Group

The target group proposed in NCHRP Report 622 for sobriety checkpoints includes fatalities related to alcohol-impairment (*4*). More specifically, this target group includes any of the crash fatalities in FARS that involve at least one impaired driver (i.e., blood alcohol content (BAC) of 0.08 or greater). This focus appears to be appropriate because sobriety checkpoints are created to identify and arrest drivers who are legally impaired. However, it should be noted that the research supporting the safety impact definition (see Step 1 description) for sobriety checkpoints focused on alcohol-related fatal and non-fatal injury crashes rather than alcohol-impaired crash fatalities and non-fatal injuries. The number of fatal crashes and fatalities are typically not the same, but this difference in the "target group" focus of the research and its suggested application was ignored in this project.

Step 3: Identify States with Applicable "Before" Status

Defining the states with an "applicable" before status requires the identification of those jurisdictions it is assumed would experience most of the safety improvement due to the application of the LSIM being considered. As indicated above, sobriety checkpoints need to be held on a regular basis (along with being well advertised) to be effective. In May2009 the IIHS indicated that 39 states legally allowed sobriety checkpoints (*16*). The Advocates for Highway and Auto Safety, however, indicated that only 12 states and the District of Columbia conducted sobriety checkpoints twice a month *(10).* In 2000, Fell, et al. found that only 11 states conducted checkpoints at least once a week while 37 States and the District of Columbia conducted checkpoints at least once a year *(2, 17*).

The project team for this research concluded that the states that would benefit the most from sobriety checkpoints were a combination of those where sobriety checkpoints were not legal and those where they were not regularly implemented. A definition of "regular implementation" was needed to the states meeting the latter criteria. Fortunately, The Governors Highway Safety Association tracks and publishes the frequency with which each state conducts sobriety checkpoints (*12*). In 2008, the GHSA indicated that 17 states conducted sobriety checkpoints an average of once a week or more. In addition, 11 states conducted sobriety checkpoints once or twice a month (*12*). It was assumed that those states that conducted sobriety checkpoints less than once or twice a month had applicable "before" status for this framework application (i.e., they did not experience the primary benefits of regularly conducted sobriety checkpoints). These are the 14 states listed below. Unfortunately, 8 states permit sobriety checkpoints but the Governors Highway Safety Association did not publish the frequency with which they were conducted. These states included Alabama, Connecticut, Indiana, Louisiana, Maine, New Mexico, North Dakota, and South Carolina, but they could not be included in this analysis (*12*).

- Alaska
- Idaho
- Iowa
- Massachusetts
- Michigan
- Minnesota
- Montana
- Oregon
- Rhode Island
- Texas
- Utah
- Washington
- Wisconsin
- Wyoming

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

The number of crash fatalities that result from alcohol-impaired drivers are estimated by NHTSA. NHTSA completes this estimate (using a double imputation model) because most drivers that are involved in a fatal crash are not actually tested for impairment (*18*). Therefore, the NHTSA method estimates the number of untested drivers who were likely alcohol-impaired. NHTSA publishes a document that summarizes alcohol-impaired fatality estimates by urban and rural locations but not on a state-by-state basis (*19*). The number of rural roadway crash fatalities due to alcohol-impaired drivers, therefore, needed to be estimated for each state in order to complete the application of the RSPII framework for sobriety checkpoints.

The state-by-state estimates completed as part of this project required the use of easily available data (e.g., FARS, NTHSA publications, etc.) and relatively simple estimation methodology. For the purposes of this project, therefore, it was decided by the project team that it would not directly use the NHTSA double imputation model to estimate the rural portion of the alcohol-impaired fatalities in the states listed above. Instead, three basic estimation approaches were used (and their results compared) to complete this step (See Table 2.5). The first method applied the percentage of fatalities in 2008 (from FARS) that were rural to the total number of alcohol-impaired fatalities estimated by NHTSA. The second method used the same approach but applied the percentage of 2008 FARS alcohol-impaired fatalities (i.e., those that involve a driver with a BAC of 0.08 or more, but not including an estimate of those that were untested, unknown, or refused) that were rural to the same NHTSA estimates. The third estimation method, on the other hand, used a different approach and estimated the rural portion of fatalities connected to an alcohol-impaired driver by applying the 2007 (the most recent year available at the time this document was written) national average of 32 percent for this type of crash fatality to all of the rural fatalities that FARS indicated had occurred within each state (*19*). The results from all three calculations are shown in Table 2.5. Overall, the estimates of alcohol-impaired rural fatalities (for the 14 states with "before" status) range from 1,533 to 1,610 (See Table 2.5). A more specific estimation approach and detailed crash data, of course, could be used if an individual state were applying the RSPII framework for this LSIM.

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

The three approaches used to estimate the rural portion of the fatality target group identified in Step 2 were described above. The results of these estimates are provided in Table 2.5. A reduction of 20 percent (the safety impact results from Step 1) was applied to all three estimates on a state-by-state basis. The results of these calculations (See Table 2.6) approximate the potential safety improvement impacts of regularly implementing sobriety checkpoints. Overall, the three options used in this application of the RSPII framework showed potential reductions in rural alcohol-impaired crash fatalities between 307 and 322. Overall, the estimates are very similar.

Step 6: Present Results

As indicated in Step 5, the three approaches used to apply to estimate the potential rural roadway safety improvements due to the regular implementation of sobriety checkpoints estimated crash fatality reductions from 307 to 322 (See Table 2.6). The difference between these estimates is only about 5 percent. The differences in the RSPII framework results are due to different approaches that were proposed to estimate the rural portion of the fatality target

Table 2.5. Alcohol-Impaired Rural Roadway Fatalities in States without Regularly Implemented Sobriety Checkpoints (2008)[6]

State	NHTSA Total Estimated Alcohol-Impaired Fatalities[1]	Rural Percentage of Total Fatalities (FARS)[2]	Approach 1: Alcohol-Impaired Fatalities[3]	Rural Percentage of Alcohol-Impaired Fatalities (FARS)[2]	Approach 2: Alcohol-Impaired Fatalities[4]	Total Rural Fatalities (FARS)[2]	Approach 3: Alcohol-Impaired Fatalities [5]
Alaska	21	76	16	83	18	47	15
Idaho	78	78	61	72	56	180	58
Iowa	89	83	74	79	71	343	110
Massachusetts	124	10	12	9	11	36	12
Michigan	282	60	169	72	202	586	188
Minnesota	135	70	94	74	100	317	101
Montana	91	92	84	96	87	211	68
Oregon	136	72	98	83	113	300	96
Rhode Island	25	20	5	7	2	13	4
Texas	1,269	52	655	48	608	1,745	558
Utah	46	64	29	79	36	176	56
Washington	182	55	99	54	98	284	91
Wisconsin	208	68	142	72	150	413	132
Wyoming	67	86	58	87	58	137	44
Total	2,753	59	1,596	58	1,610	4,788	1,533

[1]Additional information on this estimate may be found in 2008 *Traffic Safety Facts: State Alcohol-Impaired Driving Estimates* (*20*). NHTSA = National Highway Traffic Safety Administration.
[2]Derived from the Fatality Analysis Reporting System (FARS) database. Percentages have been rounded to the nearest whole number.
[3]The Approach 1 estimates apply the rural percentage of total fatalities from FARS to the NHTSA estimate of total alcohol-impaired fatalities
[4]The Approach 2 estimates apply the rural percentage of alcohol-impaired fatalities from FARs to the NHTSA estimate of total alcohol-impaired fatalities.
[5]The Approach 3 estimates apply the 2007 national average percentage of alcohol-impaired fatalities (i.e., 32 percent) to the total rural fatalities from FARS.
[6]Apparent errors in numeric values are due to round off of percentages only.

Table 2.6. Estimated Rural Roadway Crash Fatality Reductions due to the Regular Implementation of Sobriety Checkpoints (2008)

State	Approach 1: Fatality Reduction[1]	Approach 2: Fatality Reduction[2]	Approach 3: Fatality Reduction[3]
Alaska	3	4	3
Idaho	12	11	12
Iowa	15	14	22
Massachusetts	2	2	2
Michigan	34	40	38
Minnesota	19	20	20
Montana	17	17	14
Oregon	20	23	19
Rhode Island	1	0	1
Texas	131	122	112
Utah	6	7	11
Washington	20	20	18
Wisconsin	28	30	26
Wyoming	12	12	9
Total	320	322	307

[1]The Approach 1 reductions are 20 percent of an estimate that applies the rural percentage of total fatalities from FARS to the NHTSA estimate of total alcohol-impaired fatalities. See Table 2.5 and the text for more detail.
[2]The Approach 2 reductions are 20 percent of an estimate that applies the rural percentage of alcohol-impaired fatalities from FARS to the NHTSA estimate of total alcohol-impaired fatalities. See Table 2.5 and the text for more detail.
[3]The Approach 3 reductions are 20 percent of an estimate that applies the 2007 national average percentage of alcohol-impaired fatalities (i.e., 32 percent) to the total rural fatalities from FARS. See Table 2.5 and the text for more detail.

group (See Step 4). The research project team has concluded that the results of the second approach were most appropriate to use. This approach applies the rural proportion of alcohol-impaired fatalities that occur in each state (from the FARS database) and applies it to the NHTSA estimate of total alcohol-impaired fatalities. The first and third estimation approaches were considered less specific because they used, respectively, the overall rural percentage of crash fatalities in each state and the national average of alcohol-impaired crash fatalities in rural areas. These approaches do not account for the fact that there may be a higher proportion of alcohol-impaired fatalities in rural areas and/or the variability of rural crashes with alcohol-impaired drivers from state to state.

Graduated Driver Licensing Program Upgrades

The potential rural roadway crash fatality impact of the introduction of or upgrade to a graduated driver licensing (GDL) program was estimated (using the RSPII framework) as part of this project. It has long been recognized that teenage drivers are involved in fatal crashes at a rate higher than would be expected, and that some of these crashes are the likely the result of driver inexperience and/or distractions (*2*). The objective of a comprehensive GDL program is to reduce crashes and fatalities among these novice drivers by limiting and delaying their exposure to high risk driving situations.

Comprehensive GDL programs typically include three stages that include requirements that delay the acquisition of a full unrestricted license by teenage drivers. Three stage programs include a learner's permit phase, an intermediate stage, and then full licensure. The programs can include a range of components but two that were specifically addressed in NCHRP Report 622 were restrictions on the number of passengers and nighttime driving by young or novice drivers (*4*). Additional detail about GDL programs and their components is available in the Phase I report for this project and various other references (*2*, *3*, *10*). The application of the RSPII framework to estimate the potential rural roadway crash fatality impacts of GDL program upgrades is documented below.

Step 1: Define Potential Safety Impact

Research studies that focus on the safety impacts of GDL programs generally show that they can reduce roadway crash fatalities among teenage drivers (*2*). A summary of the GDL program evaluations completed since 2002 by Shope, for example, generally showed that comprehensive GDL programs can produce a 20 to 40 percent reduction in crash risk for younger drivers (*21*). The authors of NCHRP Report 622 appear to have used these results and those from Baker, et al. to conservatively propose that a 20 percent reduction in crash fatalities and injuries involving 16-year old drivers is a good estimate of the safety impacts due to the implementation of a three-stage GDL program (*4*, *21*, *22*). The potential rural roadway safety impact of introducing a three-stage GDL program is described in this RSPII framework application (See Step 5), but it was also discovered that in 2008 only three states did not already have what was generally described as a "three-stage" GDL program. The results of two other research studies, therefore, were also used to define the potential safety impacts of GDL programs in various stages of development (*22*, *23*). These studies generally focus on the number of components within existing GDL programs and the safety improvements that might occur if they were increased (i.e., the GDL programs were upgraded). The results of these studies are briefly summarized below, but more detail is provided in the Phase I project report (*3*).

The magnitude of the safety impacts that result from a GDL program generally appears to be related to the number of components it contains. A national study of GDL programs (completed for the AAA Foundation for Highway Safety) with a range of components was recently completed (*22*). This study found that GDL programs with 5 of 7 components resulted in a reduction in16-year old driver fatal crash rates of 38 percent and an injury crash rate reduction of 40 percent. It also found that programs with 3 or fewer components produced no statistically significant reduction in 16-year old driver fatal crash rates (*22*). Those with four components, on the other hand, produced a statistically significant reduction of 21 percent in this crash rate. Overall, the evaluation of three-stage GDL programs (which can include any number of components) completed for this study found that they appeared to produce only an 11 percent reduction in population-based fatal crash involvement rates for 16-year olds (*22*). In other words, not all three-stage GDL programs are likely as effective as the research results used in NCHRP Report 622 (*4*, *22*).

The safety impacts of GDL programs with a range of components (i.e. varying status) were also the focus of an earlier study by Morrisey, et al. (*23*). This project focused on the GDL program ratings that are completed by the Insurance Institute of Highway Safety (IIHS). More detail on this rating "index" is available in the Phase I project report (*3*). Morrisey, et al. determined that GDL programs rated as "good" (i.e., more components) by the IIHS resulted in a 19.4 percent reduction in 15- to 17-year-old driver fatalities (*23*). GDL programs categorized as "fair", however, produced a 5.4 percent in the same fatality target group. "Marginal" GDL programs, on the other hand, reduced 15- to 17-year-old driver fatalities by less than one percent. Overall, it was concluded that the impacts due to fair and marginal GDL programs were not statistically different than zero (*23*). It should be noted that it appears this research focused on the reduction in the fatalities of 15- to 17-year old drivers rather than the fatal crash rates involving young drivers that were considered in the studies summarized above.

Step 2: Determine Applicable Target Group

In Step 1 three research projects were used to define the potential roadway safety impacts of GDL programs. The results of these projects actually apply to two fatality target groups. The authors of NCHRP Report 622 primarily used the results from Shope's summary and proposed that the target group include fatalities from crashes that involved one or more 16-yearold drivers (*4, 21*). Using a similar logic, the results from the AAA study can also be applied to this fatality target group (*22*). The documentation from the third study summarized above, however, appears to indicate that its results only pertain to the number of 15- to 17-year old driver crash fatalities (*23*). Therefore, the target group for the application of this study does not include any non-driver fatalities that might occur when a 15- to 17-year old is driving. Both target groups identified above are used in the following steps to apply the results of all three documents.

Step 3: Identify States with Applicable "Before" Status

An application of the potential safety impacts from the three studies described in Step 1 also required the definition of three different lists of states with applicable "before' status. First, the potential safety impacts from NCHRP Report 622 were only applicable to those states without a three-stage GDL program (*4*). As previously indicated, in 2008 only three states (Arkansas, Kansas, and North Dakota) did not meet this criterion for "before" status. In addition, Arkansas and Kansas also very recently passed legislation that removes them from this "before" status (i.e., they now or will soon have three-stage GDL programs) (*24)*. The value of applying this approach with 2008 data (our evaluation year) is clearly limited.

The second study described in Step 1 was done for AAA (*22*). This study analyzed the potential safety impacts of GDL programs with a range of components (*22*). The seven components considered in the study are contained in the following list:

1. A minimum age of at least 16 years for gaining a learner's permit.
2. A requirement to hold the learner's permit for at least 6 months before gaining a license that allows any unsupervised driving.
3. A requirement for certification of at least 30 hours of supervised driving practice during the learner stage.

4. An intermediate stage of licensing with a minimum entry age of at least 16 years and 6 months.
5. A nighttime driving restriction for intermediate license holders, beginning no later than 10 PM.
6. A passenger restriction for intermediate license holders, allowing no more than one teenaged passenger (except family members).
7. A minimum age of 17 years for full, unrestricted licensure (*22*).

In general, this study found that states with 5 components experienced the greatest fatality reductions (*22*). Therefore, it was concluded that the applicable "before" states for the safety impacts from this study are those with less than five GDL program components. These states, and the number of GDL program components they are believed to have, are shown in Table 2.7. The level of the safety impact (See Step 1) applied to each state would be based on the number of components its program includes.

The third study noted in Step 1 calculated the potential safety impacts of GDL programs that had been assigned various IIHS ratings (*23*). The IIHS has characterized GDL programs as "good," "fair," "marginal" or "poor" for many years. These ratings are based on the number and type of components in the GDL program. The criteria used by the IIHS to define each rating at the time this research was completed (IIHS has a different definition now) are shown in Table 2.8 (*23*). As indicated in Step 1, this study found that "good" programs resulted in a statistically significant 19 percent reduction to 15- to 17- year old driver fatalities. The safety impacts of "fair" and "marginal" programs were much smaller (*23*). It was concluded, therefore, that the applicable "before" states for the potential safety impacts from this study were those without "good" programs. The criteria for a "good" rating when Morrisey, et al. completed their study (an old definition) was compared to the current status of the GDL programs and applicable "before" states were identified (*23*). Overall, 32 states did not meet these criteria and are listed in Table 2.9. A total of 20 states were rated as "fair" and 12 rated as "marginal". No programs received a "poor" rating.

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

In this step the rural portion of the two fatality target groups identified in Step 2 was acquired from the FARS database for the applicable "before" states listed in Step 3. The application of the potential safety impacts due to the introduction of a three-stage GDL program (See NCHRP Report 622) was only relevant to three states (See Step 3) (*4*, *21*). In 2008 there were only 17 applicable rural roadway crash fatalities (See Table 2.10) in these three states (i.e., Arkansas, Kansas, and North Dakota). Thirty-eight states (See Table 2.8), however, were applicable to the approach using the AAA study results (*22*). A total of 351 rural roadway crash fatalities involving at least one 16-year old driver occurred in these states in 2008 (See Table 2.10). The Morrisey, et al. study results, on the other hand, were only applicable to 15- to 17-year old driver rural roadway crash fatalities in 32 states (See Table 2.11) (*23*).

Table 2.7. Graduated Driver Licensing Program Components by State[1]

State	Number of Components	State	Number of Components
Alabama	3	Montana	2
Alaska	3	Nebraska	4
Arizona	3	New Hampshire	3
Arkansas	3	New Mexico	3
California	4	North Carolina	3
Colorado	4	North Dakota	1
Florida	3	Ohio	4
Georgia	4	Oklahoma	4
Hawaii	3	Oregon	3
Idaho	3	South Carolina	3
Illinois	4	South Dakota	2
Iowa	2	Tennessee	4
Kansas	3	Texas	2
Louisiana	3	Utah	4
Maine	3	Vermont	3
Michigan	3	Virginia	4
Minnesota	3	Washington	3
Mississippi	2	Wisconsin	3
Missouri	3	Wyoming	2

[1]Only those states with less than five components are listed.

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

In this step the potential safety impacts (i.e., fatality reductions) from the three studies described in Steps 1 are applied to the rural portion of the fatality target group (See Step 4) in each of the "before" states identified in Step 3. First, the process suggested in NCHRP Report 622 for calculating the safety impact of a three-stage GDL program only could be applied to three states in 2008 (*4*, *21*). A 20 percent reduction in the fatality target group identified for this approach would only result in a reduction of approximately 3 rural roadway crash fatalities (i.e., Arkansas = 1, Kansas = 2, and North Dakota = 0) (*4*, *21*). As indicated Step 4, the value of this application is limited. An application of the safety impact results from the AAA study, on the other hand, indicate that upgrading the GDL programs to five or more components in the states listed in Table 2.10 might reduce rural roadway fatalities by 120 deaths (See Table 2.12) (*22*). This estimate was calculated by applying the appropriate research-based fatality reduction (See Step 1) to the states listed in Table 2.10. Finally, the statistically significant safety impacts estimated by Morrisey, et al. were also applied (See Table 2.11 for the applicable "before" states and number of rural roadway fatalities (*23*). Overall, a 19 percent reduction in 15- to -17-year

Table 2.8. Insurance Institute of Highway Safety Graduated Driver Licensing Program Rating Criteria (*Adapted from 23*)

IIHS Characterization	Definition
Good	Both of the following two conditions are required: • A mandatory learner's period of at least 6 months • An "optimal" restriction on the initial license that lasts until age 17 (either a night driving restriction beginning by 10 p.m. or allowing no more than one teen passenger)
Fair	Either of the following two conditions are required: • An "optimal" night-driving or passenger restriction lasting until age 17 without regard to the learner's period • A mandatory learner's period of any length and an "optimal" night driving or passenger restriction lasting until age 16 1/2.
Marginal	Any of the following three conditions is required: • A mandatory learner's period of any length and either a night-driving or passenger restriction. • A mandatory learner's period of at least 6 months • Any night-driving or passenger restriction on the initial license.
Poor	• A mandatory learner's period less than 6 months and no restrictions on night driving or passengers.

old driver fatalities was applied state-by-state to those listed in Table 2.11 and a total estimated fatality reduction of 57 was calculated (See Table 2.13).

Step 6: Present Results

Three studies that focused on the safety impact of GDL programs were used in this application of the RSPII. First, the impact of introducing a three-stage GDL program, as suggested in NCHRP Report 622, was applied but only three states had an appropriate "before" state in 2008 (*4*). Therefore, it was estimated that the application of this LSIM would only produce a reduction of three rural roadway crash fatalities. The value of this approach is very limited because the definition of what constitutes a three-stage GDL program in the literature is too general. The second GDL program application of the RSPII framework considered the safety impact results from a recent AAA study (*22*). This approach estimated that a reduction of 120 rural roadway fatalities would occur if all the GDL programs in the United States included five or more components. The reductions estimated by the first two approaches apply only to those rural crash fatalities that involve at least one 16-year old driver. The third RSPII framework application used some older results from a Morrisey, et al. study (*23*). These results focus on the potential fatality reduction impacts to 15- to 17-year old drivers if all GDL programs were improved to an IIHS rating of "good". In this case, a reduction of only 57 fatalities was estimated.

Table 2.9. Insurance Institute of Highway Safety Graduated Driver Licensing Rating[1]

State	Rating	State	Rating
Alabama	Marginal	Nebraska	Fair
Alaska	Fair	New Hampshire	Marginal
Arizona	Fair	New Mexico	Fair
Arkansas	Marginal	North Carolina	Fair
Florida	Marginal	North Dakota	Marginal
Idaho	Marginal	Oklahoma	Fair
Iowa	Marginal	Oregon	Fair
Kansas	Fair	Pennsylvania	Marginal
Louisiana	Marginal	South Carolina	Fair
Maine	Fair	South Dakota	Marginal
Maryland	Fair	Texas	Fair
Michigan	Marginal	Utah	Fair
Minnesota	Fair	Vermont	Fair
Mississippi	Fair	Washington	Fair
Missouri	Fair	Wisconsin	Fair
Montana	Marginal	Wyoming	Fair

[1]Ratings based on criteria used in Morrisey, et al. study applied to current program status (*23*).

Overall, it was concluded that the approach that used the AAA study produced results that were the most useful to rural roadway safety policy decision-makers (*22*). The fatality reductions it produced are included in the summary to this chapter. The results of the AAA study were the most recent and comprehensive research of the three that were considered. Its results were also applicable to all the rural roadway crash fatalities that involved 16-year old drivers (*22*). The NCHRP Report 622 approach that focused on the introduction of three-stage GDL programs, on the other hand, was not specific enough and the Morrisey, et al. study results applied to a very limited fatality target group (*4*, *23*).

Mandatory Ignition Interlock Installation

The fifth LSIM considered as part of this project was the mandatory installation of ignition interlocks. An ignition interlock is a device that stops a car from being started unless the driver provides a breath sample with a blood alcohol content (BAC) under a predetermined level (e.g., 0.02). The device also typically requires a “running retest” to ensure the driver remains sober while driving. Additional information about ignition interlocks can be found in the Phase I project report (*3*).

The required installation of ignition interlocks in the vehicles of some or all drivers convicted of driving while intoxicated (DWI) is possible in most states. In some states, however, this installation is mandatory for first-time DWI offenders and in other states it is a discretionary

Table 2.10. Rural Roadway Crash Fatalities Involving at Least One 16-Year Old Driver in States with Fewer than Five Graduated Licensing Program Components (2008)

State	Rural Fatalities Involving a 16-Year-Old Driver	State	Rural Fatalities Involving a 16-Year-Old Driver
Alabama	17	Montana	5
Alaska	2	Nebraska	8
Arizona	8	New Hampshire	3
Arkansas	7	New Mexico	4
California	6	North Carolina	15
Colorado	3	North Dakota	1
Florida	22	Ohio	33
Georgia	13	Oklahoma	4
Hawaii	1	Oregon	1
Idaho	5	South Carolina	12
Illinois	8	South Dakota	5
Iowa	7	Tennessee	24
Kansas	9	Texas	30
Louisiana	9	Utah	3
Maine	2	Vermont	1
Michigan	14	Virginia	13
Minnesota	9	Washington	6
Mississippi	13	Wisconsin	10
Missouri	15	Wyoming	3
Total			351

punishment. Several estimates of the potential rural roadway crash fatality impacts from the mandatory use of ignition interlocks are documented in the following paragraphs.

Step 1: Define Potential Safety Impact

Ignition interlock devices are designed to stop additional drunk-driving and reduce recidivism (i.e., additional offenses) by convicted DWI offenders. In fact, the research has shown that they can be extremely effective at reducing the occurrence of alcohol-impaired driving during the time period in which they are installed. The authors of NCHRP Report 622, based on a review of this research, concluded that ignition interlocks should be expected to reduce DWI offender recidivism by 37 to 90 percent (*25, 26*). They suggest that a 37 percent reduction should be used to estimate the crash fatality impact as a result of mandatory ignition interlock installation (*4*). In other words, an assumption was made that there is a one to one relationship between recidivism and the potential reduction in alcohol-related crash fatalities involving drivers with a previous DWI offense. No documentation, however, has been found to

Table 2.11. Rural Roadway Crash Fatalities of 15- to 17-Year Old Drivers in States with a Graduated Licensing Program that has a Fair, Marginal, or Poor Rating (2008)

State	Rural 15- to 17-Year Old Driver Fatalities	State	Rural 15- to 17-Year Old Driver Fatalities
Alabama	16	Nebraska	7
Alaska	1	New Hampshire	1
Arizona	2	New Mexico	4
Arkansas	11	North Carolina	19
Florida	25	North Dakota	3
Idaho	5	Oklahoma	10
Iowa	8	Oregon	3
Kansas	6	Pennsylvania	17
Louisiana	13	South Carolina	16
Maine	4	South Dakota	4
Maryland	9	Texas	31
Michigan	9	Utah	3
Minnesota	11	Vermont	1
Mississippi	15	Washington	2
Missouri	17	Wisconsin	9
Montana	5	Wyoming	3
Total			290

support the validity of this assumption. It also does not appear that the direct crash fatality impacts of ignition interlocks has been quantified. The approach proposed in NCHRP Report 622, therefore, was used during this application of the RSPII framework. However, to evaluate the potential impact of this assumption being incorrect on the results, a total of three fatality reductions (i.e., 25, 37, and 50 percent) have been considered (See Step 5).

Step 2: Determine Applicable Target Group

The target group impacted by the installation of ignition interlocks, as proposed in NCHRP Report 622, is alcohol-related crash fatalities that involve at least one driver with a previous DWI conviction (*4*). Historically, alcohol-related fatalities have been defined by NHTSA as those resulting from a crash involving at least one driver with almost any type of BAC (i.e., a BAC of 0.01 or more) (*27*). This target group appears appropriate for ignition interlocks because do not generally allow a vehicle to start if the driver has even a small amount of BAC. They are usually set to a BAC of 0.02 rather than the 0.08 level used to define alcohol impairment.

Table 2.12. Estimated Rural Roadway Crash Fatality Reduction for Upgrading to at Least Five Graduated Licensing Program Components (2008)

State	Rural Fatalities Involving a 16-Year Old Driver	Fatality Reduction
Alabama	17	6
Alaska	2	1
Arizona	8	3
Arkansas	7	3
California	6	3
Colorado	3	1
Florida	22	8
Georgia	13	4
Hawaii	1	3
Idaho	5	2
Illinois	8	2
Iowa	7	3
Kansas	9	3
Louisiana	9	3
Maine	2	1
Michigan	14	5
Minnesota	9	3
Mississippi	13	5
Missouri	15	6
Montana	5	2
Nebraska	8	2
New Hampshire	3	1
New Mexico	4	2
North Carolina	15	6
North Dakota	1	0
Ohio	33	7
Oklahoma	4	1
Oregon	1	0
South Carolina	12	5
South Dakota	5	2
Tennessee	24	5
Texas	30	11
Utah	3	1
Vermont	1	0
Virginia	13	3
Washington	6	2
Wisconsin	10	4
Wyoming	3	1
Total	351	120

Table 2.13. Estimated Rural Roadway Crash Fatality Reduction for Upgrading to a Graduated Licensing Program Rated as "Good" (2008)

State	Rural 15- to 17-Year Old Driver Fatalities	Fatality Reduction
Alabama	16	3
Alaska	1	0
Arizona	2	0
Arkansas	11	2
Florida	25	5
Idaho	5	1
Iowa	8	2
Kansas	6	1
Louisiana	13	2
Maine	4	1
Maryland	9	2
Michigan	9	2
Minnesota	11	2
Mississippi	15	3
Missouri	17	3
Montana	5	1
Nebraska	7	1
New Hampshire	1	0
New Mexico	4	1
North Carolina	19	4
North Dakota	3	1
Oklahoma	10	2
Oregon	3	1
Pennsylvania	17	3
South Carolina	16	3
South Dakota	4	1
Texas	31	6
Utah	3	1
Vermont	1	0
Washington	2	0
Wisconsin	9	2
Wyoming	3	1
Total	290	57

The NHTSA FARS database includes data about alcohol-related crash fatalities. However, as mentioned previously (in Step 2 for the "Regular Application of Sobriety Checkpoints" LSIM), an imputation process is also applied by NHTSA to account for the fact that a larger number of alcohol-related crash fatalities would be identified if the sobriety of all drivers were tested. In other words, this imputation process is an approximation of the number of drivers involved in a fatal crash that, if they had been tested, would have changed the crash to an alcohol-related incident (*18*).

NHTSA has historically documented an estimate of the number of alcohol-related crash fatalities in each state (*20*). These estimates, however, are not completed for the target group defined for this LSIM (i.e., alcohol-related fatalities connected to drivers with previous DWI conviction). The state-by-state magnitude of this fatality target group, therefore, had to be estimated using easily available data (e.g., FARS, NTHSA publications, etc.) and a relatively simple estimation methodology. The methodology followed to complete these estimates assumed that the ratio of NHTSA estimated alcohol-related fatalities to those in the FARS database also applied to alcohol-related fatalities involving drivers with previous DWI convictions (*20*). The ratios calculated for each state, along with the estimated total number of alcohol-related crash fatalities involving driver(s) with a previous DWI conviction (i.e., the ignition interlock installation target group) are shown in Table 2.14. It should be noted that only those states with an applicable "before" status (See Step 3) are included in this table.

Step 3: Identify States with Applicable "Before" Status

In 2008 Alabama, South Dakota, and Vermont were the only states that did not allow the use of ignition interlocks as one of their potential penalties for a drunk-driving offense (*28*). Forty-seven states allowed the installation of ignition interlocks for various DWI-related conditions. The most stringent laws that exist require ignition interlock installation for all DWI convictions (including first-time offenders). This lack of this type of law was used in this project to define the applicable "before" states for the ignition interlock LSIM. In 2008, only 10 states had laws that required the installation of ignition interlocks for all DWI offenders (*29*). The other 40 states listed in Table 2.14 were considered to have an applicable "before" status for this LSIM. These states are the states it was assumed would experience the majority of the safety improvements produced by the mandatory installation of ignition interlocks for all DWI convictions.

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

The target group identified in Step 2 for this LSIM included alcohol-related (i.e., driver(s) with a BAC of 0.01 or more) crash fatalities involving one or more drivers with a previous DWI conviction. Estimates of the total number of fatalities in this target group for each of the applicable "before" states are shown in Table 2.14. In this step the rural portion of fatalities in this target group also need to be estimated state-by-state. These estimates were calculated by multiplying the estimates from Table 2.14 (i.e., the total number of fatalities in the target group) and the rural percentage of alcohol-related fatalities connected to driver(s) with a previous DWI conviction contained in the FARS database. The results of this estimation approach are shown in Table 2.15. Overall, it was estimated that 734 of the 1,166 fatalities in the target group (approximately 63 percent) were rural. It should be noted, however, that this approach does assume that the urban-rural proportions of the fatality target group data in FARS (from tested

Table 2.14. Estimate of Alcohol-Related Crash Fatalities Involving Driver(s) with a Previous Driving while Intoxicated (DWI) Conviction (2008)

State[1]	Ratio of NHTSA Estimate to FARS Database Alcohol-Related Crash Fatalities[2]	FARS Alcohol-Related Crash Fatalities Involving Driver(s) with a Previous DWI Conviction[2]	Estimate of Alcohol-Related Crash Fatalities Involving Driver(s) with a Previous DWI Conviction[3]
Alabama	1.77	21	37
California	1.39	89	124
Connecticut	1.44	3	4
Delaware	1.50	6	9
Florida	1.79	32	57
Georgia	1.82	37	67
Hawaii	1.28	4	5
Idaho	1.46	13	19
Indiana	1.70	21	36
Iowa	2.51	6	15
Kansas	1.76	11	19
Kentucky	1.75	24	42
Maine	1.42	3	4
Maryland	1.36	1	1
Massachusetts	1.48	9	13
Michigan	1.86	17	32
Minnesota	1.39	27	38
Mississippi	4.20	12	50
Missouri	1.48	18	27
Montana	1.32	13	17
Nevada	1.39	5	7
New Hampshire	1.29	2	3
New Jersey	1.46	10	15
New York	2.05	21	43
North Carolina	1.35	26	35
North Dakota	1.30	8	10
Ohio	1.30	40	52
Oklahoma	1.56	23	36
Oregon	1.28	5	6

Table 2.14. Continued

Pennsylvania	1.58	30	47
Rhode Island	1.76	0	0
South Carolina	1.55	33	51
South Dakota	1.08	5	5
Tennessee	3.48	9	31
Texas	2.05	48	98
Vermont	1.07	2	2
Virginia	1.49	15	22
West Virginia	1.25	7	9
Wisconsin	1.32	43	57
Wyoming	1.50	14	21
Total	1.65	713	1,166

[1]Only those states with an applicable "before" status are shown. See Step 3 text for more detailed description.
[2]Additional information on this estimate may be found in *Traffic Safety Facts: 2008 State Alcohol-Impaired Driving Estimates* (*20*). NHTSA = National Highway Traffic Safety Administration. FARS = Fatality Analysis Reporting System.
[3]Estimate is product of first two columns.

drivers) also applies to the estimated crash fatalities due to less than complete BAC testing (See Step 2 for additional details).

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

The research reviewed to determine the potential safety impacts of the mandatory installation of ignition interlocks has focused on their reduction in DWI offense recidivism rather than alcohol-related fatalities. NCHRP Report 622 suggests that a 37 percent reduction in DWI offense recidivism should be expected with the installation of ignition interlocks and that it should be applied to the rural portion of the fatality target group (See Step 2) (*4*). This suggestion assumes that a one-to-one relationship exists between DWI offense recidivism and the reduction in fatalities (i.e., alcohol-related crash fatalities involving drivers with a previous DWI offense). The data used to define DWI offense recidivism in the research reviewed (See Step 1) will determine whether this is a reasonable assumption, but it is unlikely every driver convicted of two or more DWI offenses is involved with a fatal crash. The sensitivity analysis completed in response to this assumption is described in the next paragraph and the results are shown in Table 2.16.

The project team for this research study considered a range of reductions in the fatality target group to evaluate the potential impact of the assumption above being incorrect. First, a 25 percent reduction was applied to the rural portion of the fatality target groups in each "before" state. This percentage was chosen as a more conservative impact estimate (i.e., that every percentage point of recidivism reduction was not matched by a similar reduction in the fatality target group). The 37 percent reduction, which was suggested in NCHRP Report 622, was also

Table 2.15. Estimate of Rural Roadway Alcohol-Related Fatalities Involving Driver(s) with a Previous Driving while Intoxicated (DWI) Conviction in States without Mandatory Ignition Interlock Installation (2008)

State	Rural Percentage of Alcohol-Related Fatalities Involving Driver(s) With a Previous DWI Conviction[1]	Estimate of Alcohol-Related Fatalities Involving Driver(s) with a Previous DWI Conviction[2]	Rural Roadway Alcohol-Related Fatalities Involving Driver(s) with a Previous DWI Conviction[3]
Alabama	71	37	26
California	42	124	52
Connecticut	33	4	1
Delaware	67	9	6
Florida	59	57	34
Georgia	38	67	25
Hawaii	25	5	1
Idaho	69	19	13
Indiana	67	36	24
Iowa	83	15	12
Kansas	64	19	12
Kentucky	83	42	35
Maine	100	4	4
Maryland	0	1	0
Massachusetts	33	13	4
Michigan	88	32	28
Minnesota	63	38	24
Mississippi	92	50	46
Missouri	72	27	19
Montana	92	17	16
Nevada	20	7	1
New Hampshire	100	3	3
New Jersey	40	15	6
New York	57	43	25
North Carolina	69	35	24
North Dakota	88	10	9
Ohio	63	52	33
Oklahoma	78	36	28
Oregon	100	6	6

Table 2.15. Continued

Pennsylvania	50	47	24
Rhode Island	0	0	0
South Carolina	97	51	49
South Dakota	100	5	5
Tennessee	78	31	24
Texas	29	98	28
Vermont	100	2	2
Virginia	67	22	15
West Virginia	86	9	8
Wisconsin	74	57	42
Wyoming	93	21	20
Total	63	1,166	734

[1]Calculated from information in FARS database.
[2]See Table 2.14.
[3]Estimate is product of first two columns.

applied (*4*). Then, a reduction of 50 percent was considered. This percentage was applied to evaluate the impact on the RSPII framework results if the NCHRP Report 622 suggestion is too conservative (*4*). The results from all three approaches are shown in Table 2.16.

Step 6: Present Results

Three rural roadway crash fatality reduction estimates were calculated when the RSPII framework was applied to calculate the rural roadway crash fatality impacts of mandatory ignition interlock installation (See Table 2.16). The estimates range from 186 to 374. Overall, it is clear that the fatality reduction (or potential safety impact) applied within the RSPII framework can have a significant impact on its results. The application of a 37 percent reduction to alcohol-related crash fatalities (involving driver(s) with a previous DWI conviction) was suggested in NCHRP Report 622 (*4*). In this case, this approach would result in an estimated reduction of 268 deaths (See Table 2.16). At this point in time, however, it was also proposed that a more conservative 25 percent reduction approach may be more appropriate. The results from the application of a 25 percent reduction in alcohol-related crash fatalities (involving a driver with a previous DWI conviction) is shown in Table 2.16. This approach was suggested because the research results used in NCHRP Report 622 are based on reductions in recidivism rather than fatalities and the potential relationship between these two variables needs further investigation (*4*). Overall, however, the general lack of information about this relationship also did not allow the research team to determine whether the 37 percent or 25 percent fatality reduction approach was more accurate. Therefore, it was decided to include the results from the approach suggested in NCHRP Report 622 (i.e., the use of a 37 percent reduction) in the summary of this chapter.

Table 2.16. Estimated Rural Roadway Crash Fatality Reduction due to Mandatory Ignition Interlock Installation (2008)

State	Rural Roadway Alcohol-Related Fatalities Involving Driver(s) with a Previous DWI Conviction[1]	25 Percent Reduction[2]	37 Percent Reduction[2]	50 Percent Reduction[2]
Alabama	26	7	10	13
California	52	13	19	26
Connecticut	1	0	0	1
Delaware	6	2	2	3
Florida	34	9	13	17
Georgia	25	6	9	13
Hawaii	1	0	0	1
Idaho	13	3	5	7
Indiana	24	6	9	12
Iowa	12	3	4	6
Kansas	12	3	4	6
Kentucky	35	9	13	18
Maine	4	1	1	2
Maryland	0	0	0	0
Massachusetts	4	1	1	2
Michigan	28	7	10	14
Minnesota	24	6	9	12
Mississippi	46	12	17	23
Missouri	19	5	7	10
Montana	16	4	6	8
Nevada	1	0	0	1
New Hampshire	3	1	1	2
New Jersey	6	2	2	3
New York	25	6	9	13
North Carolina	24	6	9	12
North Dakota	9	2	3	5
Ohio	33	8	12	17
Oklahoma	28	7	10	14
Oregon	6	2	2	3
Pennsylvania	24	6	9	12

Table 2.16. Continued

Rhode Island	0	0	0	0
South Carolina	49	12	18	25
South Dakota	5	1	2	3
Tennessee	24	6	9	12
Texas	28	7	10	14
Vermont	2	1	1	1
Virginia	15	4	6	8
West Virginia	8	2	3	4
Wisconsin	42	11	16	21
Wyoming	20	5	7	10
Total[3]	734	186	268	374

[1]Estimate from Table 2.15. DWI = Driving While Intoxicated.
[2]Range of percent reductions considered for evaluation purposes. Reduction is product of percentage indicated and first column.
[3]Apparent errors in totals are due to round-off.

Automated Speed Enforcement

Automated speed enforcement was the sixth and final LSIM chosen for consideration during Phase II of this research project. This type of enforcement is typically accomplished primarily through the use of cameras and/or radar that are capable of monitoring and recording the speed of a vehicle on the roadway. If the speed of that vehicle exceeds a predetermined threshold (e.g., 5 miles per hour over the posted speed limit) a photograph can be used to identify the vehicle owner or driver and a ticket for the speeding violation is mailed. The ability to use automated enforcement, however, varies from state to state. Some states do not have specific legislation that permits the use of automated enforcement and haven't attempted its application, but others have also implemented it (more often with red-light-running offenses) without explicit enabling legislation (*30*).

The potential safety impact of implementing automated speed enforcement could be particularly significant along rural roadways because it is a contributing factor in a large percentage of fatal crashes that occur along these facilities. The comprehensive application of this LSIM in rural areas, however, also clearly has its challenges (see the next chapter of this report for some of these). Several estimates of the potential rural roadway crash fatality impact of automated speed enforcement were calculated through the application of the RSPII framework. These calculations are described step-by-step in the following paragraphs.

Step 1: Define Potential Safety Impact

Crash injury severity increases with vehicle speed (*31*). In addition, a larger variability in vehicle speeds along a roadway can often result in a greater number of crashes (*31*). Overall, it has been shown that the majority of the speed-related crash fatalities in the country occur along rural roadways (*1*). In many cases, however, it is only one of several contributing factors.

A review of the literature revealed few documented attempts at automated speed enforcement in the United States (*32*, *33*). The studies that were completed also focused, not surprisingly, on the speed impacts of automated enforcement rather than the safety or crash impacts. For example, an IIHS study in Montgomery County, Maryland found that mobile speed camera reduced average vehicles speeds by 14 percent (*32*). The number of vehicles traveling more than 10 miles per hour over the speed limit also decreased by 82 percent (*32*). In addition, a study of the automated enforcement speed camera program along an urban freeway in Scottsdale, Arizona has also been completed (*33*). This study concluded that the percentage of vehicles travelling faster than 75 mph was reduced from 15 percent to less than 2 percent after the program was implemented. Neither of these studies directly considered the crash, injury or fatality reduction that might have occurred due to the implementation of these automated speed enforcement efforts.

The implementation of automated speed enforcement is more typical outside the United States and several research projects focused on its safety and/or speed impacts have been completed (*34*, *35*, *36*). In general these studies indicate that the implementation of automated speed enforcement can reduce both speeds and crashes (*34*, *35*, *36*). A summary of several automated speed enforcement studies (conducted in Australia, Canada, and Europe) by Pilkington and Kinra indicated that type of activity can reduce crashes by 5 to 69 percent, crash injuries by 12 to 65 percent, and crash fatalities by 17 to 71 percent (*34*). More specifically, a review of 21 automated speed enforcement studies by Wilson, et al. also included five rural area evaluations that indicated they produced crash reductions of 20 to 71 percent (*35)*. Finally, the evaluation of an automated speed enforcement system on an urban freeway around Barcelona, Spain also indicated that it improved roadway safety (*36*).

The safety impact of this LSIM is discussed in NCHRP Report 622 (*4*). The safety impacts proposed in NCHRP Report 622 have been applied within the RPSII framework for each of the previous five LSIMs (*4*). For the automated speed enforcement LSIM, the authors of NCHRP Report 622 appear to have used the results of the Pilkington and Kinra summary described in the previous paragraph to conclude that automated speed enforcement could lead to a 20 to 40 percent decrease in speed-related crashes (*4*, *34*). They then extend this conclusion to, and suggest that, a 20 percent reduction in speed-related crash fatalities could be used to evaluate the impact of automated speed enforcement technologies (*4*). This approach, given the limited amount of research in this subject area, appeared to be reasonable and was also applied in this project. This generally seems to be the lower end of the fatality impact information that is available. Additional research, based in the United States, on the crash, injury, and fatality impacts of automated speed enforcement is needed.

Step 2: Determine Applicable Target Group

The target group for this safety improvement includes those crash fatalities defined as speed-related. The NHTSA definition of a speed-related crash includes those that involve a driver charged with a speeding-related offense and/or if a contributing factor to the crash was racing, driving too fast for conditions, or exceeding the posted speed limit (*37*). The number of urban and rural speed-related fatalities in each state can be obtained from the NHTSA FARS database. However, a number of contributing factors (speed-related and others) can be listed in the NTHSA FARS database for each fatal crash. However, the significance (e.g., was speed the primary cause) of each contributing factor to each crash is not identified. It is also generally understood that speed is likely listed as a contributing factor for the crashes included in most of the fatality target group for the other LSIMs considered in this research. The methods used to address this issue are described in the following paragraphs. The use of more specific data (e.g., crash reports) at the state-level may allow more accurate, better safety impact estimations to be completed for this LSIM.

Step 3: Identify States with Applicable "Before" Status

The application of automated speed enforcement is very limited within the United States. In 2008, the website for the IIHS listed 49 communities that used cameras (in some manner) to reduce excessive speeding (*38*). In addition, at the time this report was written Arizona was using automated speed enforcement cameras along state highways and Illinois was using them within construction zones. Overall, however, the systematic application of automated speed enforcement, especially in rural areas, is generally non-existent. Therefore, for the purposes of this research all 50 states were considered to have an applicable "before" status for this LSIM. In other words, it was assumed that all of the states would still experience some form of safety benefits due to the systematic implementation of automated speed enforcement.

Step 4: Calculate Rural Portion of Target Group within Selected "Before" States

The NHTSA definition of "speed-related" crashes was used in this research project (See Step 2). It includes crash fatalities that involve a driver charged with a speeding-related offense and/or if a contributing factor to the crash is racing, driving too fast for conditions, or exceeding the posted speed limit. This definition was applied to obtain the number of speed-related crash fatalities along roadways with a rural functional classification from the FARS database for all 50 states (See Table 2.17). The number of rural speed-related crash fatalities found in each state ranged from as little as one in Rhode Island to as many as 796 in Texas. Overall, the total number of rural speed-related crash fatalities in 2008 within the United States was 6,937. Table 2.17 also includes a column that contains half of the total rural speed-related crash fatalities in each state. The impact on this "partial" rural fatality target group due to automated enforcement is also calculated (See Step 5) to account for the fact that not all speed-related fatal crashes have speed as their primary cause. Other fractions of this fatality target group could have also been considered for this LSIM, but they weren't because without more specific crash data it is unknown whether they would be any more accurate than what's already shown in Table 2.17.

Step 5: Apply Potential Safety Impact to Rural Portion of the Target Group

Table 2.17 includes two estimates of the rural portion of the automated speed enforcement fatality target group (See Step 4). In this step of the RSPII framework a 20 percent reduction (See Step 1) in speed-related crash fatalities was applied to both estimates. First, 20 percent of the total number of the rural roadway speed-related fatalities was calculated (See Table 2.17). The results from this calculation approximate the maximum potential rural roadway crash fatality reduction that might occur if automated speed enforcement was systematically implemented and all the crashes in the fatality target group were primarily caused by vehicle speed. However, speed is only one of several contributing factors in most speed-related crashes and only a percentage of the fatality group would likely be impacted by automated speed enforcement. Therefore, for analysis purposes, the project team applied the same reduction (i.e., 20 percent) to half of the total number of rural roadway speed-related fatalities (See Table 2.17).

Table 2.17. Estimated Rural Roadway Speed-Related Crash Fatalities and Fatality Reductions due to Automated Speed Enforcement (2008)

State	Total Rural Roadway Speed-Related Crash Fatalities	20 Percent Reduction[1]	Half the Rural Roadway Speed-Related Crash Fatalities	20 Percent Reduction[2]
Alabama	435	87	218	44
Alaska	42	8	21	4
Arizona	140	28	70	14
Arkansas	7	1	4	1
California	112	22	56	11
Colorado	127	25	64	13
Connecticut	5	1	3	1
Delaware	3	1	2	0
Florida	336	67	168	34
Georgia	207	41	104	21
Hawaii	34	7	17	3
Idaho	39	8	20	4
Illinois	109	22	55	11
Indiana	141	28	71	14
Iowa	64	13	32	6
Kansas	125	25	63	13
Kentucky	73	15	37	7
Louisiana	100	20	50	10
Maine	58	12	29	6
Maryland	76	15	38	8
Massachusetts	11	2	6	1
Michigan	147	29	74	15
Minnesota	78	16	39	8
Mississippi	386	77	193	39
Missouri	187	37	94	19
Montana	64	13	32	6
Nebraska	44	9	22	4
Nevada	42	8	21	4
New Hampshire	41	8	21	4
New Jersey	7	1	4	1
New Mexico	113	23	57	11

Table 2.17. Continued

New York	349	70	175	35
North Carolina	458	92	229	46
North Dakota	9	2	5	1
Ohio	267	53	134	27
Oklahoma	146	29	73	15
Oregon	77	15	39	8
Pennsylvania	278	56	139	28
Rhode Island	1	0	1	0
South Carolina	458	92	229	46
South Dakota	46	9	23	5
Tennessee	117	23	59	12
Texas	796	159	398	80
Utah	75	15	38	8
Vermont	4	1	2	0
Virginia	209	42	105	21
Washington	80	16	40	8
West Virginia	57	11	29	6
Wisconsin	111	22	56	11
Wyoming	46	9	23	5
Total[3]	6,937	1,385	3,482	699

[1]This column represents a 20 percent reduction in the total number of rural roadway speed-related crash fatalities in each state.
[2]This column represents a 20 percent reduction in half the number of rural roadway speed-related crash fatalities in each state.
[3]Apparent errors in totals are due to round-off.

A determination of the actual percentage of speed-related crash fatalities in the target group that may have speed as their primary cause would require the acquisition of more specific crash data. For example, more specific estimates than what are shown in Table 2.17 might be acquired through the consideration of individual crash reports for a particular state. Unfortunately, the acquisition of this type of data for every state in the country was beyond the scope of this project.

Step 6: Present Results

Two estimates of the potential rural roadway fatality reduction impact of automated speed enforcement were calculated as part of this RSPII framework application (See Table 2.17). The first estimate assumed that all the rural speed-related fatalities defined in Step 2 would be impacted by automated enforcement and reduced by 20 percent. This approach resulted in an estimate that 1,385 rural roadway speed-related crash fatalities could be eliminated. State-by-state the reductions range from zero in Rhode Island to 159 in Texas. The second approach assumed that half of the rural roadway speed-related fatalities defined in Step 2 would be impacted (or avoided) due to automated enforcement. This calculation was completed because speed is often indicated as contributing factor in a crash but not always the primary cause (i.e., automated enforcement and a lower speed would not have stopped the fatality). In other words, it recognizes that the target groups of many LSIMs overlap and the one identified for automated enforcement may do so to a larger extent than the others considered in this project. This second calculation approach resulted in an estimate that 699 rural roadway fatalities could be avoided with automated speed enforcement. State by state the reductions range from zero in Rhode Island to 80 in Texas. Not surprisingly, this is about half the results of the first approach (any difference is due to round-off error). It was concluded that the more conservative approach that assumed only half the speed-related fatalities would be directly impacted by automated speed enforcement was more appropriate. The results from this approach are included in the summary at the end of this chapter. More detailed analysis might be done within each state (with crash reports for example) to determine the actual percentage of crash fatalities impacted by this type of program. This type of application of the RSPII framework was not possible as part of this project.

SUMMARY OF FINDINGS

In this chapter the RSPII framework developed in Phase I of this project was applied to six LSIMs. The completion of each step in the framework was described in detail. In most cases, one or more assumptions needed to be made in order to apply the research results available to the fatality crash data that was available to the project team for a state-by-state national application of the framework. In addition, several different methods were also often used to complete one or more of the steps in the framework. The reasons for this approach vary from LSIM to LSIM, but included the wide range of research results, the application of the results from one or more research studies, and concerns about the applicability of the LSIM to the entire fatality target group identified. The RSPII framework results for each LSIM were compared and the individual fatality reduction selected as the most reasonable by the project team is listed below:

- Primary enforcement of seat belt use – 209
- Universal motorcycle helmet use – 299
- Regular application of sobriety checkpoints – 322
- Graduate driver licensing program upgrades – 120
- Mandatory ignition interlock installation – 268
- Automated speed enforcement – 699

These results were selected from those calculated for each LSIM for a number of reasons. In many cases they are the result of an application of the RSPII framework inputs suggested in NCHRP Report 622 (*4*). In other cases they are what the project team considered more applicable or possibly more likely. Overall, the results from the application of the RSPII framework do show that the implementation of the LSIMs considered could result in a relatively substantial reduction in rural roadway crash fatalities. However, it should be noted that the individual reductions listed above can not be summed and that most of them overlap. Some of the challenges related to the application of the RSPII framework, several of which impact the value and use of its results, are described in Chapter 3. In general, however, a national state-by-state estimation of potential fatality reductions to safety improvements (using FARS data) can almost always be improved when this type of calculation is done for an individual state with more specific crash data. The estimates in this report should be used as a starting point for various activities. Some of these are documented in the final chapter of this report.

Chapter 3. RSPII Framework and LSIM Field Application Challenges

In Chapter 2 the RSPII framework proposed in Phase I of this project was applied to six LSIMs (*3*). The results of these calculations show that their implementation and enforcement could help reduce the number of rural roadway crash fatalities in the United States. The assumptions and methods used to apply the RSPII framework, given the current state of the relevant research, were also noted in Chapter 2. The challenges that were addressed by the application of these assumptions are described in this chapter. Their application generally limits the usefulness or robustness of the framework results (i.e., they help identify where "errors" may be introduced), but also helps identify potential areas for future research (See Chapter 4). The fatality reduction estimates produced as part of this project should only be used for information and comparative purposes. The "accuracy" of their magnitudes should be updated and refined with more specific crash data within each individual state. The scope of this project was limited to the use and application of data easily available for the entire country (e.g., FARS).

The validity and usefulness of the RSPII framework results are also related to the actual comprehensive and effective application of the LSIMs along roadways in rural areas. The second part of this chapter describes some of the potential challenges the research team has identified related to this issue. These challenges are almost entirely connected to the availability of resources (e.g., people, funding, etc.) in rural areas. In addition, the low volume rural roadway environment, spread over a wide area, also produces a situation where the application and/or an enforcement of an LSIM can be especially difficult to effectively and efficiently plan. The response to these challenges will influence the effectiveness of the LSIM and the validity of the framework results. It should be noted that most LSIM research focuses on targeted and well-designed applications. Therefore, the assumption inherent in the research-based results of the RSPII framework are that any new and proposed mitigation would also be effectively implemented, applied, and/or enforced as those evaluated in the research. The impacts of all the challenges noted in this chapter will influence these activities.

RSPII FRAMEWORK APPLICATION CHALLENGES

The six step RSPII framework applied in this report was developed in Phase I of this project (*3*). The processes and decisions that would need to be made in order to apply each step were noted (*3*). In Chapter 2 of this report the RSPII framework was applied to six LSIMs. The usefulness and robustness of the RSPII framework results are measured by the same characteristics of the research used in its application and how well the research assumptions match the implementation of the LSIM. The wide range of possibilities for the various inputs to the RSPII framework, however, requires the use of several assumptions, generalizations, and/or multiple applications (these are noted in Chapter 2 for each LSIM). Of course, in the future any new research that was relevant to the application of the RSPII framework would be used to adjust the approach used for its application. Any necessary assumptions and/or generalizations that are noted or described (see Chapter 2) also will impact the results of the RSPII framework. Several of the challenges to the application of the RSPII framework that were addressed by the assumptions and/or generalizations described in Chapter 2 are noted the following list and described in more detail within the following paragraphs:

- Variability of Research Results
- Lack of Rural Applications Research
- Variability/Documentation of the Research Safety Measures
- Availability of Data About the Fatality Target Group
- Variability in LSIMs Applied

Variability of Research Results

The first step in the RSPII framework includes the identification of quantitative research results that define the safety impact of an LSIM. The six LSIMs considered in this document, along with 17 other safety improvement measures related to human behavior, were categorized as "proven" in NCHRP Report 622 (*4*). The authors of that document defined an LSIM as "proven" if its positive safety impact was supported by "…consistent positive evidence from several high-quality evaluations" (*4*). This is similar to a portion of the "proven" definition used for what are primarily (but not all) infrastructure-related safety improvement measures within the NCHRP Report 500 series (*39*). This definition includes the need for a "proven" measure to have "…properly designed evaluations…that show the strategy to be effective" (*39*). In recent years the definition of currently accepted "…properly designed evaluations…" for infrastructure-related safety improvement measures has been applied very stringently (i.e., often including the need for an empirical Bayesian approach to modeling/evaluating crash data) (*39*). It is assumed that the research used to identify a LSIM as "proven" in NCHRP Report 622 did not generally meet this type of stringent definition (*4*). It is possible that this difference is simply a recognition by the NCHRP Report 622 authors that very few studies that focus on behavior-related safety improvement measures (including LSIMs) would meet this type of definition for "proven". It is also possible that other more appropriate and equally equivalent and acceptable statistical analyses of crash data are available for evaluating behavior-related safety improvement measures. The characteristics of crash data and its requirements for analysis, however, generally do not vary. Overall, when the documented evaluations related to LSIMs are reviewed it needs to be recognized that the range of approaches used to quantify their roadway safety impacts may be one of several reasons for the variability that appears to exist in the research results.

The variability in the research results for LSIMs was one of the challenges that had to be addressed in the application of the application of the RSPII framework. One of the reasons for this variability, which was described previously, may be the variability in the evaluation approaches used to study LSIMs. The range of safety impacts (e.g., crash, injury, and/or fatality reductions) for individual LSIMs that were suggested for application in NCHRP Report 622 are also often based on the results of one or more studies and/or meta-analysis summaries. When study results are combined its important that their results be of comparable validity and that the meeting of this requirement (or the lack thereof) be documented. Of course, the range of reported safety impacts due to individual LSIMs could also simply be due to the relatively large variety of characteristics, application approaches, and factors that could alter their effectiveness. The research results are simply defining that variability. Unfortunately, the origins of the variability in the results that are being used in RSPII framework are more likely a combination of the reasons noted above. The wide range of potential safety impacts for one LSIM presented a challenge to the application of the RSPII framework. The response was to apply the lower end of the range in the RSPII framework in order to be conservative. This assumption or generalization was suggested in NCHRP Report 622 and also used in this project. This approach assumes the LSIM research considered was adequate, but acknowledges that it generally focuses on well-designed applications (i.e., more successful LSIM programs are studied). It does not, however, address the actual origins of the variability in the research results or their validity. The final chapter in this report includes recommendations for future LSIM research.

Lack of Rural Applications Research

Another significant assumption or generalization that had to be used in every application of the RSPII framework described in this report was that research results available all applied to the implementation of LSIMs in rural areas. Almost none of the research reviewed for this project considered the safety impacts of LSIMs along rural roadways or attempted to evaluate the potential difference in safety impacts of an LSIM in rural and urban areas. Overall, there were only one or two studies that even made this differentiation, but it was not their primary focus. It could be hypothesized, therefore, that the LSIMs considered in this research could have a higher (or lower) potential crash fatality reduction impact than that reported in the literature. For example, some of the contributing factors to a crash addressed by the LSIMs in this document occur more often in rural areas. This could result in a higher safety impact along rural roadways. On the other hand, one could assume that rural areas will have to implement LSIMs over a larger area with fewer staff and resources. This situation could make them less effective than those implemented in an urban area. Overall, there is simply no evidence that rural LSIMs are more or less effective than their comparable urban counterparts. This challenge was addressed by simply assuming that the research results available applied equally to rural and urban roadways. Additional rural LSIM research is recommended in Chapter 4.

Variability/Documentation of Research Safety Measures

During Phase I of this project it was concluded that the focus of the RSPII framework application would be to estimate the potential impact of the implementation, alteration, and enforcement of LSIMs on rural roadway crash *fatalities*. Estimating the impact on crash fatalities is also the focus of the process proposed in NCHRP Report 622 (*4*). A review of the literature, however, found that the research projects that attempted to quantify the safety impacts of LSIMs focused on a variety of measures. Some of the measures of safety that were evaluated include fatalities, fatal crashes, severe injuries, severe injury crashes, total crashes, and crash rates. Some of the research projects considered multiple measures and others only one. In addition, it must also be assumed that the individual studies considered in the meta-analyses and referenced by NCHRP Report 622 and this project all evaluated same safety measure. One challenge to the application of the RSPII framework that is related to the variability in research safety measures is that the "best" project may not have evaluated crash fatalities. The response to this challenge is described in the next paragraph.

The lack of research focused on the potential fatality impacts of LSIMs was another challenge to the application of the RSPII framework. This challenge was overcome by assuming, when needed, that the non-fatality reduction results in the research were also applicable to fatalities. In some cases, as suggested in NCHRP Report 622, this might include the application of research results that note reductions in fatal *crashes* to the number of fatalities. It is generally understood that the impact of safety improvement on these two measures may be similar but is not exactly the same. In other cases, using the RSPII framework might require the application of research results related to reductions in crashes, crash risk, or recidivism to the number of fatalities. There is a difference in the roadway safety impact shown by these various safety measures (e.g., fatalities and total crashes). The state-of-the-research, however, may not provide an alternative when the impact of an LSIM is being considered. Unfortunately, this type of assumption (even if the LSIM safety impacts from the research are considered robust) can impact the validity and usefulness of the RSPII framework results. Additional research on the rural roadway crash fatality impacts of LSIMs is proposed in Chapter 4.

The challenge related to using the proper safety measure in the RSPII framework is also amplified by the fact that the research documents being reviewed are not always specific enough to determine what the project evaluated. For example, the words "fatality" and "fatal crash" are often used interchangeably. As noted above, the data that describe these events are not the same and the impact of an LSIM on each may also vary. Another example of a lack of specificity in some LSIM-related documents includes the use of the terms "alcohol-related" and "alcohol-impaired" crashes and/or fatalities. These two types of crashes and/or related fatalities are defined differently and, if used in an evaluation may result in different LSIM impacts. In other cases the safety measure being considered for LSIM might also be restricted to drivers of a particular age (rather than all occupants or participants in an incident). All these distinctions are important when research results are being applied. More specific documentation also allows the research results to be applied in a more correct manner.

Availability of Data about Fatality Target Group

Another input required for the application of the RSPII framework is data that defines the fatality target group. The potential safety impact and fatality target group for each LSIM are generally defined by the research (See Chapter 2). The state-by-state application of the RSPII framework completed in this research, however, required the use of the FARS database. The collection of crash data from each state was outside the scope and budget of the project. In some cases, unfortunately, the data available in FARS for a particular fatality target group were not as easily available as expected. The rural fatality target group identified in the research may have been somewhat unusual, very finely defined, the result of what is typically an estimation process, or simply not a part of the generally available FARS database. The assumptions or generalizations used to address these particular issues typically involved using some type of estimation or approximation process (see Chapter 2 for a detailed description of the methods followed). Overall, however, it is expected that the use and application of more specific crash data (e.g., crash reports) available within an individual state may result in fewer RSPII framework assumptions and generalizations (along with better framework results). This type of application within individual states is recommended in Chapter 4.

Variability in LSIMs Applied

One of the steps in the RSPII framework includes the identification of the states expected to receive the majority of the benefits related to the implementation or update of the LSIM being considered. These are referred to in this document as the states with applicable "before" status. In theory, only those states that had LSIMs with the same characteristics as those evaluated in the safety impact research (used to complete Step 1 of the framework) would be included in this category. Unfortunately, there are LSIM characteristics that might impact the magnitude of its potential safety impact and not generally documented in research reports. A few of these characteristics include the wording of the legislation; program staffing, policy, administration and application; and levels of enforcement.

One of the challenges in the implementation of the RSPII framework was the variability in the LSIMs applied. One of the RSPII framework steps directly impacted by this variability is the identification of applicable "before" status states. However, the identification of all the characteristics of each LSIM that could potentially impact its safety improvement effectiveness and/or were different than the LSIMs evaluated in the research (used to complete Step 1 of the framework) was not within the scope of this project. In most cases, therefore, a generalization was required to identify the applicable "before" states for each LSIM. In some cases these states were defined in a manner similar to those suggested in NCHRP Report 622 and in other cases an attempt was made to identify the LSIM characteristics that influence whether or not a state would experience most of its safety impacts. The status of the LSIM programs or legislation in each state, if available, was acquired from various publications and websites.

It should be noted that this challenge is also directly related to the "variability in research results" described above. One potential source of this variability is the fact that any one type of LSIM (e.g., graduated driver licensing programs) could have a wide range of characteristics. There is a recommendation in Chapter 4 that each state should do its own application of the RSPII framework. As part of this application each states should make its own conclusions about whether it should be a "before" state.

LSIM FIELD APPLICATION CHALLENGES

There are two types of challenges that impact the validity and/or robustness of the RSPII framework results. The challenges connected to the appropriate application of the RSPII framework itself were discussed previously. The second type of challenge includes those encountered during the implementation of the six LSIMs considered within rural areas. Each of the LSIMs has challenges that are relatively unique. Some examples of this type of challenge might include the following:

- Completing seat belt use surveys to measure the impact of a primary seat belt law
- The need for exemptions to graduate licensing program requirements
- Selection of proper locations to initiate sobriety checkpoints and automated enforcement
- Motorcycle helmet use enforcement
- Cost of ignition interlock installation

These are just a few of the potential challenges that would need to be addressed in the implementation and/or enforcement of LSIMs within rural areas. Many others also exist. Overall, it should be noted, however, that the use of the RSPII framework generally assumes that any new LSIMs would be implemented and enforced as well as or better than the LSIMs evaluated in the research and used to define their safety impact (in Step 1 of the framework.

Overall, it has been concluded that the challenges related to the implementation and/or enforcement of LSIMs within rural areas are generally connected to two factors. First, the rural governmental agencies that would typically need to complete the activities related to an LSIM implementation also normally operate with limited resources. The essential resources that are typically limited in rural jurisdictions include staffing, physical equipment, and budgets. In fact, in many cases an individual staff member within a rural governmental agency might be required to complete tasks that are done by multiple people in larger metropolitan areas. The successful implementation and/or enforcement of an LSIM in a rural area will need to account for the inherently limited resources within this type of jurisdiction. This consideration is needed immediately after the installation and in the long-term. The costs of any additional resources for the short- and long-term application of an LSIM should be compared to the benefits it provides. It is also expected, however, that in some cases an LSIM will be enacted and/or required and additional resources will not be made available. This approach to the implementation of LSIMs will likely limit their application, enforcement, and effectiveness.

A second factor that impacts or challenges the implementation and/or enforcement of many LSIMs in a rural area is related to their physical layout. Rural jurisdictions have many miles of roadway that serve very few vehicles on a day-to-day basis. This large area of potential problem roadway segments makes the identification of locations that require the implementation and/or enforcement of many LSIMs very difficult. A systematic application and/or enforcement plan of LSIMs in rural areas may be necessary. In other words, if a certain safety-related characteristics exist along a particular roadway segment that can be addressed by an LSIM then it may need to be considered for implementation and/or enforcement at this location (and at those that are similar). The implementation and/or enforcement of LSIMs can also be done on a random basis, but the effectiveness of this method may not be very effective. In either case, the application and/or enforcement of LSIMs in rural jurisdictions will likely occur over a wide area and need to focus on a small population of drivers or vehicles. Overall, however, if appropriately applied and enforced, LSIMs in rural areas should be just as effective as those in urban areas.

SUMMARY OF POTENTIAL IMPACTS

The objective of this chapter was to introduce and describe some of the challenges that were encountered in the application of the proposed RSPII framework and would likely impede the field implementation of LSIMs in rural areas. The generalizations or assumptions that were used by the research team to overcome the challenges to the application of the RSPII framework were also described. Many of these challenges appear to be related to gaps in the LSIM research (i.e., the current state-of-the-knowledge) and what the inherent variability in the characteristics of LSIMs, their implementation, and/or their enforcement (e.g., primary seat belt use enforcement legislation varies and this impacts enforcement). In addition, it is generally assumed that the LSIMs evaluated in research projects for their potential safety impacts are not always “typical”. In other words, the research results in some cases may be an indication of what occurs with the “best” situations.

The assumptions and generalizations used to overcome the challenges to the application of the RSPII framework will impact the accuracy, usefulness, and robustness of its results. However, it should also be noted that it is unlikely (at least in the short-term) that these types of assumptions/generalizations could ever be completely removed. Assumptions/generalizations are often needed when state-by-state safety impact calculations are completed with data available nationally. The FARS database was used in this research project. More accurate estimates of LSIM safety impacts, however, might be completed if more specific state-level data (e.g., crash reports) and existing LSIM status were used. The application of the RSPII framework by individual states is recommended in Chapter 4 and would likely result in a more accurate calculation of LSIM impacts

The potential safety impact of an LSIM is also related to its implementation and/or enforcement of LSIMs within rural areas. However, there are a number of challenges to the effective and efficient completion of these tasks. The research used to apply the RSPII framework is generally based on LSIMs that have been well implemented, tracked closely, and/or enforced aggressively. These types of characteristics are not always true when an LSIM is actually applied in either an urban or rural area. In rural areas there is also the additional challenge of limited resources and the large amount of infrastructure (e.g., miles of roadway). These limited resources (e.g., people, funding, equipment, etc.) must be used to implement and/or enforce LSIMs over many high miles that serve low traffic volumes and small density of people. These challenges are generally inherent in the rural roadway environment, but they will need to be overcome for the potential safety improvements of an LSIM to be experienced. It is proposed that special approaches to "rural" LSIM applications and/or enforcement may need to be developed or considered to maximize their effectiveness. The creation of guidance documents about the special consideration related to the rural application of LSIMs is one of the recommendations in Chapter 4.

Overall, this chapter has discussed some of the challenges to the application of the RSPII framework and the implementation of the LSIMs in rural areas. This research project used the current state-of-the-knowledge with respect to LSIMs and was completed to show that these types of calculations could be done. The RSPII framework proposed (and NCHRP Report 622), along with the assumptions and generalizations described, is simply a tool that can be used to make these calculations (*4*). Additional research on LSIM characteristics and impacts, along with more accurate (e.g., state-level) data, will improve the outcome of the RSPII framework. These types of activities are recommended in the next chapter. The results in this research document should only be used as a general indicator of the impacts each LSIM could potentially have on the number of rural roadway fatalities in each state. More accurate estimates by each state are recommended in Chapter 4.

Chapter 4. Conclusions and Recommendations

CONCLUSIONS

The following conclusions are based on the results of the research project activities described in this document.

- This research project was completed in two phases. Phase I focused on the feasibility of a research-based rural safety policy improvement index (RSPII). It was determined that the RSPII was theoretically feasible, given the research available, and a framework for its application was developed. The report for the first phase of the project was published in May 2009 (*3*). Six "proven" legislatively-based safety improvement measures (LSIMs) were also selected in Phase I for consideration within the RSPII framework. Phase II of this project focused on the application of the RSPII framework and the challenges related to its use and the implementation of LSIMs in rural areas. The results of these activities are described in this report.

- The RSPII framework consists of six steps. These steps include 1) defining the potential safety impact of an LSIM, 2) determining the applicable fatality target group, 3) identifying states with applicable "before" status, 4) calculating the rural portion of the fatality target group for the selected 'before" states, 5) applying the potential safety impact to the rural portion of the fatality target group, and 6) presenting the results. The output from the first three steps of this framework should be based (as closely as possible) on the content of the currently available research or state-of-the-knowledge. The last three steps involve the use of the Fatality Analysis Reporting System (FARS), the application of the research, and the presentation of the results. The assumptions and generalizations needed to apply each step of the RSPII framework to the LSIMs considered in this research are documented in this report.

- The six LSIMs considered in Phase II of this project included the primary enforcement of seat belt use, universal motorcycle helmet use, regular application of sobriety checkpoints, graduated drivers licensing upgrades, mandatory ignition interlock installation, and automated speed enforcement. These six LSIMs were defined as "proven" in NCHRP Report 622 (*4*). In general, the authors of NCHRP Report 622 concluded that the positive safety impacts of these LSIMs are supported and quantified with high-quality research (*4*). The RSPII framework results for each of the LSIMs considered in this research are described below.

- The first LSIM considered with the RSPII framework was the enactment and enforcement of a primary seat belt enforcement law. The potential rural roadway crash fatality impacts of this LSIM were estimated. Existing research was used to estimate that a primary enforcement safety belt law would result in a reduction in fatalities of approximately 8 percent (*4*). The number of lives saved due to this LSIM was also calculated with the NTHSA BELTUSE software. The fatality target group used for this LSIM focused on rural unbelted front seat vehicle occupant fatalities ($\geq$ 13 years old). In mid-2008 it was determined that 24 states met the applicable "before" status criteria for this LSIM. Overall, it was estimated the primary enforcement of seat belt use could reduce the number of rural roadway crash fatalities 209.

- The second LSIM considered with the RSPII framework was the enactment and enforcement of a universal motorcycle helmet use law. Existing research was used, along with NCHRP Report 622, to estimate that a 20 percent reduction in motorcyclist fatalities would be expected due to this LSIM (*4*, *8*). Rural motorcyclist fatalities were considered the fatality target group for this LSIM. In mid-2008 it was determined that 30 states did not have a universal motorcycle helmet law and were applicable "before" states for this LSIM. The number of lives saved (using a NTHSA estimation process) due to the universal use of motorcycle helmets was calculated and the 20 percent reduction in motorcycle fatalities noted above was applied. It was estimated that this LSIM could result in a reduction of 299 rural motorcyclist fatalities.

- The third LSIM considered with the RSPII framework was the regular application of sobriety checkpoints. Existing research on this topic, along with NCHRP Report 622, was used to estimate that a 20 percent reduction in alcohol-impaired fatalities (the selected fatality target group) might be expected with the effective application of this LSIM (*4*, *15*). It was also concluded that the applicable "before" states for this LSIM should be those that the literature indicated did not conduct sobriety checkpoints at least once or twice a month (*12*). Overall, there were 14 states that were included in this group and it was estimated that the regular application of sobriety checkpoints could potentially produce a reduction of 322 rural alcohol-impaired crash fatalities. It should be noted that if the frequency of sobriety checkpoint use in a state was unknown it was dropped from further consideration. In addition, the number of alcohol-impaired fatalities in the United States is estimated by NHTSA because only a portion of drivers are tested. These estimates, along with the FARS database, were used to approximate the number of rural alcohol-impaired fatalities in this study.

- The fourth LSIM considered within the RSPII framework was upgrades to graduated driver licensing programs. In this case, the research results from two studies were primarily applied because the NCHPR Report 622 suggestions for the implementation and impact of three-stage GDL programs was not considered adequate (*4*, *22*, *23*). The first study included a calculation in the reduction of 16-year old driver fatal and injury crash rates for GDL programs with a different number of components (e.g., 5 of 7 components, 4 components, and 3 or fewer components) (*22*). The second study considered the potential safety impacts of GDL programs with different IIHS ratings (e.g., good, fair, and marginal). This study focused reductions in 15- to 17-year old driver fatalities (*23*). It should be noted that these two studies focus on different fatality target groups and their results need to be applied to states with a range of components and/or IIHS ratings. The study based on the number of GDL program components was more recent and chosen as the preferred approach. Overall, it was determined that rural roadway crash fatalities that involve a 16-year old driver might be reduced by 120 if the GDL programs in 38 states were increased to at least 5 components.

- The fifth LSIM considered within the RSPII framework was the mandatory installation of ignition interlocks. The research on this subject area that was summarized in NCHRP Report 622 indicates that the application of this LSIM could reduce recidivism among alcohol-impaired drivers by 37 to 90 percent (*4*, *25, 26*). NCHRP Report 622 proposes that the 37 percent reduction could be applied to the number of alcohol-related crash fatalities involving a driver with a previous DWI conviction. This approach to estimating the safety impact of this LSIM, however, assumes a one-to-one ratio between recidivism and crash fatalities. Therefore, for comparison purposes only, reductions of 25, 37, and 50 percent were considered. Similar to the approach used for the sobriety checkpoint LSIM, the fatality target group (i.e., alcohol-related crash fatalities involving a driver with a previous DWI conviction) also needed to be approximated based on the estimates of alcohol-related crash fatalities from NHTSA and the content of the FARS database. A range of potential fatality reductions was calculated for the 40 applicable "before" states. In mid-2008 these states do not mandate ignition interlock installation after a driver was convicted of his/her first DWI. The application of a 37 percent reduction (proposed by NCHRP Report 622) resulted in an estimated reduction of 268 rural alcohol-related fatalities involving a driver with a previous DWI conviction.

- The sixth LSIM considered within the RSPII framework was the application of automated speed enforcement. The current use of automated speed enforcement in the Untied States, however, is very limited. In fact, all 50 states were considered to have an applicable "before" status for this LSIM. Not surprisingly, the literature available about the crash reduction impacts of this LSIM generally focuses on international applications (*4*, *34*, *35*, *36*). NCHRP Report 622 proposes the application of a 20 percent reduction to estimate the impact of automated speed enforcement on speed-related crash fatalities (*4*). In this research a similar reduction was also applied to half this fatality target group. This approach was followed because the speed-related fatality data in FARS is generally connected to multiple contributing factors, but speed may not be the primary cause of the incident. The application of the safety impact research results to half the fatality target group was simply considered a conservative (and possibly more appropriate) estimate of the potential safety improvements that could result from automated speed enforcement. Overall, this approach estimated that 699 rural roadway speed-related crash fatalities might be avoided if automated speed enforcement was systematically applied in the United States.

- The fatality reduction results presented in this report should be used to initiate discussions about the impact LSIMs could have on rural roadway safety. The application of the proposed RSPII framework within each state should have access to more accurate crash data and also require fewer assumptions and generalizations. Any application of the proposed RSPII framework, however, would still need to overcome several challenges. In Chapter 3 some of the challenges to the application of the RSPII framework are noted. These challenges are primarily related to gaps in the current state-of-the-knowledge with respect to LSIM impacts and the inherent variability in the characteristics of LSIMs, their implementation, and/or their enforcement. The challenges related to the implementation of LSIMs in rural areas, on the other hand, are generally connected to a lack of resources (e.g., staff, funding, etc.) and the need to apply these measures over a wide physical area. The application of any assumptions or generalizations, of course, will impact the validity, accuracy, and robustness of the RSPII framework results. The results in this report should only be used as a starting point for more detailed analysis (if determined to be appropriate) in each state.

RECOMMENDATIONS

The following recommendations focus on the use of and improvement to the research results described in this document.

- It is recommended that the RSPII framework results included in this document only be used to initiate further discussion and activities (if considered necessary) within each state that focus on the estimation and evaluation of the potential rural roadway safety impacts due to LSIMs. The national state-by-state RSPII framework application documented in this report required the use of the FARS database (and a focus on fatalities) and a number of assumptions and generalizations. The availability and use of more specific crash data within each state should allow a more comprehensive safety impact evaluation (e.g., fatalities, injuries, and crashes) and some of the assumptions/generalizations applied in this research may no longer be necessary. This type of approach should result in a more accurate and valid statewide RSPII framework results. Overall, the results provided in this document should only be considered gross approximations until more specific statewide calculations are completed.

- It is recommended that additional and more comprehensive research be completed on the potential safety impacts of the six LSIMs considered in this project (and many of the others listed in NCHRP Report 622) (*4*). For example, additional research that quantifies the fatal, injury, and/or crash impacts due to mandatory ignition interlock installation is needed. An assumption was necessary to apply this LSIM within the RSPII framework. The other assumptions and generalizations described in this report could also be addressed in a similar manner. Some of the recommended characteristics of more comprehensive LSIM research are listed below.

    - The incorporation (as appropriate) and use of generally accepted statistical analyses that approximate those expected when crash data is evaluated with respect to engineering safety improvements. These methodologies are generally common knowledge and will likely be discussed in the upcoming American Association of State Highway and Transportation Officials (AASHTO) *Highway Safety Manual*. The wide range of potential safety impacts that sometimes exists for some LSIMs could be the result of their inherent variability and/or the different analyses used to evaluate them.

    - The documentation of all LSIM characteristics and factors that might impact the reported research results and/or the implementation of the LSIMs in the field.

- ➢ The differentiation of potential rural and urban roadway safety impacts due to an LSIM. None of the research documented considered in this project for the six LSIMs appeared to focus on this difference. The rural application of many LSIMs can have many challenges. If effectively implemented, however, they might have more impact than in urban areas. Research is needed to quantify any differences between rural and urban applications. The development of guidance documents for the implementation of LSIMs in rural areas would also be desirable.

- ➢ The consideration of potential safety impacts defined by various measures. For example, the potential impacts of LSIMs could be evaluated, if appropriate, using fatal, injury, and property damage crash data. It is also important to differentiate, in the research documentation, between the number of crashes and the severity of those crashes (e.g., fatal crashes and crash fatalities).

- ➢ Research projects that focus on the details or factors that may impact the effectiveness of an LSIM. These factors will vary by LSIM. For example, it would be of interest to determine what the difference is in the safety impacts of primary seat belt laws that focus only on front seat vehicle occupants and those that apply to vehicle occupants of any age and in all seat locations. In other cases, the rural and/or fatality impacts of an LSIM may still need to be evaluated and defined more specifically.

- It is recommended that the process in this document (and NCHRP Report 622) be systematically applied, as needed, to quantitatively estimate the potential safety impacts of behavioral highway safety countermeasures (e.g., LSIMs) and plan for their rural and/or urban implementation. The RSPII framework or NCHRP Report 622 procedures, however, should be applied with a complete recognition of the robustness of the research being used and how that impacts the validity of the application results (*4*). Additional details about the research used would be desirable in this document and NCHRP Report 622 (*4*). This information would allow a more confident application of the proposed RSPII framework or NCHRP Report 622 procedures (*4*). In fact, during the application of the processes, the factors that could impact the validity their outcomes need to be thoroughly understood by the practitioner in order to adequately defend the results. Documenting this level of detail about each of the research projects used in this study, however, was beyond its scope. It is recommended, therefore, that a website be developed that provides and rates this type of critical information and the safety impact results of the applicable LSIM research. A similar website exists for the crash modification factors of infrastructure-related safety improvement measures.

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