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The Effectiveness of Daytime Running Lights For Passenger Vehicles

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16. Abstract

The analysis evaluates the effects of daytime running lights (DRLs) against three types of target crashes: (1) two-passenger-vehicle crashes excluding rear-end crashes, (2) single-passenger-vehicle to pedestrians/cyclists crashes, and (3) single-passenger-vehicle to motorcycle crashes. Each crash type was examined at three crash severity levels – fatal, injury, and all severity. The basic approach is a control-comparison analysis of real-world crash involvements for DRL-equipped vehicles and non-DRL vehicles. Ratio of odds ratios were used to derive the DRL effects. A 95-percent confidence interval was used to infer statistically significant conclusions. The Fatality Analysis Reporting System and the State Data System were the crash data sources used for this analysis.

The analysis found that DRLs have no statistically significant overall effects on the three target crashes. When combining these three target crashes into one target crash, the DRL effects were also not statistically significant. When examined separately for passenger cars and light trucks/vans (LTVs), DRLs in LTVs significantly reduced LTVs' involvements in the target two-vehicle crashes by 5.7 percent. However, the remaining DRL effects on these three target crashes were not statistically significant. Although not statistically significant, DRLs might have unintended consequences for pedestrians and motorcyclists. Particularly, the estimated negative effects for LTVs were relatively large and cannot be completely ignored.

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TABLE OF CONTENTS

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The report estimates the effectiveness of daytime running lights (DRLs) against three daytime crashes: single-passenger-vehicle-to-pedestrian/pedalcyclist crashes, single-passenger-vehicle-to-motorcycle crashes, and two-passenger-vehicle crashes excluding rear-end crashes. Currently, the National Highway Traffic Safety Administration (NHTSA) is in the rulemaking process in response to General Motor's (GM) petition to mandate DRLs. This report will affect the rulemaking decision. Therefore, the report is considered to contain "highly influential scientific information" as defined in the Office of Management and Budget's (OMB) "Final Information Quality Bulletin for Peer Review" (available at www.whitehouse.gov/omb/inforeg/peer2004/peer_bulletin.pdf). In accordance with the requirements of Sections II and III of OMB's Bulletin, the report had to be peer-reviewed.

The three reviewers were selected by NHTSA staff. They volunteered their services for reviewing the report. They assessed the scientific adequacy of the draft report and identified weaknesses in order for NHTSA to be able to strengthen the report. The publication of the report does not necessarily imply that the reviewers supported or concurred with its findings. You may access their comments, the agency's responses to their comments, and the entire report in the NHTSA docket (Number NHTSA-2008-0153) at http://dms.dot.gov. The agency has tried to address all of the comments in the final version of the report. The text and footnotes of the report single out some of the reviewers' comments that instigated additions or revisions to the analyses.

EXECUTIVE SUMMARY

This is the third statistical analysis conducted by the National Highway Traffic Safety Administration (NHTSA) to evaluate the effectiveness of daytime running lights (DRLs) for passenger vehicles (PVs) which included passenger cars (PCs) and light trucks and vans (LTVs). The main focus of the analysis is to assess the DRL effects in a more current traffic environment. Specifically, the analysis examined the DRL effects against three daytime target crashes: (1) two-PV crashes excluding rear-end crashes, (2) single-PV-to-pedestrian/pedalcyclist crashes, and (3) single-PV-to-motorcycle crashes. Each of the target crashes were examined at three severity levels: fatal, injury, and all severity. In addition, the analysis examined the potential effects of headlamps during dawn and dusk conditions by estimating the effects of DRLs under two daytime definitions, one including dawn and dusk and the second excluding dawn and dusk.

Study Design

The basic study design is a control-comparison method that compares the crash involvement of DRL-equipped vehicles with that of non-DRL vehicles. The control-comparison method categorizes crashes into control crashes and comparison crashes (or target crashes). The control crashes are single-vehicle crashes excluding pedestrians/pedalcyclists. The target crashes are the three crash types mentioned above. The method is similar to the method used in previous studies. However, other than crash sources used, there are some differences between this analysis and the previous studies:

(a) The analysis compares specific make models of PCs and LTVs with DRLs versus earlier versions of identical make models, as opposed to all DRL-equipped make models versus all non-DRL make model vehicles adopted in the second study.
(b) The analysis chooses ratio of odds ratios, in lieu of simple odds used in previous studies, as the primary statistic to estimate the magnitude of DRL effects.

The purpose of selecting matched vehicle models is to control vehicle-specific factors so that the presence and absence of DRL would be the only difference between DRL and non-DRL vehicles. This reduced the likelihood of DRL effects being influenced by vehicle variations within the same models of DRL and non-DRL vehicles. Antilock brake systems (ABS), for example, have been proven to reduce crashes. If ABS was introduced at the time that coincided with the implementation of DRLs, it might increase the apparent effects of DRL.

Ratio of odds ratios was chosen over simple odds for its relatively high sensitivity to sample size and the additional level of control for confounding factors. Prior studies had demonstrated that DRL effects were very sensitive to the statistics used to measure the effects. Compared to simple odds, ratio of odds ratios has a stronger confounding-factor-control ability and produces relatively more conservative estimates. The derived estimates based on ratio of odds ratios, if found statistically significant, would be more defendable. Therefore, all the conclusions of this analysis were based solely on ratio of odds ratios.

Data Sources

Two police-reported crash sources maintained by NHTSA were used for the analysis. Fatality Analysis Reporting System (FARS) data from 2000 to 2005 were used for assessing the effectiveness of DRLs against target fatal crashes. The State Data Systems were used for estimating the DRL effectiveness against target injury crashes and all crashes. Nine States with a relatively high percentage of known Vehicle Identification Numbers (VIN) and with the most current available years of data were selected for analysis. The States and the corresponding years of data used for analysis were: Florida (2000-2004), Illinois (2000-2003), Maryland (2000-2004), Michigan (2004-2005), Missouri (2000-2005), Nebraska (2000-2004), Pennsylvania (2000-2001, 2003-2005), Utah (2000-2004), and Wisconsin (2000-2003).

Summary of Results

Two sets of effectiveness are presented here. Each corresponds to a daytime classification based on the light conditions during which crashes occurred. The first set of effectiveness corresponds to daytime defined as a condition that included daylight, dawn, and dusk. The second set of results is for daytime excluding dawn and dusk. Presenting these two sets of results addresses the concern that headlamp effects might be mixed with the DRL effects. During dawn and dusk conditions, headlamps might be turned on and they could contribute to crash reductions along with DRLs. However, real-world crash data did not report headlamp on/off status. As a result, the analysis is unable to directly isolate the headlamp effects. Instead, the analysis provides these two sets of effectiveness rates and examines the impacts of DRL when dawn and dusk conditions are included and when they are excluded.

For each of the target crashes, effectiveness is derived for three crash severity levels: fatal, injury, and all crashes. Injury crashes included fatal crashes. All crashes included fatal, injury, and property-damage-only crashes. A positive effectiveness suggests that DRLs would reduce target crashes. A negative effectiveness suggests that DRLs might have unintended adverse effects. The DRLs effects for injury crashes and all crashes were the combined effects of nine States. Boldfaced numbers are statistically significant estimates at the 0.05 level.

Including Dawn and Dusk

Two-Passenger-Vehicle Crashes Excluding Rear-End Crashes (Target Two-PV Crashes)

- The following shows the effectiveness of DRLs against the daytime target Two-PV crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-8.9	13.8	0.7
Injury Crashes	2.3	8.2	3.9
All Crashes	-2.0	**5.7**	0.3

- DRLs significantly reduced the LTVs' involvement in daytime target Two-PV crashes by 5.7 percent at the 0.05 level.
- The remaining results were not statistically significant at the 0.05 level.
- For PCs, there was no consistent pattern indicating whether DRLs would reduce PCs' involvement in daytime target Two-PV crashes. As shown, DRLs seemed to reduce PCs' involvement in target Two-PV injury crashes but increase its involvements in target Two-PV fatal and all crashes.
- For LTVs, DRL effects were progressively higher with crash severity and the effects were all positive. It seems that DRLs were more likely to reduce LTV involvements in daytime target Two-PV crashes.
- For PCs and LTVs combined, DRLs would reduce the target Two-PV injury crashes by 3.9 percent. DRLs had almost no effect on daytime target Two-PV fatal crashes and all crashes. These estimated effects were not statistically significant.

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist Crashes (Single-PV-to-PED/CYC)

- The following shows the effectiveness of DRLs against daytime Single-PV-to-PED/CYC crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	19.1	-2.3	0.1
Injury Crashes	2.0	-13.1	-1.7
All Crashes	-1.6	-12.8	-4.3

- None of the results were statistically significant at the 0.05 level.
- Although not statistically significant, DRLs in cars were more likely to reduce daytime Single-PC-to-PED/CYC fatal and injury crashes. In contrast, DRLs in LTVs seemed to have an unintended consequence against single-LTV crashes involving pedestrians and pedalcyclists. The large negative effects, although not statistically significant, cannot be totally ignored.
- For PCs and LTVs combined, DRLs seemed to have no effect on Single-PV-to-PED/CYC fatal crashes. However, DRLs seemed to have a negative impact on single-vehicle injury and all crashes involving pedestrians and pedalcyclists.

Single-Passenger-Vehicle-to-Motorcycle Crashes (Single-PV-to-Motorcycle)

- The following shows the effectiveness of DRLs against daytime Single-PV-to-Motorcycle crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-4.4	-15.1	-7.5
Injury Crashes	5.8	-22.6	-0.5
All Crashes	1.2	-12.2	-1.9

- All the results were not statistically significant.
- There was greater degree of uncertainty in the effects of DRLs on daytime Single-PV-to-Motorcycle crashes since the crash sizes were relatively small compared to other target crashes.
- For fatal crashes, effectiveness of DRLs for both PCs and LTVs were negative. It seemed that DRLs were more likely to increase daytime fatal target motorcycle crashes.
- For PCs, DRLs seemed to reduce daytime Single-PC-to-Motorcycle injury and all crashes. However, for LTVs, DRLs seemed to have adverse effects on daytime Single-LTV-to-Motorcycle crashes. These negative effects were not statistically significant. However, these effects were relatively large and raised concerns regarding possible adverse effects on motorcycle riders.
- Overall, DRLs seemed to increase daytime Single-PV-to-Motorcycle crashes.

All Target Crashes Combined

- The following shows the effectiveness of DRLs against all three daytime target crashes combined:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-2.1	9.7	2.9
Injury Crashes	2.3	6.1	3.3
All Crashes	-2.0	5.1	0.1

- The target Two-PV crashes comprised the vast majority of the combined crash sample. Thus, the effects of DRLs for the combined target crashes and related statistical conclusions were similar to those presented for the target Two-PV crashes.
- DRLs seemed to reduce the LTVs' involvement in daytime target crashes by 5.1 percent. The effect was borderline statistically significant at the 0.05 level.
- The remaining results were not statistically significant at the 0.05 level.
- DRLs seemed more likely to reduce daytime target fatal and injury crashes.
- However, DRLs would have no overall effects on all daytime target crashes. All crashes included fatal, injury, and property-damage-only crashes (PDO). Note that all crashes were mostly PDO crashes.

<u>Excluding Dawn and Dusk</u>

As expected, the exclusion of dawn and dusk conditions had a negligible influence on the DRL effectiveness. Consequently, the magnitude of the DRL effects and statistical conclusions are very similar to those presented in the previous section. Generally, there were no discernable trends as to whether the exclusion of dawn and dusk conditions diminished the overall DRL effects on daytime target Two-PV crashes. However, for Single-PV-to-PED/CYC crashes and Single-PV-to-Motorcycle crashes, the effects of DRL were slightly diminished when dawn and dusk were not considered. All estimated effects were not statistically significant.

Target Two-PV Crashes

- The following shows the effectiveness of DRLs against the daytime target Two-PV crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-9.3	15.2	1.2
Injury Crashes	2.7	8.7	4.4
All Crashes	-2.5	4.5	-0.5

- All the results were not statistically significant.

Single-PV-to-PED/CYC Crashes

- The following shows the effectiveness of DRLs against Single-PV-to-PED/CYC crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	16.4	-3.4	0.1
Injury Crashes	1.9	-14.1	-2.0
All Crashes	-2.4	-15.7	-5.6

- All results were not statistically significant.

Single-PV-to-Motorcycle Crashes

- The following shows the effectiveness of DRLs against daytime Single-PV-to-Motorcycle crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-9.4	-17.3	-11.4
Injury Crashes	3.7	-24.5	-2.5
All Crashes	-1.2	-17.3	-5.0

- All the results were not statistically significant.

All Target Crashes Combined

- The following shows the effectiveness of DRLs against all three daytime target crashes combined:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-3.1	10.8	2.8
Injury Crashes	2.6	6.5	3.7
All Crashes	-2.5	3.8	-0.7

- All the results were not statistically significant.

CHAPTER 1. INTRODUCTION

This is the third statistical analysis NHTSA has conducted to evaluate the effects of daytime running lights (DRLs) for passenger vehicles. Passenger vehicles included passenger cars (PCs) and light trucks and vans (LTVs). Previously, NHTSA's studies[1] used two different statistics, ratio of odds ratios and simple odds, to estimate the main effects of DRLs. However, the derived results specifically for two-vehicle opposite/angle crashes where DRLs were assumed to have a greater impact indicated contradictory conclusions. Prior studies validated by NHTSA's two studies showed that DRL effects were very sensitive to the statistics used. Compared to simple odds, ratio of odds ratios has a stronger confounding-factor-control ability and produces relatively conservative results. With these characteristics, results based on ratios of odds ratios are considered to be more defendable than those derived from simple odds. Therefore, the focus of this analysis is to reexamine the effects of DRLs under the most current traffic environment based on the ratio of odds ratios measurement. All of the conclusions derived from this analysis were solely based on that statistic. A detailed description of this statistic is provided in the Methodology chapter (Chapter 2). Note that this analysis does not intend to estimate the novelty and intrinsic effects of DRLs to determine whether the increase in DRLs on the road would gradually diminish the DRL effects or impair the conspicuity of pedestrians, pedalcyclists, and motorcyclists. Concerns have been raised about DRLs obscuring the conspicuity of motorcyclists (whose motorcycle lights are on all the time). A timeline trend analysis would be more appropriate for this type of analysis. It is beyond the scope of this analysis.

DRLs were intended to improve the noticeability and detectability of a vehicle during daylight by providing enough light to contrast the vehicle from its background. In 1972, Finland was the first country to mandate DRLs for four-wheel motor vehicles, but the law was only applicable during five months in the winter. Later on in 1997 Finland gradually extended their DRL law to cover the entire year and all roads. Currently, a total of 18 countries have made DRLs mandatory for four-wheel motor vehicles but with various implementation strategies (e.g., applicable to certain months or specific types of roadways). Two recent reports commissioned by the European Union (EU) provided a comprehensive assessment of DRL legislation and DRL activities worldwide.[2] [3] [4] The following briefly summarizes DRL legislation based on these EU reports:

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[1] (a) Tessmer, J.M. (2000). A Preliminary Assessment of the Crash-Reducing Effectiveness of Passenger Car Daytime Running Lamps (DRLs) (DOT HS 808 645).

(b) Tessmer, J. (2005). An Assessment of Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs) (DOT HS 809 760).

[2] TNO. (2003). Daytime Running Lights, Deliverable Report 3: Final Report, TNO Human Factors, Contract Number: ETU/B27020B-E3-2002-DRL-S07.18830 (TREN/E3/27-2002).

[3] Commandeur, J. (2004). State of the Art with Respect to Implementation of Daytime Running Lights (R-2003-28). SWOV Institute for Road Safety Research.

[4] Saving Lives with Daytime running lights (DRL), (2006). A Consultation Paper, European Commission, Directorate General for Energy and Transport, DG TREN E3.

- Finland (effective year 1997[5]), Sweden (1977), Norway (1985), Iceland (1998), Denmark (1990), Austria (no information on effective date), Estonia (no information on effective date), Latvia (no information on effective date) and Slovenia (no information on effective date) required DRLs to be on the entire year and on all roadways.
- Hungary (1993), Italy (2002), and Portugal (no information on effective date) also required DRLs to be on the entire year, but the requirement was only applicable to rural or indicated roadways.
- Czech Republic (2001), Lithuanian (no information on effective date), Poland (1991), and Slovakia (no information on effective date) required DRLs to be on during the winter months on all roadways.
- Israel (1996) required DRLs to be on only during winter and only on rural roadways.
- Canada required all new passenger cars manufactured after December 1, 1989, to be equipped with DRLs. In practice, the Canadian's DRL legislation applied year round and on all roadways.

In Europe and Israel, DRL laws are considered to be behavior-based standards that require drivers to turn lights (i.e., headlamps) on during applicable time periods. These behavior-based implementation strategies are different from the technology-based DRL standards that are implemented in Canada and the United States.
The United States does not require DRLs. But, if voluntarily equipped, DRLs are required to comply with the requirements specified in Federal Motor Vehicle Safety Standard (FMVSS) No. 108, "Lamps, Reflective Devices, and Associated Equipment." The provision covering the voluntary installation of DRLs in passenger vehicles was incorporated into FMVSS No. 108 in January 1993 in response to a General Motors (GM) petition to permit, but not require, DRLs.[6] The DRL performance requirements resolve conflicts among State laws that inadvertently prohibited certain forms of daytime running lights and harmonizing with Canadian DRL requirements.

The 1993 FMVSS No. 108 final rule limits the maximum light intensity output of DRLs to 7,000 candela. The 7,000 candela is about one-tenth the intensity of a standard high-beam headlamp and is equivalent to the maximum intensity output allowable in Canada. NHTSA received numerous complaints regarding DRL glare, prompting the administration to issue a Notice of Proposed Rulemaking (NPRM) in 1998 to address the glare concerns.

In the 1998 NPRM[7], NHTSA proposed to gradually reduce the DRL intensity output of passenger vehicles from 7,000 to 1,500 candela through three phases. In Phase 1, the maximum intensity output would be required to be reduced to 3,000 candela for DRLs utilizing the high headlamp beam, starting one year after publication of the final rule. In Phase 2, the maximum intensity output would be reduced to 3,000 candela for DRLs utilizing low headlamp beams,

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[5] DRLs were first required in 1972 during five winter months, extended to seven months in 1973, extended further to the entire year but outside built-up areas in 1982, and to all roads for the whole year in 1997.

[6] DOT Docket Number 87-6; Notice 5

[7] DOT Docket Number NHTSA 98-4124; Notice 1

starting two years after publication of the final rule. In Phase 3, the maximum intensity output would be reduced to 1,500 candela for all DRLs, starting four years after publication of the final rule. NHTSA rescinded the NPRM in 2004, deciding that DRL glare and many other interrelated issues surrounding DRLs would be addressed in the context of responding to GM's 2001 petition to mandate DRLs on new vehicles.[8]

In addition to glare, there are concerns that DRLs might make motorcycles, pedestrians, and pedalcyclists less conspicuous and that DRLs would increase fuel consumption and have an adverse impact on the environment.

DRL Installation in the U.S.

After amending FMVSS No. 108 to allow the installation of DRLs in 1993, GM began to install DRLs on selected 1995 model year vehicles. By the 1997 model year, all GM vehicles had DRLs as standard equipment. Volvo, Volkswagen, and Saab introduced DRLs into the U.S. market beginning with 1995 models. These DRLs included reduced intensity high beam, reduced intensity low beam, reduced intensity high-low beam, turn-signal-based, dedicated lamp, and full intensity low beam. Recently, more manufacturers have also chosen to install DRLs in their vehicles. Toyota installed DRLs as standard or optional equipment with certain models, and with a driver-controllable on-off switch beginning with the 1988 Corolla. Lexus installed high-beam or turn-signal-based DRLs on all U.S. models beginning with the 1999 model year. Subaru equipped the Legacy with DRLs beginning with the 2000 model year and the Impreza with 2002 models. Honda equipped the Accord and Civic with DRLs as standard equipment starting with the 2006 model year.

Based on available R. L. Polk vehicle registration data and DRL installation information, NHTSA estimated that about 27 percent of 2005 model year vehicles had DRLs as standard equipment compared to 4 percent for 1995 model year vehicles. The big increase in DRL installation was between 1995 and 1996 and between1996 and 1997 model year vehicles. Afterward, the rate remained fairly consistent and did not vary significantly. Table 1-1 shows the estimated percentage of passenger vehicles equipped with DRLs by vehicle type and vehicle model year. Note that DRL installations are expected to be higher for 2006 and newer model year vehicles since Toyota and Honda continue to increase DRL installation in their model lines.

[8] DOT Docket Number NHTSA 2004-17243

Table 1-1
Estimated Percentage of New Model Year Passenger Vehicles Equipped With DRLs

	Model Year										
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
PC	4.0	21.3	31.1	33.2	34.9	31.5	28.5	26.4	24.3	26.2	24.6
LTV	3.9	21.8	28.2	28.3	29.4	29.5	26.1	30.8	31.8	29.1	29.6
All	4.0	21.5	29.8	31.0	32.4	30.6	27.4	28.6	28.1	27.8	27.2

Data Source: R. L. Polk vehicle registration

Table 1-2 shows the estimated percentage of on-road passenger vehicles (i.e., all registered vehicles) equipped with DRLs by calendar year from 1995 to 2005. As shown, about 18 percent of on-road passenger vehicles had DRLs in 2005 compared to merely 0.3 percent in 1995.

Table 1-2
Estimated Percentage of On-road Passenger Vehicles Equipped With DRLs by Calendar Year

	Calendar Year										
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
PC	0.2	1.6	3.4	5.6	7.9	10.0	11.8	13.3	14.5	15.6	16.5
LTV	0.3	2.1	4.8	7.6	10.2	12.6	14.3	16.4	18.0	19.4	20.6
All	0.3	1.8	3.8	6.3	8.7	10.9	12.8	14.5	15.9	17.1	18.2

Data Source: R. L. Polk vehicle registration

International Studies of DRL Effectiveness

Since the 1970s, numerous scientific studies have been conducted in Europe, Canada, and the United States to evaluate the effects of DRLs. Studies from Europe and Canada were generally pre- and post-law studies. DRLs are not required in the United States, thus all studies in the United States were vehicle-fleet-based control-comparison analyses. In addition, DRL laws in Europe are behavior-based standards which are different from the technology-based DRL requirements implemented in the United States and Canada. Therefore, DRLs in European studies, especially in the early ones, generally represent the concept of turning lights (i.e., headlamps) on during daytime hours. In contrast, DRLs in U.S. studies represent dedicated lamps which were automatically turned on with vehicle engines.

A majority of the European studies consistently found that a DRL law was associated with a reduction in crashes. The effects varied from 4 percent to 27 percent depending on crash type, crash severity, season, roadway conditions, and light conditions. The DRL effects found in the U.S. studies were less consistent and more uncertain.

The following summarizes the international studies on DRL effects. Many studies already provided an extensive literature review of DRL effectiveness.[9][10][11] The summary incorporated many of the conclusions from these reviews. Note that the summary here serves only as a reference in assessing DRL global effects. It is not meant to be comprehensive.

European Studies

A 1976 study in Finland found that DRLs would reduce daytime multi-vehicle crashes and pedestrian/pedalcyclist crashes on rural roads by 21 percent.[12] A 1981 study in Sweden based on two years pre-law and two years post-law data concluded that the DRL law would reduce daytime crashes by 11 percent, pedestrian/cyclist crashes by 17 percent, and bicycle/moped crashes by 21 percent.[13] In Norway, a 1993 study by Elvik[14] found that DRLs would reduce daytime multi-vehicle crashes by 15 percent in the summer. However, the same study found that DRLs had no effects on multi-vehicle crashes in the winter. Also, there was no effect on crashes involving pedestrians or motorcyclists. None of the results were statistically significant.

Two studies in 1993 and 1995 evaluating Denmark's 1990 DRL law showed consistent results. These studies concluded that two years after enactment of the law, DRLs reduced daytime multiple-vehicle crashes by 6 to 7 percent, and reduced motor-vehicle-to-pedalcyclist crashes by 4 percent. However, the second study also showed that DRLs significantly increased motor vehicle-to-pedestrian crashes by 16 percent.[15][16]

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[9] Elvik, R., Christensen, P., and Olsen, S. (2004). Daytime Running Lights Interim Report 2: A Systematic Review of Effects on Road Safety (TOI Report 668/2003). TOI, Norway.

[10] Perlot, A. and Prower, S. (2003). Review of the Evidence for Motorcycle and Motorcar Daytime Lights. Federation of European Motorcyclists' Association and British Motorcyclists Federation.

[11] Tessmer, J. (2005). An Assessment of Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs) (DOT HS 809 760).

[12] Andersson, K., Nilsson, G., and Salusjarvi, M. (1976). The effect of recommended and compulsory use of vehicle lights on road accidents in Finland (Report 102A). Linkoping, Sweden: National Road and Traffic Research Institute.

[13] Andersson, K., and Nilsson, G. (1981). The effect on accidents of compulsory use of running lights during daylight hours in Sweden, Report 208A. Linkoping, Sweden: National Road and Traffic Research Institute.

[14] Elvik, R. (1993). The effects of accidents of compulsory use of daytime running lights for cars in Norway. *Accident Analysis and Prevention 25*(4), 383-398.

[15] Hansen, L. K. (1993). Daytime running lights in Denmark – Evaluation of the safety effect, Copenhagen: Danish Council of Road Safety Research.

[16] Hansen, L. K. (1994). Daytime running lights: Experience with compulsory use in Denmark. Fersi Conference, Lille.

A 1995 Hungarian study by Hollo[17] estimated that DRLs reduced the rural daytime "frontal and cross traffic" crashes by 7 to 8 percent. However, the effect might be biased upward since it was mixed with the effects from other confounding factors such as speed limit reduction, stricter seat belt laws, increased police patrols, higher fines, and increased public awareness of traffic-related issues.

More recently, a 2004 report by Elvik et al.[18] provided a comprehensive review of 25 studies on DRL effects on cars and summarized the overall DRL effects by a meta-analysis technique. The report concluded that DRLs for cars would reduce 5 to 10 percent of daytime multi-party crashes. The reduction is lower than the 10 to 15 percent derived by Elvik's 1996 analysis. Although the 2004 report stated that the relationship between the DRL effects and crash severity was rather weak, the report assumed a 15-percent reduction for fatal multi-party crashes, a 10-percent reduction for serious injury crashes, a 5-percent reduction for slight injury crashes, and no effects for property-damage-only crashes for a further cost-benefit analysis. The progression of effects and the size of the effects were disputed by a TRL[19] study, which suggested that DRLs would reduce all injury crashes by 3.9 to 5.9 percent. The TRL study suggested that a mean effect of 5 percent for all injury crashes is more plausible.

Studies from these countries provided substantial evidence that DRLs would reduce crashes however not without concerns. Commonly raised concerns were that DRLs might have adverse effects on the conspicuity of pedestrians, pedalcyclists, and motorcycles and DRLs might increase fuel consumption and have an adverse impact on the environment.

Canadian Studies

Sparks' 1993 study[20] which examined Canadian government fleet data found that DRLs reduced twilight, two-vehicle crashes by 15 percent. The effect was statistically significant. Two reports produced by Transport Canada also showed positive DRL effects. Of these, Arora et al.[21] concluded in 1994 that DRLs significantly reduced daytime two-vehicle opposite direction

[17]Hollo, P. Changes of the DRL-Regulations and their Effects on Traffic Safety in Hungary, Paper presented at the conference: Strategic Highway Safety Program and Traffic Safety, the Czech Republic, September 20-22, 1995. Preprint for sessions on September 21, 1995.

[18] Elvik, R., Christensen, P., and Olsen, S. (2004). Daytime Running Lights Interim Report 2: A Systematic Review of Effects on Road Safety (TOI Report 668/2003). TOI, Norway..

[19] Knight, I., Sexton, B., Barlett, R., Barlow, T., Latham, D., and NcCrae, I. (2006). Daytime Running Lights (DRL): A Review of the Reports from the European Commission (PPR 170).

[20]Sparks, G., Ncudorf, R., Smith, A., Wapman, K., and Zador, P. (1993). The effect of daytime running lights on crashes between two vehicles in Saskatchewan: a study of a government fleet. *Accident Analysis and Prevention, 25,* 619-625.

[21]Arora, H., Collard, D., Robbins, G., Welbourne, E.R., and White, J.G. (1994). Effectiveness of Daytime Running Lights in Canada (Report No. TP1298 [E]). Ottawa, Ontario: Transport Canada.

crashes by 8 percent. Tofflemire and Whitehead[22] in 1997 reanalyzed the Canadian DRL law and found that DRLs reduced opposite direction and angle crashes by 5.3 percent. The result was also statistically significant.

U.S. Studies

In contrast, DRL effects from U.S. studies were less consistent. DRLs are not required in the United States, thus all studies in the United States were vehicle-fleet-based analyses. In 2000, NHTSA conducted a preliminary study[23] to evaluate the effects of DRLs. The estimated effects ranged from -8 to 2 percent for fatal two-vehicle opposite-direction crashes, 5 to 7 percent for non-fatal crashes, and 28-29 percent for single-vehicle-to-pedestrian crashes. The range of effects primarily resulted from two different statistics. In 2005, the agency reexamined the effectiveness of DRLs using the same statistical techniques as in the 2000 report but used a different set of crash data.[24] Conclusions from this updated study were similar to those in the earlier study: -7.9 to 5 percent for daytime two-vehicle opposite and angle crashes, 3.8 to 12 percent for single-vehicle-to-pedestrian/cyclist crashes, and 23 to 26 percent for single-vehicle-to-motorcycle crashes.

In addition to agency studies, a 2002 study by Farmer et al.[25] at the Insurance Institute for Highway Safety concluded that DRLs were associated with a significant 3.2-percent reduction in daytime multi-vehicle crashes. In 2003, Thompson[26] presented a paper at the April SAE meeting in Washington, DC. He estimated that DRLs reduced multiple-vehicle collisions by 2.3 percent to 12.4 percent, depending on DRL types. In addition, Bergkvist (based on a study conducted by Exponent Failure Analysis associated and commissioned by GM) [27] estimated that DRLs in GM vehicles reduced daytime multiple-vehicle crashes by 5 to 13 percent depending on light conditions and roadway types. However, the same study also showed that DRLs reduced nighttime multiple-vehicle crashes by 5 percent. Thus, the reduction of 5 to 13 percent in crashes might not be tenable.

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[22] Tofflemire, T. and Whitehead, P. (1997). An Evaluation of the Impact of Daytime Running Lights on Traffic Safety in Canada. *Journal of Safety Research, 28(4)*.

[23] Tessmer, J.M. (2000). A Preliminary Assessment of the Crash-Reducing Effectiveness of Passenger Car Daytime Running Lamps (DRLs) (DOT HS 808 645).

[24] Tessmer, J.M. (2005). An Assessment of Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs) (DOT HS 809 760).

[25] Farmer, C. and Williams, A. (2002). Effects of daytime running lights on multiple-vehicle daylight crashes in the United States. *Accident Analysis And Prevention, 34*, 197-203.

[26] Thompson, P.A. (2003). Daytime Running Lamps (DRLs) for Pedestrian Protection (SAE Paper 2003-0102072).

[27] Bergkvist, P. (1998). Daytime Running Lights (DRLs) – A North American Success Story (ESV Paper 395). Proceedings of 17th Enhanced Safety Vehicle Conference, Amsterdam, The Netherlands.

Organization of the Remaining Report

The following outlines the remaining structure of the report. Chapter 2 describes the study design, statistical methodology, and data sources. Chapter 3 presents baseline crash samples for estimating the effectiveness of DRLs. Chapter 4 estimates the effectiveness of DRLs. Chapter 5 discusses results and conclusions. In addition, Appendix A lists detailed crash definitions. Appendix B provides a different tabulation of crash cases from those presented in Chapter 3. The crashes were retabulated by data sources, DRL status, and by vehicle model years. Finally, Appendix C presents the DRL effects estimated from the simple odds and compares the DRL effects estimated from the two statistics.

CHAPTER 2. STUDY DESIGN AND DATA SOURCES

2.1 Study Design

The analysis design is a control-comparison method that compares crash involvement of DRL-equipped vehicles to that of non-DRL vehicles. The ratio of odds ratios was used to measure the DRL effects. A 95-percent confidence interval was used to determine the range of the true effects. The 95-percent confidence interval also was used to infer whether the estimated DRL effects were statistically significant at the 0.05 level.

The control-comparison method was chosen because it attempts to control confounding factors whose effects could obscure the real impact of DRLs. Antilock brake systems (ABS), for example, have proven to reduce multi-vehicle crashes on wet roads by 14 percent.[28] If ABS was introduced at the time that coincided with the implementation of DRLs, it might be confused with DRL effects. The method is similar to that used in previous studies.[29] [30] However, there are some differences between this analysis and previous studies other than the crash sources used:

- The analysis compares specific make models of PCs and LTVs with DRLs versus earlier versions of identical make models without DRLs, as opposed to all DRL-equipped make models versus all non-DRL make model vehicles adopted in NHTSA's second study by Tessmer in 2005.
- The analysis chooses ratio of odds ratios, instead of simple odds used in the previous studies, as the primary statistic to estimate the magnitude of the DRL effects.

The purpose of selecting matched vehicle models for analysis is to further control vehicle-specific confounding factors such as ABS. Ratio of odds ratios was chosen over simple odds as the primary statistic for two reasons. First and foremost, the ratio of odds ratios provides an additional control for confounding factors that could influence the daytime/nighttime occurrence of control and target crashes. Second, it is relatively more sensitive to crash sample size, and therefore it produces more conservative estimates which are clearly defined in the conclusions. With these characteristics, results derived from ratio of odds ratios, if found statistically significant, are considered to be more defendable. Prior studies, including NHTSA's two studies, have demonstrated that DRL effects were very sensitive to the statistics used to measure the effects. In a situation like this, a statistic with a stronger confounding-factor-control ability along with a relatively more conservative statistical inference is more desirable. Therefore, all the conclusions from this analysis were solely based on ratio of odds ratios.

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[28] Kahane, C. J. (1994). A Preliminary Evaluation of the Effectiveness of Antilock Brake System (ABS) for Passenger Cars (DOT HS 808 206).

[29] Tessmer, J.M. (2000). A Preliminary Assessment of the Crash-Reducing Effectiveness of Passenger Car Daytime Running Lamps (DRLs) (DOT HS 808 645).

[30] Tessmer, J.M. (2005). An Assessment of Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs) (DOT HS 809 760).

Control and Comparison Method

The first step in the process is to identify control and comparison (i.e., target) crashes and light conditions at the time when crashes occurred. Control crashes are crashes that would not be affected by the presence or absence of DRLs while the comparison crashes (or target crashes) would. Single passenger-vehicle crashes excluding pedestrian/pedalcyclist were considered not to be affected by DRLs and served as the control crashes. Two passenger-vehicle crashes excluding rear-end crashes (target Two-PV), single passenger-vehicle-to-pedestrian/pedalcyclist crashes (Single-PV-to-PED/CYC), and single passenger-vehicle-to-motorcycle crashes (Single-PV-to-Motorcycle) were the three target crashes examined in the analysis. The exclusion of rear-end crashes from the analysis is due to the uncertainty as to whether DRLs would impact the rear-end crashes. Single-PV-to-PED/CYC and Single-PV-to-Motorcycle crashes were examined separately. This is intended to address the concern that DRLs when lit could make pedestrians, cyclists, and motorcycles less conspicuous and in turn might adversely affect crashes involving pedestrians, cyclists, and motorcyclists.

Light conditions at the time when crashes occurred were classified as daytime and nighttime. The control condition is "nighttime" and the comparison condition is "daytime." For the purpose of this analysis, daytime was first defined as a condition that included daylight, dawn, and dusk conditions for a series of comparisons to derive DRL effectiveness. Then, in another set of comparisons, daytime excluded dawn and dusk. Presenting these two sets of comparisons addresses concerns over the impacts of headlamps on DRL effects. During dawn and dusk conditions, headlamps might be turned on and could contribute to crash reductions along with DRLs. Therefore, the inclusion of dawn and dusk might increase the appearance of DRL effectiveness. The police-reported real-world crash databases did not report the headlamp on-off status. Therefore, the analysis is unable to discern the effects of DRLs from that of headlamps. Instead, the analysis provides these two sets of effectiveness rates and examines the impacts of DRLs if dawn and dusk conditions are included or excluded.

For each of the target crashes, the DRL effectiveness is derived for three crash severity levels (fatal, injury, and all crashes) and two vehicle types (PCs and LTVs). Injury crashes include fatal crashes. All crashes include fatal, injury, and property damage only (PDO) crashes.

Contingency Table

Essentially, any pair of control-target crashes are constructed into two 2x2 contingency tables. One table is for crashes involving DRL-equipped vehicles and the other is for non-DRL vehicles. The two 2x2 contingency tables can be noted as:

DRL-equipped vehicles

Light Condition	Target Crashes	Control Crashes
Daytime	N_1	N_2
Nighttime	N_3	N_4

Non-DRL vehicles

Light Condition	Target Crashes	Control Crashes
Daytime	N_5	N_6
Nighttime	N_7	N_8

As shown in these contingency tables, the target and control crashes were segregated by the light condition (i.e., daytime and nighttime). This segregation attempts to further control factors that would impact the occurrence of target and control crashes at daytime and nighttime. Specifically, the control crashes, passenger-vehicle crashes excluding pedestrian/pedalcyclist, would be more likely to occur at nighttime and involve alcohol than the target two-vehicle crashes.

The eight frequencies shown in these 2x2 contingency tables were then used to derive the ratio of odds ratios statistic and subsequently the effectiveness of DRLs and standard error.

Ratio of Odds Ratios

Odds ratios were computed first and separately for DRL-equipped and non-DRL vehicles. Odds ratio is the odds of target crashes occurring in the daytime condition divided by the odds of the control crashes occurring in the daytime. Using the notation as shown above, the odds ratio (R_1) for DRL-equipped vehicles thus is defined as

$$R_1 = \frac{N_1}{N_3} \div \frac{N_2}{N_4} = \frac{N_1 * N_4}{N_2 * N_3}.$$

Similarly, the odds ratio (R_2) for non-DRL-vehicles is defined as

$$R_2 = \frac{N_5}{N_7} \div \frac{N_6}{N_8} = \frac{N_5 * N_8}{N_6 * N_7}.$$

Ratio of odds ratios, R, is the ratio of these two odds ratios, i.e., $R = \frac{R_1}{R_2}$. The value of R represents the relative odds of daytime target crashes involvements between DRL-equipped vehicles and non-DRL vehicles.

The hypothesis is that if there were no observed DRL effects, these two odds ratios would be identical. Therefore, if DRLs had no effects on daytime target crashes, the value of R would be 1. If DRLs had a positive effect, the risk of DRL-equipped vehicles involved in the daytime target crashes would be expected to be smaller than that of non-DRL vehicles and R would be less than 1. On the contrary, if DRLs had an adverse effect, R would be greater than 1.

The effectiveness (E) is defined as the percentage reductions in these ratios in vehicles with DRLs versus earlier versions of same make-models without DRLs:

$$E = 100 * (1 - R) = 100 * (1 - \frac{R_1}{R_2}).$$

Positive values of E (or R < 1) imply a reduction in daytime target crashes and, conversely, negatives values indicate an increase in daytime target crashes.

Standard Error and Confidence Interval

The value of R can range from 0 to infinity (∞) and is a highly skew distribution. Thus, the standard error (SE) of R is not easily computed. By contrast, the SE for the lognormal transformation of R, i.e., the e-based logarithm of R (= ln(R) = ln(1-E)) can be conveniently derived. It is the square root of the sum of the reciprocal of the eight crash frequencies used to calculate R[31], i.e.:

$$\text{Standard Error of } \ln(R) = \sigma_{\ln(R)} = \sqrt{\sum_{i=1}^{8} \frac{1}{N_i}}$$

When $\sigma_{\ln(R)}$ is small, a standard error of the effectiveness E expressed in percent can be approximated by $100*R*\sigma_{\ln(R)}$, i.e.:

$$\text{Standard Error of } E = \sigma_E = 100 * R * \sqrt{\sum_{i=1}^{8} \frac{1}{N_i}}$$

A confidence interval provides a range within which the true effect is likely to fall. The 95 percent confidence interval for E can be computed as:

$$E \pm 1.96 * \sigma_E.$$

However, the 95-percent confidence interval of E deriving using the above formula, which normalizes the distribution of E, can be highly inaccurate when $\sigma_{\ln(R)}$ is large. Since the report evaluates three different target crashes using FARS and nine State Data, the variation of $\sigma_{\ln(R)}$ is expected to be relatively large for small States (e.g., Utah) and for small target crashes (e.g., motorcycle crashes). Therefore, instead of using the approximation formula presented above, the confidence intervals of E are derived using the traditional log-transformation process. The log-transformation process is first to locate the lower and upper 95-percent confidence limits of

[31] Hansen, M., Hurwitz, W., and Madow, W. (1953). Sample Survey Methods and Theory, Volume I, 512-514. New York, New York: John Wiley & Sons.

ln(R); then apply the exponential function to these confidence limits to form the confidence interval for R; and finally, subtract these limits from 1 to derive the 95-percent confidence interval for E. The 95-percent confidence interval limits based on the log-transformation process can be calculated by the following formula:

$$1 - e^{\ln(R) \pm 1.96 * \sigma_{\ln(R)}}$$, where e is the exponential function.[32]

A 95-percent confidence interval means that 95 percent of the time the range would contain the true effects. This interval was used to infer statistical significance of the effects. If the interval contains 0 (no effects), this implies that the estimated results were not statistically significant at the 0.05 level. If the interval does not contain 0, this implies that the estimated effects were statistically significant. A quite narrow confidence interval implies that the estimated effects are quite precise. On the contrary, if the confidence interval is wide, the estimated effects are less precise. Thus, any statistically significant results accompanied by a wide confidence interval need to be treated with caution. Additional information such as trends of the effects should also be considered in interpreting the results.

2.2 Data Sources

This analysis used three databases: FARS, State Data System (State data), and R. L. Polk vehicle registration data (Polk data). FARS is a census of police-reported fatal crashes within the 50 States, the District of Columbia, and Puerto Rico. FARS (excluding Puerto Rico) was selected to assess the DRL effectiveness against daytime target fatal crashes. The primary objective of the analysis is to evaluate the impacts of DRLs under the current traffic environment. Therefore, FARS data from 2000 to 2005 were used for the analysis.

The State data is a collection of databases that contain a census of police-reported crashes from each State and were used to derive the baseline samples for all crashes and injury crashes. All crashes include fatal, injury, and property damage only (PDO) crashes. Injury crashes included police-reported possible injury, non-incapacitating, incapacitating, and fatal injury crashes. Currently, there are a total of 32 States in the State Data System maintained by the agency's National Center for Statistics and Analysis. The collected information varies from State to State because many States have different data collection and reporting standards (usually based on monetary damage). Many of these States did not provide the Vehicle Identification Numbers (VINs) which are critical for identifying DRL status and minimizing vehicle variations among States. Some States reported VINs but did so inconsistently throughout the years. Some States reported VINs but not beyond the year 2000. Only nine States, with a relatively high percentage of reported VINs (over 80% reporting rate for each year) and with the most current available years of data (2000 onwards), were selected for the analysis. These States were Florida (2000-2004), Illinois (2000-2003), Maryland (2000-2004), Michigan (2004-2005), Missouri (2000-2005), Nebraska (2000-2004), Pennsylvania (2000-2001, 2003-2005), Utah (2000-2004), and Wisconsin (2000-2003). Michigan had only two years worth of data. Pennsylvania did not have 2002 VIN data. Table 2-1 lists these crash data sources that were used in the analysis.

[32] Changes in response to Dr. Morris's comments.

Table 2-1
Real-World Police-Reported Crash Data Included in the Analysis

Data Source	Calendar Year
FARS	2000-2005
State Data	
Florida (FL)	2000-2004
Illinois (IL)	2000-2003
Maryland (MD)	2000-2004
Michigan (MI)	2004-2005
Missouri (MO)	2000-2005
Nebraska (NE)	2000-2004
Pennsylvania (PA)	2000-2001, 2003-2005 (no 2002)
Utah (UT)	2000-2004
Wisconsin (WI)	2000-2003

In addition to FARS and the State data, the analysis also used 1995-2005 Polk data as the basis to estimate DRL installation rates for 1995 to 2005 model year vehicles and for calendar years from 1995 to 2005. The estimated installation rates were presented in the introduction. Polk data were a snapshot of registered vehicles as of July 1 of each year, at the time when the new model year vehicles were not fully exposed. Therefore, new model vehicle registrations (e.g., 1995 model year in 1995 calendar year) were generally underreported and smaller than the same model year vehicles registered in the following calendar year (i.e., one-year-old models; e.g., 1995 model year in 1996 calendar year). Although the absolute number of new vehicle registrations differed between the two consecutive years immediately after the vehicles were introduced into the market, the DRL installation rates (as standard equipment) derived from these two consecutive calendar years were almost identical. The estimated installation rates based on the number reported in the second calendar year were presented in the introduction.

2.3 Data Preparation

VIN Decoding

VIN decoding is a two-step process. First, FARS and the State Data were decoded using the PC VINA software developed by R. L. Polk & Co. to obtain DRL and ABS status information (VIN-decoded files).[33] DRLIGHTS and ABS were two variables in the VIN-decoded files representing the DRL and ABS installation status (i.e., standard, optional, none). The VIN-decoded files were then merged back with the original FARS and State data. The merged files were then run through a series of 10 VIN-decoding programs to obtain more detailed vehicle information such as vehicle make model, model year, vehicle body type, wheelbase, restraint

[33] The VIN-decoded files for FARS and the State data were generated by the National Center for Statistics and Analysis within NHTSA. These files included vehicle safety features such DRL and ABS that were obtained from VIN. The PC VINA software developed by R. L. Polk & Co. was used for this purpose. PC VINA verifies VINs and provides description information about the vehicle.

type, etc. (processed filed). These 10 VIN-decoding programs were developed by the agency[34], which decoded vehicle features according to the information provided in the Passenger Vehicle Identification Manuals published by the National Insurance Crime Bureau. The programs generate standard descriptions for vehicle make, model, body type, and restraint systems. Each vehicle was assigned a 5-digit vehicle make model code, 5-digit vehicle group code, 4-digit restraint type code, and codes for other vehicle-related information. The 5-digit vehicle make model code (MMP) and 1-digit truck type code (TRKTYP) was uniformly used across databases to extract baseline crash cases for further statistical analyses.

Note that the NHTSA-developed VIN-decoding software can be applied to any data files that collect VIN and standardize the identification of vehicle make models, restraint systems, and vehicle groups across different crash databases. This is particularly useful to analysts who constantly use different crash data sources and require a uniform link between these databases by vehicle make models.

Crash Definition

Crash type, light condition, and vehicle type are three primary variables needed to be defined. FARS is a standardized crash database. Therefore, a set of variables can be applied to FARS across different calendar years. Variables used to define fatal crash types are: NUM_VEH (number of vehicles involved), MAN_COLL (manner of collision), and HARM_EV (harmful event). The variable LGT_COND was used to define light conditions. The VIN decoded variable TRKTYP was used to define vehicle type.

In contrast, the information collected in the State Data System is not standardized. Each State collects crash information based on its coding and reporting standards. Thus, variables used to define crashes, light condition, and vehicle type varied among States. These definitions are too cumbersome to include here. Appendix A details these definitions based on FARS and the State data.

2.4 Vehicle Make Models Selection

The processed FARS and Florida and Michigan State data were used to compile a library of vehicle make models by model year along with their DRL status (not equipped, optional, standard equipment). These files were large enough to produce a library that contains almost all the on-road vehicle make models. Vehicle selections were based on the information contained in this library. Models were included in the analysis if the models met the following criteria:
(a) Had DRL status transitioned from “not equipped” at all (0% installation) directly to “standard equipment” for all (100%) within two consecutive model years.
(b) Did not have significant changes in body structure.
(c) Did not have added crash avoidance safety features in the DRL-equipped vehicles.

[34] The 10 VIN-decoded programs were developed by the Regulatory Evaluation Division, Office of Regulatory Analysis and Evaluation, Administrator for National Center for Statistics and Analysis. These programs were PC based SAS programs.

(d) DRL-equipped vehicles had already been on the road in 2000, the first calendar year of data.

The selection criteria were set to control the vehicle-specific confounding factors such as ABS. Further, to minimize the vehicle age effects, only two model years prior to and after DRLs became the standard equipment were included in the analysis (two-year models). However, a few models had only one model year before and after the full installation of DRLs included in the analysis (one-year model). These models had DRLs starting with 2000 model year vehicles, canceled production, or redesigned a year after DRLs became standard equipment.

Tables 2-2 and 2-3 list the selected vehicle models. Table 2-2 is for PCs and Table 2-3 is for LTVs. As shown in the introduction, DRL installation increased significantly from 1995 to1996 and from 1996 to 1997 model year vehicles. Afterward, DRL installation stabilized from 1997 to 2005 model years. The big increase in these two consecutive model years was primarily attributed to GM vehicles. GM began to equip DRLs with some of the 1995 model year vehicles. By model year 1997, all GM vehicles had DRLs as standard equipment. In contrast, some other manufacturers started to equip certain models with DRLs more recently, and some have not yet equipped their vehicles with DRLs. Toyota equipped the Corolla, Avalon, and Celica beginning with model years 1998, 1999, and 2000, respectively. Honda equipped the Accord and Civic with DRLs starting with the 2006 model year. Therefore, it is not surprising that the majority of the selected vehicles were GM vehicles. The vast majority of the vehicles in the sample were two-year models. Oldsmobile Aurora, Subaru Legacy, and Toyota Celica were one-year models. All LTVs were two-year models. The following shows the composition of manufacturers for selected vehicles:

Passenger cars

Manufacturer	Percent
GM	86
Toyota	9
Lexus	2
VW	2
Subaru	1
Volvo	< 1

LTVs

Manufacturer	Percent
GM	100

DRL status was mainly decoded from VIN using the PC VINA software developed by R. L. Polk. For a few vehicle models, the program provided confusing information. For example, DRLs were coded as “optional” equipment for 1995 and 1996 Buick Century and Buick Regal, which were different from that cited in the other literature such as Farmer's study[35] and a report done by the Exponent Inc.[36] Earlier published studies and internet vehicle specification data were consulted to resolve the questionable DRL status. However, for GM vehicles, the analysis mostly relied on the report by Exponent since the report was contracted by GM and was assumed to contain more reliable DRL information on GM vehicles. DRL status had changed for the following make models:

- Buick Century – 1995 and 1996 model years,
- Buick Regal – 1995 and 1996 model years,
- Chevrolet Monte Carlo, 1995 model year,
- Oldsmobile Bravada, 4 doors, 4x4 – 1996 model year,
- Pontiac Grand Prix – 1996 model year, and
- Pontiac Transport – 1995 and 1996 model years.

Eventually, the Buick Century was excluded from the analysis since the vehicle body frame changed between non-DRL vehicles (1995-1996 models) and DRL vehicles (1997-1998 models). Most importantly, the brake and handling systems were also different between these two bodies.

As shown in the following tables, the majority of DRL-equipped PCs were 1996 to 1998 model year vehicles. Their non-DRL counterparts were mostly 1994 to 1996 model year vehicles. For LTVs, the majority of DRL-equipped vehicles were 1996 and 1997 model year vehicles, and non-DRL vehicles were mostly 1994 and 1995 model year vehicles. All vehicle models used in the analysis are before the introduction of electronic stability control (ESC), thus ESC is not relevant in this study.[37]

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[35] Farmer, C. and Williams, A. (2002). Effects of daytime running lights on multiple-vehicle daylight crashes in the United States. *Accident Analysis And Prevention, 34*, 197-203.

[36] Study of DRL Mechanization in U.S., Exponent Inc., Failure Analysis Associates, 2003.

[37] In response to Dr. Green's comments.

Table 2-2
Matched Make/Models for Passenger Cars

Vehicle Group Number and Make/Model	Without DRL Model Year	With DRL Model Year
18002 Buick LeSabre	1995-1996	1997-1998
18003 Buick Park Ave	1995-1996	1997-1998
18005 Buick Riviera	1995-1996	1997-1998
18018 Buick Skylark	1994-1995	1996-1997
18020 Buick Regal	1995-1996	1997-1998
19003 Cadillac Deville	1994-1995	1996-1997
19014 Cadillac Seville	1994-1995	1996-1997
20004 Chevrolet Corvette Y	1995-1996	1997-1998
20009 Chevrolet Camaro F	1995-1996	1997-1998
20016 Chevrolet Cavalier J	1994-1995	1996-1997
20019 Chevrolet Beretta/Corsica	1993-1994	1995-1996
20020 Chevrolet Lumina	1995-1996	1997-1998
20032 Chevrolet Nova/Prizm	1994-1995	1996-1997
20034 Chevrolet GEO Metro	1993-1994	1995-1996
20036 Chevrolet Monte Carlo	1995-1996	1997-1997
21002 Olds Delta	1994-1995	1996-1997
21003 Olds 98	1995	1996
21020 Olds Supreme W	1996-1997	1998-1999
21021 Olds Achieva/Alero	1994-1995	1996-1997
21022 Olds Aurora	1995	1996
22002 Pontiac Bonneville	1994-1995	1996-1997
22009 Pontiac Firebird F	1995-1996	1997-1998
22016 Pontiac Sunbird/Fire J	1994-1995	1996-1997
22018 Pontiac Grand AM N	1994-1995	1996-1997
22020 Pontiac Grand Prix W*	1995-1996	1997-1998
24001 Saturn SL Z	1994-1995	1996-1997
24002 Saturn SC Z	1995-1996	1997-1998
24003 Saturn SW Z	1994-1995	1996-1997
30040 VW Jetta	1993-1994	1995-1996
30042 VW Golf/Cabriolet	1993-1994	1995-1996
30046 VW Passat	1994-1995	1996-1997

Table 2-2 (Continued)
Matched Make/Models for Passenger Cars

Vehicle Group Number and Make/Model	Without DRL Model Year	With DRL Model Year
48034 Subaru Legacy	1999	2000
49032 Toyota Corolla	1996-1997	1998-1999
49033 Toyota Celica	1999	2000
49043 Toyota Avalon	1997-1998	1999-2000
51041 Volvo 960	1993-1994	1995-1996
51042 Volvo 850	1993-1994	1995-1996
59031 Lexus ES 250/300	1997-1998	1999-2000
59032 Lexus LS 400/430	1997-1998	1999-2000
59033 Lexus SC 300/400/430	1997-1998	1999-2000
59034 Lexus GS 300	1997-1998	1999-2000

Table 2-3
Match Make/Models for Light Trucks and Vans

Vehicles Make/Model	Without DRL Model Year	With DRL Model Year
20200 Chevrolet S10 Pickup	1993-1994	1995-1996
20201 Chevrolet T10 4x4 Pickup	1993-1994	1995-1996
20202 Chevrolet S10 Maxicab Pickup	1993-1994	1995-1996
20203 Chevrolet T10 Maxicab Pickup	1993-1994	1995-1996
20210 Chevrolet C10/R10 Pickup	1994-1995	1996-1997
20211 Chevrolet K10/V10 Pickup	1994-1995	1996-1997
20212 Chevrolet C10 C-Cab Pickup	1994-1995	1996-1997
20213 Chevrolet K10 4x4 X-Cab Pickup	1994-1995	1996-1997
20220 Chevrolet C20/R20 Pickup	1994-1995	1996-1997
20221 Chevrolet K20/V20 4x4 Pickup	1994-1995	1996-1997
20222 Chevrolet C20 X-Cab Pickup	1994-1995	1996-1997
20223 Chevrolet K20 X-Cab Pickup	1994-1995	1996-1997
20230 Chevrolet C30/R30 Pickup	1994-1995	1996-1997
20231 Chevrolet K30/V30 Pickup	1994-1995	1996-1997
20232 Chevrolet C30 X-Cab Pickup	1994-1995	1996-1997
20233 Chevrolet K30 4x4 X-Cab Pickup	1994-1995	1996-1997
20234 Chevrolet C3500 Crew Pickup	1994-1995	1996-1997
20235 Chevrolet K3500 Crew 4x4 Pickup	1994-1995	1996-1997
20300 Chevrolet S10 Blazer 2DR	1994-1995	1996-1997
20301 Chevrolet S10 Blazer 2DR 4x4	1994-1995	1996-1997
20302 Chevrolet Blazer/Trailblazer 4DR	1994-1995	1996-1997

Table 2-3 (Continued)
Match Make/Models for Light Trucks and Vans

Vehicles Make/Model	Without DRL Model Year	With DRL Model Year
20303 Chevrolet Blazer/Trailblazer 4DR 4x4	1994-1995	1996-1997
20311 Chevrolet Tahoe/K-Blazer 2DR 4x4	1994-1995	1996-1997
20312 Chevrolet Tahoe 4DR	1994-1995	1996-1997
20313 Chevrolet Tahoe 4DR 4x4	1994-1995	1996-1997
20322 Chevrolet Suburban C1500/R10 4x4	1994-1995	1996-1997
20323 Chevrolet Suburban C1500/V10 4x4	1994-1995	1996-1997
20326 Chevrolet Suburban C2500/R20	1994-1995	1996-1997
20327 Chevrolet Suburban K2500/V20 4x4	1994-1995	1996-1997
20330 Chevrolet GEO Tracker	1994-1995	1996-1997
20331 Chevrolet GEO Tracker 2DR 4x4	1994-1995	1996-1997
20404 Chevrolet Astro Ext Cargo Van	1995-1996	1997-1998
20405 Chevrolet Astro 4x4 Ext Cargo Van	1995-1996	1997-1998
20406 Chevrolet Astro 4x4 Ext Pass Van	1995-1996	1997-1998
20407 Chevrolet Astro 4x4 Ext Pass Van	1995-1996	1997-1998
20410 Chevrolet G10 Cargo Van	1995-1996	1997-1998
20420 Chevrolet G20 Cargo Van	1995-1996	1997-1998
20422 Chevrolet G20 Pass Van	1995-1996	1997-1998
20430 Chevrolet G30 Cargo Van	1995-1996	1997-1998
20432 Chevrolet G30 Pass Van	1995-1996	1997-1998
20434 Chevrolet G30 Ext Cargo Van	1995-1996	1997-1998
20436 Chevrolet G30 Ext Pass Van	1995-1996	1997-1998
20510 Chevrolet C1500 Incompl Pickup	1994-1995	1996-1997
20511 Chevrolet K1500 4x4 Incompl	1994-1995	1996-1997
20512 Chevrolet C1500 X-Cab Incompl	1994-1995	1996-1997
20513 Chevrolet K1500 X-Cab Incompl	1994-1995	1996-1997
20520 Chevrolet C2500 Incompl	1994-1995	1996-1997
20521 Chevrolet K2500 4x4 Incompl	1994-1995	1996-1997
20530 Chevrolet C3500 Incompl	1994-1995	1996-1997
20531 Chevrolet K3500 4x4 Incompl	1994-1995	1996-1997
20532 Chevrolet C3500 X-Cab Incompl	1994-1995	1996-1997
20534 Chevrolet C3500 Crew Incompl	1994-1995	1996-1997
20604 Chevrolet Astro Ext Incompl	1995-1996	1997-1998
20605 Chevrolet Astro 4x4 Ext Incompl	1995-1996	1997-1998
20638 Chevrolet Cutaway	1995-1996	1997-1998
20702 Chevrolet Forward Control 4x2	1995-1996	1997-1998
20822 Chevrolet Suburban C15 Incompl	1994-1995	1996-1997

Table 2-3 (Continued)
Match Make/Models for Light Trucks and Vans

Vehicles Make/Model	Without DRL Model Year	With DRL Model Year
20823 Chevrolet Suburban K15 4x4 Incompl	1994-1995	1996-1997
21302 Olds Bravada	1993-1994	1996-1997 (no 1995)
21303 Olds Bravada 4x4	1993-1994	1996-1997 (no 1995)
22442 Pontiac Transport	1995-1996	1997-1998
23200 GMC Sonoma/S15 Pickup	1993-1994	1995-1996
23201 GMC Sonoma/T15 4x4 Pickup	1993-1994	1995-1996
23202 GMC Sonoma/S15 Maxicab Pickup	1993-1994	1995-1996
23203 GMC Sonoma/T15 Maxicab Pickup	1993-1994	1995-1996
23210 GMC Sierra C1500 Pickup	1994-1995	1996-1997
23211 GMC Sierra K1500 4x4 Pickup	1994-1995	1996-1997
23212 GMC Sierra C1500 X-cab Pickup	1994-1995	1996-1997
23213 GMC Sierra K1500 4x4 X-cab Pickup	1994-1995	1996-1997
23220 GMC Sierra C2500 Pickup	1994-1995	1996-1997
23221 GMC Sierra K2500 4x4 Pickup	1994-1995	1996-1997
23222 GMC Sierra C2500 X-cab Pickup	1994-1995	1996-1997
23223 GMC Sierra K2500 4x4 X-cab Pickup	1994-1995	1996-1997
23230 GMC Sierra C3500 Pickup	1994-1995	1996-1997
23231 GMC Sierra K3500 4x4 Pickup	1994-1995	1996-1997
23232 GMC Sierra C3500 X-cab Pickup	1994-1995	1996-1997
23233 GMC Sierra K3500 4x4 X-cab Pickup	1994-1995	1996-1997
23234 GMC Sierra C3500 Crew Pickup	1994-1995	1996-1997
23235 GMC Sierra K3500 Crew 4x4 Pickup	1994-1995	1996-1997
23300 GMC Jimmy 2DR	1994-1995	1996-1997
23301 GMC Jimmy 2DR 4x4	1994-1995	1996-1997
23302 GMC Jimmy/Envoy 4DR	1994-1995	1996-1997
23303 GMC Jimmy/Envoy 4DR 4x4	1994-1995	1996-1997
23311 GMC Yukon 2DR 4x4	1994-1995	1996-1997
23312 GMC Yukon 4DR	1994-1995	1996-1997
23313 GMC Yukon 4DR 4x4	1994-1995	1996-1997
23322 GMC Suburban C1500	1994-1995	1996-1997
23323 GMC Suburban K1500 4x4	1994-1995	1996-1997
23326 GMC Suburban C2500	1994-1995	1996-1997

Table 2-3 (Continued)
Match Make/Models for Light Trucks and Vans

Vehicles Make/Model	Without DRL Model Year	With DRL Model Year
23327 GMC Suburban K2500 4x4	1994-1995	1996-1997
23404 GMC Safari Ext Cargo Van	1995-1996	1997-1998
23406 GMC Safari Ext Passenger Van	1995-1996	1997-1998
23407 GMC Safari Ext Passenger Van 4x4	1995-1996	1997-1998
23410 GMC G10 Cargo Van	1995-1996	1997-1998
23420 GMC G20 Cargo Van	1995-1996	1997-1998
23422 GMC G20 Passenger Van	1995-1996	1997-1998
23430 GMC G30 Cargo Van	1995-1996	1997-1998
23432 GMC G30 Passenger Van	1995-1996	1997-1998
23434 GMC G30 Ext Cargo Van	1995-1996	1997-1998
23436 GMC G30 Ext Passenger Van	1995-1996	1997-1998
23510 GMC Sierra C1500 Incompl	1994-1995	1996-1997
23511 GMC Sierra K1500 4x4 Incompl	1994-1995	1996-1997
23512 GMC Sierra C1500 X-Cab Incompl	1994-1995	1996-1997
23513 GMC Sierra K1500 4x4 X-Cab Incompl	1994-1995	1996-1997
23530 GMC Sierra C3500 Incompl	1994-1995	1996-1997
23531 GMC Sierra K3500 4x4 Incompl	1994-1995	1996-1997
23604 GMC Safari Ext Incompl	1995-1996	1997-1998
23605 GMC Safari 4x4 Ext Incompl	1995-1996	1997-1998
23610 GMC G10 Incompl Van	1995-1996	1997-1998
23638 GMC Cutaway	1995-1996	1997-1998
23702 GMC Forward Control 4x2	1995-1996	1997-1998
23822 GMC Suburban C15 Incompl	1994-1995	1996-1997
23823 GMC Suburban K15 4x4 Incompl	1994-1995	1996-1997

CHAPTER 3. BASELINE CRASH CASES

The baseline crashes were vehicle-based. Since the analysis limited vehicles to certain make models and model years, the vehicle-based samples essentially were equivalent to crash-based samples. The first two sections present the baseline crashes, each with different daytime definitions as described in the previous chapter. In the first section, daytime included daylight, dawn, and dusk conditions. In the second section, daytime included only the daylight condition where dawn and dusk conditions were excluded. Finally, the last section provides descriptive characteristics for vehicle age, driver age, and driver gender for the crash sample.

The two sections containing the sample tabulations had an identical structure in presenting crashes. Fatal crash involvements were presented first, then injury crashes, and finally all crashes. For each crash severity level, crashes were tabulated by crash type (i.e., control and target), crash light condition (daytime and nighttime), vehicle type (PCs and LTVs), and DRL status (DRL-equipped, non-DRL). As described in the previous chapter, fatal crash involvements were derived from 2000 – 2005 FARS. Injury and all crash involvements were derived from the selected nine States. Therefore, for injury crashes and all crashes, cases from individual States as well as from States combined were provided.

Note that Appendix B also reports these crashes but in a different format. Crashes were tabulated by DRL status and vehicle model years. This additional information allows readers to examine the spread of vehicle model years.

3.1 Including Dawn and Dusk

Crashes were presented in a series of tables. Table 3-1 tabulates baseline fatal control crashes and three target crashes. Tables 3-2 to 3-11 are for police-reported injury crashes. Tables 3-12 to 3-21 were for all police-reported crashes.

As shown in these tables, the target Two-PV crashes obtained from FARS and individual States were sufficient for statistical analysis, even for the small and less populated States such as Utah and Nebraska. However, for Single-PV-to-PED/CYC and Single-PV-to-Motorcycle crashes, several States did not have adequate cases to induce any meaningful results. This problem is particularly acute for motorcycle crashes. For example, only four States – Florida, Illinois, Pennsylvania, and Wisconsin – had sufficient car-to-motorcycle crash samples larger than 10 (the minimum sample size used in the analysis) in each of the tabulated cells to generate the DRL effects for passenger cars. For LTVs, Florida was the only State that met the minimal sample size criterion to derive the DRL effects.

Fatal Crashes

Table 3-1
Fatal Crashes Including Dawn and Dusk

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	928	993	678	724	1,606	1,717
Nighttime	1,394	1,380	916	916	2,310	2,296
Target Two-PV (1)						
Daytime	1,695	1,722	1,084	1,214	2,779	2,936
Nighttime	777	795	534	483	1,311	1,278
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	173	198	157	159	330	357
Nighttime	378	324	232	225	610	549
Single-PV-to-Motorcycle (3)						
Daytime	130	125	109	122	239	247
Nighttime	56	52	34	41	90	93
All Target Crashes (1) + (2) + (3)						
Daytime	1,998	2,045	1,350	1,495	3,348	3,540
Nighttime	1,211	1,171	800	749	2,011	1,920

PV: passenger vehicle
Source: 2000-2005 FARS

Injury Crashes

Table 3-2
Injury Crashes Including Dawn and Dusk
Florida (2000 – 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,078	922	429	375	1,507	1,297
Nighttime	903	810	396	404	1,299	1,214
Target Two-PV (1)						
Daytime	7,833	7,015	2,618	2,493	10,451	9,508
Nighttime	2,425	2,103	853	749	3,278	2,852
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	507	469	192	208	699	677
Nighttime	201	187	84	96	285	283
Single-PV-to-Motorcycle (3)						
Daytime	242	214	89	76	331	290
Nighttime	108	87	28	31	136	118
All Target Crashes (1) + (2) + (3)						
Daytime	8,582	7,698	2,899	2,777	11,481	10,475
Nighttime	2,734	2,377	965	876	3,699	3,253

PV: passenger vehicle
Source: State Data System

Table 3-3
Injury Crashes Including Dawn and Dusk
Illinois (2000 – 2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	878	797	324	303	1,202	1,100
Nighttime	921	833	394	344	1,315	1,177
Target Two-PV (1)						
Daytime	5,209	4,743	1,701	1,559	6,910	6,302
Nighttime	1,716	1,619	542	454	2,258	2,073
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	478	475	189	153	667	628
Nighttime	159	162	51	48	210	210
Single-PV-to-Motorcycle (3)						
Daytime	94	104	47	25	141	129
Nighttime	30	37	10	8	40	45
All Target Crashes (1) + (2) + (3)						
Daytime	5,781	5,322	1,937	1,737	7,718	7,059
Nighttime	1,905	1,818	603	510	2,508	2,328

PV: passenger vehicle
Source: State Data System

Table 3-4
Injury Crashes Including Dawn and Dusk
Maryland (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	800	653	105	127	905	780
Nighttime	188	179	27	22	215	201
Target Two-PV (1)						
Daytime	2,501	2,242	450	409	2,951	2,651
Nighttime	459	355	77	82	536	437
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	283	254	43	44	326	298
Nighttime	36	28	5	4	41	32
Single-PV-to-Motorcycle (3)						
Daytime	85	47	13	8	98	55
Nighttime	1	1	0	1	1	2
All Target Crashes (1) + (2) + (3)						
Daytime	2,869	2,543	506	461	3,375	3,004
Nighttime	496	384	82	87	578	471

PV: passenger vehicle
Source: State Data System

Table 3-5
Injury Crashes Including Dawn and Dusk
Michigan (2004 - 2005)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	606	574	258	253	864	827
Nighttime	492	493	239	211	731	704
Target Two-PV (1)						
Daytime	2,096	2,120	864	927	2,960	3,047
Nighttime	655	606	254	273	909	879
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	139	148	65	55	204	203
Nighttime	60	44	13	17	73	61
Single-PV-to-Motorcycle (3)						
Daytime	45	41	24	25	69	66
Nighttime	11	8	5	4	16	12
All Target Crashes (1) + (2) + (3)						
Daytime	2,280	2,309	953	1,007	3,233	3,316
Nighttime	726	658	272	294	998	952

PV: passenger vehicle
Source: State Data System

Table 3-6
Injury Crashes Including Dawn and Dusk*
Missouri (2000 - 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	606	574	258	253	864	827
Nighttime	492	493	239	211	731	704
Target Two-PV (1)						
Daytime	2,096	2,120	864	927	2,960	3,047
Nighttime	655	606	254	273	909	879
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	139	148	65	55	204	203
Nighttime	60	44	13	17	73	61
Single-PV-to-Motorcycle (3)						
Daytime	45	41	24	25	69	66
Nighttime	11	8	5	4	16	12
All Target Crashes (1) + (2) + (3)						
Daytime	2,280	2,309	953	1,007	3,233	3,316
Nighttime	726	658	272	294	998	952

PV: passenger vehicle
Source: State Data System
*same as Excluding Dawn and Dusk due to no specific code to separate dawn and dusk

Table 3-7
Injury Crashes Including Dawn and Dusk
Nebraska (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	268	310	130	135	398	445
Nighttime	259	258	142	139	401	397
Target Two-PV (1)						
Daytime	1,295	1,177	545	526	1,840	1,703
Nighttime	273	267	129	87	402	354
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	70	73	39	38	109	111
Nighttime	11	18	8	5	19	23
Single-PV-to-Motorcycle (3)						
Daytime	11	12	8	6	19	18
Nighttime	1	1	1	1	2	2
All Target Crashes (1) + (2) + (3)						
Daytime	1,376	1,262	592	570	1,968	1,832
Nighttime	285	286	138	93	423	379

PV: passenger vehicle
Source: State Data System

Table 3-8
Injury Crashes Including Dawn and Dusk
Pennsylvania (2000-2005*)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,673	1,566	444	504	2,117	2,070
Nighttime	1,580	1,471	409	456	1,989	1,927
Target Two-PV (1)						
Daytime	4,750	4,611	1,338	1,328	6,088	5,939
Nighttime	1,455	1,432	384	401	1,839	1,833
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	405	400	118	117	523	517
Nighttime	142	158	38	39	180	197
Single-PV-to-Motorcycle (3)						
Daytime	129	136	24	40	153	176
Nighttime	29	19	7	7	36	26
All Target Crashes (1) + (2) + (3)						
Daytime	5,284	5,147	1,480	1,485	6,764	6,632
Nighttime	1,626	1,609	429	447	2,055	2,056

PV: passenger vehicle
Source: State Data System
* excluding 2002.

Table 3-9
Injury Crashes Including Dawn and Dusk
Utah (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	250	226	139	116	389	342
Nighttime	195	161	96	87	291	248
Target Two-PV (1)						
Daytime	1,189	1,018	575	520	1,764	1,538
Nighttime	341	296	163	141	504	437
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	82	69	66	55	148	124
Nighttime	28	26	11	10	39	36
Single-PV-to-Motorcycle (3)						
Daytime	28	23	26	8	54	31
Nighttime	1	4	2	3	3	7
All Target Crashes (1) + (2) + (3)						
Daytime	1,299	1,110	667	583	1,966	1,693
Nighttime	370	326	176	154	546	480

PV: passenger vehicle
Source: State Data System

Table 3-10
Injury Crashes Including Dawn and Dusk
Wisconsin (2000-2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	823	932	416	407	1,239	1,339
Nighttime	841	907	462	471	1,303	1,378
Target Two-PV (1)						
Daytime	2,984	3,064	1,198	1,249	4,182	4,313
Nighttime	782	829	343	245	1,125	1,074
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	117	163	69	62	186	225
Nighttime	52	65	34	25	86	90
Single-PV-to-Motorcycle (3)						
Daytime	94	89	39	45	133	134
Nighttime	23	15	6	7	29	22
All Target Crashes (1) + (2) + (3)						
Daytime	3,195	3,316	1,306	1,356	4,501	4,672
Nighttime	857	909	383	277	1,240	1,186

PV: passenger vehicle
Source: State Data System

Table 3-11
Injury Crashes Including Dawn and Dusk
Nine States Combined Total

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	7,509	7,037	2,738	2,669	10,247	9,706
Nighttime	6,484	6,089	2,686	2,604	9,170	8,693
Target Two-PV (1)						
Daytime	31,378	29,150	10,771	10,424	42,149	39,574
Nighttime	9,248	8,412	3,172	2,803	12,420	11,215
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	2,184	2,145	818	772	3,002	2,917
Nighttime	763	736	261	277	1,024	1,013
Single-PV-to-Motorcycle (3)						
Daytime	793	715	296	258	1,089	973
Nighttime	222	189	64	68	286	257
All Target Crashes (1) + (2) + (3)						
Daytime	34,355	32,010	11,885	11,454	46,240	43,464
Nighttime	10,233	9,337	3,497	3,148	13,730	12,485

PV: passenger vehicle
Source: State Data System

All Crashes

Table 3-12
All Crash Severity Levels Including Dawn and Dusk
Florida (2000 – 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,549	1,389	619	571	2,168	1,960
Nighttime	1,749	1,527	719	701	2,468	2,228
Target Two-PV (1)						
Daytime	11,319	10,086	3,911	3,708	15,230	13,794
Nighttime	4,101	3,574	1,471	1,335	5,572	4,909
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	526	477	195	214	721	691
Nighttime	207	193	85	96	292	289
Single-PV-to-Motorcycle (3)						
Daytime	266	223	102	83	368	306
Nighttime	126	95	34	33	160	128
All Target Crashes (1) + (2) + (3)						
Daytime	12,111	10,786	4,208	4,005	16,319	14,791
Nighttime	4,434	3,862	1,590	1,464	6,024	5,326

PV: passenger vehicle
Source: State Data System

Table 3-13
All Crash Severity Levels Including Dawn and Dusk
Illinois (2000 – 2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	3,629	3,183	1,574	1,397	5,203	4,580
Nighttime	4,884	4,088	2,247	2,003	7,131	6,091
Target Two-PV (1)						
Daytime	28,604	26,289	9,965	8,749	38,569	35,038
Nighttime	8,789	8,066	2,814	2,406	11,603	10,472
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	491	497	198	155	689	652
Nighttime	165	167	56	48	221	215
Single-PV-to-Motorcycle (3)						
Daytime	157	178	76	49	233	227
Nighttime	45	52	19	13	64	65
All Target Crashes (1) + (2) + (3)						
Daytime	29,252	26,964	10,239	8,953	39,491	35,917
Nighttime	8,999	8,285	2,889	2,467	11,888	10,752

PV: passenger vehicle
Source: State Data System

Table 3-14
All Crash Severity Levels Including Dawn and Dusk
Maryland (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,048	1,650	362	321	2,410	1,971
Nighttime	671	591	99	94	770	685
Target Two-PV (1)						
Daytime	6,503	5,547	1,345	1,134	7,848	6,681
Nighttime	1,155	944	249	224	1,404	1,168
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	327	294	52	51	379	345
Nighttime	40	35	7	6	47	41
Single-PV-to-Motorcycle (3)						
Daytime	98	67	16	12	114	79
Nighttime	4	1	0	1	4	2
All Target Crashes (1) + (2) + (3)						
Daytime	6,928	5,908	1,413	1,197	8,341	7,105
Nighttime	1,199	980	256	231	1,455	1,211

PV: passenger vehicle
Source: State Data System

Table 3-15
All Crash Severity Levels Including Dawn and Dusk
Michigan (2004-2005)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	3,288	2,760	1,921	1,542	5,209	4,302
Nighttime	4,180	3,462	2,552	1,996	6,732	5,458
Target Two-PV (1)						
Daytime	9,739	9,292	4,238	4,336	13,977	13,628
Nighttime	2,657	2,531	1,046	1,049	3,703	3,580
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	166	169	80	62	246	231
Nighttime	66	46	16	18	82	64
Single-PV-to-Motorcycle (3)						
Daytime	73	57	28	32	101	89
Nighttime	12	10	5	5	17	15
All Target Crashes (1) + (2) + (3)						
Daytime	9,978	9,518	4,346	4,430	14,324	13,948
Nighttime	2,735	2,587	1,067	1,072	3,802	3,659

PV: passenger vehicle
Source: State Data System

Table 3-16
All Crash Severity Levels Including Dawn and Dusk*
Missouri (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,925	2,637	1,252	1,130	4,177	3,767
Nighttime	3,065	2,572	1,362	1,213	4,427	3,785
Target Two-PV (1)						
Daytime	14,048	12,220	5,831	5,573	19,879	17,793
Nighttime	3,761	3,108	1,456	1,260	5,217	4,368
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	112	98	38	43	150	141
Nighttime	79	51	18	37	97	88
Single-PV-to-Motorcycle (3)						
Daytime	83	71	35	31	118	102
Nighttime	20	20	7	7	27	27
All Target Crashes (1) + (2) + (3)						
Daytime	14,243	12,389	5,904	5,647	20,147	18,036
Nighttime	3,860	3,179	1,481	1,304	5,341	4,483

PV: passenger vehicle
Source: State Data System
* Same as excluding dawn and dusk due to no specific code to separate dawn and dusk.

Table 3-17
All Crash Severity Levels Including Dawn and Dusk
Nebraska (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,079	1,086	733	669	1,812	1,755
Nighttime	1,049	1,020	718	602	1,767	1,622
Target Two-PV (1)						
Daytime	4,177	3,906	1,904	1,782	6,081	5,688
Nighttime	774	712	362	272	1,136	984
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	74	74	41	39	115	113
Nighttime	12	19	8	5	20	24
Single-PV-to-Motorcycle (3)						
Daytime	22	15	9	9	31	24
Nighttime	4	3	2	1	6	4
All Target Crashes (1) + (2) + (3)						
Daytime	4,273	3,995	1,954	1,830	6,227	5,825
Nighttime	790	734	372	278	1,162	1,012

PV: passenger vehicle
Source: State Data System

Table 3-18
All Crash Severity Levels Including Dawn and Dusk
Pennsylvania (2000-2005*)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	3,292	3,039	861	973	4,153	4,012
Nighttime	3,433	3,062	821	930	4,254	3,992
Target Two-PV (1)						
Daytime	7,810	7,494	2,175	2,323	9,985	9,817
Nighttime	2,354	2,237	625	629	2,979	2,866
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	406	400	118	117	524	517
Nighttime	142	159	38	40	180	199
Single-PV-to-Motorcycle (3)						
Daytime	135	143	27	42	162	185
Nighttime	29	23	8	8	37	31
All Target Crashes (1) + (2) + (3)						
Daytime	8,351	8,037	2,320	2,482	10,671	10,519
Nighttime	2,525	2,419	671	677	3,196	3,096

PV: passenger vehicle
Source: State Data System
* Excluding 2002.

Table 3-19
All Crash Severity Levels Including Dawn and Dusk
Utah (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	699	620	418	316	1,117	936
Nighttime	691	550	366	299	1,057	849
Target Two-PV (1)						
Daytime	3,322	2,942	1,792	1,638	5,114	4,580
Nighttime	851	781	408	345	1,259	1,126
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	86	73	72	56	158	129
Nighttime	30	27	11	11	41	38
Single-PV-to-Motorcycle (3)						
Daytime	31	28	29	12	60	40
Nighttime	1	7	3	3	4	10
All Target Crashes (1) + (2) + (3)						
Daytime	3,439	3,043	1,893	1,706	5,332	4,749
Nighttime	882	815	422	359	1,304	1,174

PV: passenger vehicle
Source: State Data System

Table 3-20
All Crash Severity Levels Including Dawn and Dusk
Wisconsin (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,254	2,388	1,243	1,104	3,497	3,492
Nighttime	2,397	2,532	1,273	1,258	3,670	3,790
Target Two-PV (1)						
Daytime	10,059	10,160	4,543	4,549	14,602	14,709
Nighttime	2,658	2,753	1,143	1,046	3,801	3,799
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	120	169	70	63	190	232
Nighttime	53	67	35	26	88	93
Single-PV-to-Motorcycle (3)						
Daytime	121	115	50	53	171	168
Nighttime	26	22	8	13	34	35
All Target Crashes (1) + (2) + (3)						
Daytime	10,300	10,444	4,663	4,665	14,963	15,109
Nighttime	2,737	2,842	1,186	1,085	3,923	3,927

PV: passenger vehicle
Source: State Data System

Table 3-21
All Crash Severity Levels Including Dawn and Dusk
Nine States Combined Total

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	20,763	18,752	8,983	8,023	29,746	26,775
Nighttime	22,119	19,404	10,157	9,096	32,276	28,500
Target Two-PV (1)						
Daytime	95,581	87,936	35,704	33,792	131,285	121,728
Nighttime	27,100	24,706	9,574	8,566	36,674	33,272
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	2,308	2,251	864	800	3,172	3,051
Nighttime	794	764	274	287	1,068	1,051
Single-PV-to-Motorcycle (3)						
Daytime	986	897	372	323	1,358	1,220
Nighttime	267	233	86	84	353	317
All Target Crashes (1) + (2) + (3)						
Daytime	98,875	91,084	36,940	34,915	135,815	125,999
Nighttime	28,161	25,703	9,934	8,937	38,095	34,640

PV: passenger vehicle
Source: State Data System

3.2 Excluding Dawn and Dusk

The following tables mirror those reported in the previous section. Daytime categorization is the only change between these two sections. Thus, nighttime crash frequencies are identical to those previously reported. Crash cases under dawn and dusk conditions were generally small. Consequently, the impacts of not including crashes occurring during the dawn and dusk conditions in the analysis were negligible.

Note that Missouri is the only State that did not provide a differentiating coding for dawn and dusk conditions. Therefore, the daytime definition did not change for Missouri throughout the analysis. Since crash cases in dawn and dusk conditions were uniformly small for all of the other eight States and for FARS, it's reasonable to assume that this pattern would also apply to Missouri. The dawn and dusk cases comprise less than 1 percent of the aggregated sample and do not have significant impacts on the combined effects. Missouri produced a very moderate sample, but if excluded, the estimated combined results would be even less precise. Therefore, Missouri is included in the section set of crash sample.

Fatal Crashes

Table 3-22
Fatal Crashes Excluding Dawn and Dusk

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	839	900	612	648	1,451	1,548
Nighttime	1,394	1,380	916	916	2,310	2,296
Target Two-PV (1)						
Daytime	1,591	1,614	1,012	1,143	2,603	2,757
Nighttime	777	795	534	483	1,311	1,278
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	154	171	139	138	293	309
Nighttime	378	324	232	225	610	549
Single-PV-to-Motorcycle (3)						
Daytime	124	114	102	111	226	225
Nighttime	56	52	34	41	90	93
All Target Crashes (1) + (2) + (3)						
Daytime	1,869	1,899	1,253	1,392	3,122	3,291
Nighttime	1,211	1,171	800	749	2,011	1,920

PV: passenger vehicle
Source: 2000-2005 Fatality Analysis Reporting System (FARS)

Injury Crashes

Table 3-23
Injury Crashes Excluding Dawn and Dusk
Florida (2000 – 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	993	849	389	343	1,382	1,192
Nighttime	903	810	396	404	1,299	1,214
Target Two-PV (1)						
Daytime	7,444	6,643	2,464	2,342	9,908	8,985
Nighttime	2,425	2,103	853	749	3,278	2,852
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	466	433	185	187	651	620
Nighttime	201	187	84	96	285	283
Single-PV-to-Motorcycle (3)						
Daytime	230	191	86	71	316	262
Nighttime	108	87	28	31	136	118
All Target Crashes (1) + (2) + (3)						
Daytime	8,140	7,267	2,735	2,600	10,875	9,867
Nighttime	2,734	2,377	965	876	3,699	3,253

PV: passenger vehicle
Source: State Data System

Table 3-24
Injury Crashes Excluding Dawn and Dusk
Illinois (2000 – 2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	771	712	291	260	1,062	972
Nighttime	921	833	394	344	1,315	1,177
Target Two-PV (1)						
Daytime	4,897	4,477	1,585	1,472	6,482	5,949
Nighttime	1,716	1,619	542	454	2,258	2,073
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	441	434	175	139	616	573
Nighttime	159	162	51	48	210	210
Single-PV-to-Motorcycle (3)						
Daytime	90	99	45	23	135	122
Nighttime	30	37	10	8	40	45
All Target Crashes (1) + (2) + (3)						
Daytime	5,428	5,010	1,805	1,634	7,233	6,644
Nighttime	1,905	1,818	603	510	2,508	2,328

PV: passenger vehicle
Source: State Data System

Table 3-25
Injury Crashes Excluding Dawn and Dusk
Maryland (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	780	633	99	124	879	757
Nighttime	188	179	27	22	215	201
Target Two-PV (1)						
Daytime	2,475	2,216	444	403	2,919	2,619
Nighttime	459	355	77	82	536	437
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	283	252	43	44	326	296
Nighttime	36	28	5	4	41	32
Single-PV-to-Motorcycle (3)						
Daytime	85	47	13	8	98	55
Nighttime	1	1	0	1	1	2
All Target Crashes (1) + (2) + (3)						
Daytime	2,843	2,515	500	455	3,343	2,970
Nighttime	496	384	82	87	578	471

PV: passenger vehicle
Source: State Data System

Table 3-26
Injury Crashes Excluding Dawn and Dusk
Michigan (2004 - 2005)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	536	502	234	224	770	726
Nighttime	492	493	239	211	731	704
Target Two-PV (1)						
Daytime	1,963	2,010	815	868	2,778	2,878
Nighttime	655	606	254	273	909	879
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	131	132	62	53	193	185
Nighttime	60	44	13	17	73	61
Single-PV-to-Motorcycle (3)						
Daytime	41	38	24	24	65	62
Nighttime	11	8	5	4	16	12
All Target Crashes (1) + (2) + (3)						
Daytime	2,135	2,180	901	945	3,036	3,125
Nighttime	726	658	272	294	998	952

PV: passenger vehicle
Source: State Data System

Table 3-27
Injury Crashes Excluding Dawn and Dusk*
Missouri (2000 - 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,133	1,057	493	449	1,626	1,506
Nighttime	1,105	977	521	470	1,626	1,447
Target Two-PV (1)						
Daytime	3,521	3,160	1,482	1,413	5,003	4,573
Nighttime	1,142	905	427	371	1,569	1,276
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	103	94	37	40	140	134
Nighttime	74	48	17	33	91	81
Single-PV-to-Motorcycle (3)						
Daytime	65	49	26	25	91	74
Nighttime	18	17	5	6	23	23
All Target Crashes (1) + (2) + (3)						
Daytime	3,689	3,303	1,545	1,478	5,234	4,781
Nighttime	1,234	970	449	410	1,683	1,380

PV: passenger vehicle
Source: State Data System
* Same as including dawn and dusk due to no specific code to separate dawn and dusk.

Table 3-28
Injury Crashes Excluding Dawn and Dusk
Nebraska (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	233	264	105	118	338	382
Nighttime	259	258	142	139	401	397
Target Two-PV (1)						
Daytime	1,232	1,117	517	501	1,749	1,618
Nighttime	273	267	129	87	402	354
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	67	69	37	37	104	106
Nighttime	11	18	8	5	19	23
Single-PV-to-Motorcycle (3)						
Daytime	9	12	8	5	17	17
Nighttime	1	1	1	1	2	2
All Target Crashes (1) + (2) + (3)						
Daytime	1,308	1,198	562	543	1,870	1,741
Nighttime	285	286	138	93	423	379

PV: passenger vehicle
Source: State Data System

Table 3-29
Injury Crashes Excluding Dawn and Dusk
Pennsylvania (2000-2005*)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,582	1,452	414	466	1,996	1,918
Nighttime	1,580	1,471	409	456	1,989	1,927
Target Two-PV (1)						
Daytime	4,553	4,418	1,296	1,251	5,849	5,669
Nighttime	1,455	1,432	384	401	1,839	1,833
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	381	381	109	112	490	493
Nighttime	142	158	38	39	180	197
Single-PV-to-Motorcycle (3)						
Daytime	124	128	24	38	148	166
Nighttime	29	19	7	7	36	26
All Target Crashes (1) + (2) + (3)						
Daytime	5,058	4,927	1,429	1,401	6,487	6,328
Nighttime	1,626	1,609	429	447	2,055	2,056

PV: passenger vehicle
Source: State Data System
* Excluding 2002.

Table 3-30
Injury Crashes Excluding Dawn and Dusk
Utah (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	213	206	131	102	344	308
Nighttime	195	161	96	87	291	248
Target Two-PV (1)						
Daytime	1,104	953	544	486	1,648	1,439
Nighttime	341	296	163	141	504	437
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	75	61	59	48	134	109
Nighttime	28	26	11	10	39	36
Single-PV-to-Motorcycle (3)						
Daytime	28	20	25	7	53	27
Nighttime	1	4	2	3	3	7
All Target Crashes (1) + (2) + (3)						
Daytime	1,207	1,034	628	541	1,835	1,575
Nighttime	370	326	176	154	546	480

PV: passenger vehicle
Source: State Data System

Table 3-31
Injury Crashes Excluding Dawn and Dusk
Wisconsin (2000-2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	739	844	373	357	1,112	1,201
Nighttime	841	907	462	471	1,303	1,378
Target Two-PV (1)						
Daytime	2,840	2,935	1,140	1,189	3,980	4,124
Nighttime	782	829	343	245	1,125	1,074
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	109	155	68	58	177	213
Nighttime	52	65	34	25	86	90
Single-PV-to-Motorcycle (3)						
Daytime	90	86	37	44	127	130
Nighttime	23	15	6	7	29	22
All Target Crashes (1) + (2) + (3)						
Daytime	3,039	3,176	1,245	1,291	4,284	4,467
Nighttime	857	909	383	277	1,240	1,186

PV: passenger vehicle
Source: State Data System

Table 3-32
Injury Crashes Excluding Dawn and Dusk
Nine States Combined Total

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	6,980	6,519	2,529	2,443	9,509	8,962
Nighttime	6,484	6,089	2,686	2,604	9,170	8,693
Target Two-PV (1)						
Daytime	30,029	27,929	10,287	9,925	40,316	37,854
Nighttime	9,248	8,412	3,172	2,803	12,420	11,215
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	2,056	2,011	775	718	2,831	2,729
Nighttime	763	736	261	277	1,024	1,013
Single-PV-to-Motorcycle (3)						
Daytime	762	670	288	245	1,050	915
Nighttime	222	189	64	68	286	257
All Target Crashes (1) + (2) + (3)						
Daytime	32,847	30,610	11,350	10,888	44,197	41,498
Nighttime	10,233	9,337	3,497	3,148	13,730	12,485

PV: passenger vehicle
Source: State Data System

All Crashes

Table 3-33
All Crash Severity Levels Excluding Dawn and Dusk
Florida (2000 – 2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,412	1,265	557	518	1,969	1,783
Nighttime	1,749	1,527	719	701	2,468	2,228
Target Two-PV (1)						
Daytime	10,751	9,516	3,680	3,477	14,431	12,993
Nighttime	4,101	3,574	1,471	1,335	5,572	4,909
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	481	441	188	193	669	634
Nighttime	207	193	85	96	292	289
Single-PV-to-Motorcycle (3)						
Daytime	253	198	99	78	352	276
Nighttime	126	95	34	33	160	128
All Target Crashes (1) + (2) + (3)						
Daytime	11,485	10,155	3,967	3,748	15,452	13,903
Nighttime	4,434	3,862	1,590	1,464	6,024	5,326

PV: passenger vehicle
Source: State Data System

Table 3-34
All Crash Severity Levels Excluding Dawn and Dusk
Illinois (2000 – 2003)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	3,011	2,671	1,187	1,077	4,198	3,748
Nighttime	4,884	4,088	2,247	2,003	7,131	6,091
Target Two-PV (1)						
Daytime	26,878	24,739	9,368	8,224	36,246	32,963
Nighttime	8,789	8,066	2,814	2,406	11,603	10,472
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	454	454	182	141	636	595
Nighttime	165	167	56	48	221	215
Single-PV-to-Motorcycle (3)						
Daytime	151	170	73	46	224	216
Nighttime	45	52	19	13	64	65
All Target Crashes (1) + (2) + (3)						
Daytime	27,483	25,363	9,623	8,411	37,106	33,774
Nighttime	8,999	8,285	2,889	2,467	11,888	10,752

PV: passenger vehicle
Source: State Data System

Table 3-35
All Crash Severity Levels Excluding Dawn and Dusk
Maryland (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,001	1,611	348	312	2,349	1,923
Nighttime	671	591	99	94	770	685
Target Two-PV (1)						
Daytime	6,453	5,486	1,330	1,124	7,783	6,610
Nighttime	1,155	944	249	224	1,404	1,168
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	327	291	52	51	379	342
Nighttime	40	35	7	6	47	41
Single-PV-to-Motorcycle (3)						
Daytime	98	67	16	12	114	79
Nighttime	4	1	0	1	4	2
All Target Crashes (1) + (2) + (3)						
Daytime	6,878	5,844	1,398	1,187	8,276	7,031
Nighttime	1,199	980	256	231	1,455	1,211

PV: passenger vehicle
Source: State Data System

Table 3-36
All Crash Severity Levels Excluding Dawn and Dusk
Michigan (2004-2005)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,568	2,196	1,430	1,142	3,998	3,338
Nighttime	4,180	3,462	2,552	1,996	6,732	5,458
Target Two-PV (1)						
Daytime	9,148	8,769	3,986	4,100	13,134	12,869
Nighttime	2,657	2,531	1,046	1,049	3,703	3,580
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	154	152	76	60	230	212
Nighttime	66	46	16	18	82	64
Single-PV-to-Motorcycle (3)						
Daytime	68	54	28	29	96	83
Nighttime	12	10	5	5	17	15
All Target Crashes (1) + (2) + (3)						
Daytime	9,370	8,975	4,090	4,189	13,460	13,164
Nighttime	2,735	2,587	1,067	1,072	3,802	3,659

PV: passenger vehicle
Source: State Data System

Table 3-37
All Crash Severity Levels Excluding Dawn and Dusk*
Missouri (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	2,925	2,637	1,252	1,130	4,177	3,767
Nighttime	3,065	2,572	1,362	1,213	4,427	3,785
Target Two-PV (1)						
Daytime	14,048	12,220	5,831	5,573	19,879	17,793
Nighttime	3,761	3,108	1,456	1,260	5,217	4,368
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	112	98	38	43	150	141
Nighttime	79	51	18	37	97	88
Single-PV-to-Motorcycle (3)						
Daytime	83	71	35	31	118	102
Nighttime	20	20	7	7	27	27
All Target Crashes (1) + (2) + (3)						
Daytime	14,243	12,389	5,904	5,647	20,147	18,036
Nighttime	3,860	3,179	1,481	1,304	5,341	4,483

PV: passenger vehicle
Source: State Data System
* Same as including dawn and dusk due to no specific code to separate dawn and dusk.

Table 3-38
All Crash Severity Levels Excluding Dawn and Dusk
Nebraska (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	916	918	588	550	1,504	1,468
Nighttime	1,049	1,020	718	602	1,767	1,622
Target Two-PV (1)						
Daytime	3,998	3,726	1,814	1,701	5,812	5,427
Nighttime	774	712	362	272	1,136	984
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	71	70	39	38	110	108
Nighttime	12	19	8	5	20	24
Single-PV-to-Motorcycle (3)						
Daytime	17	15	9	7	26	22
Nighttime	4	3	2	1	6	4
All Target Crashes (1) + (2) + (3)						
Daytime	4,086	3,811	1,862	1,746	5,948	5,557
Nighttime	790	734	372	278	1,162	1,012

PV: passenger vehicle
Source: State Data System

Table 3-39
All Crash Severity Levels Excluding Dawn and Dusk
Pennsylvania (2000-2005*)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	3,059	2,818	783	886	3,842	3,704
Nighttime	3,433	3,062	821	930	4,254	3,992
Target Two-PV (1)						
Daytime	7,475	7,186	2,084	2,190	9,559	9,376
Nighttime	2,354	2,237	625	629	2,979	2,866
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	382	381	109	112	491	493
Nighttime	142	159	38	40	180	199
Single-PV-to-Motorcycle (3)						
Daytime	130	134	27	40	157	174
Nighttime	29	23	8	8	37	31
All Target Crashes (1) + (2) + (3)						
Daytime	7,987	7,701	2,220	2,342	10,207	10,043
Nighttime	2,525	2,419	671	677	3,196	3,096

PV: passenger vehicle
Source: State Data System
* Excluding 2002.

Table 3-40
All Crash Severity Levels Excluding Dawn and Dusk
Utah (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	596	529	358	269	954	798
Nighttime	691	550	366	299	1,057	849
Target Two-PV (1)						
Daytime	3,115	2,758	1,679	1,518	4,794	4,276
Nighttime	851	781	408	345	1,259	1,126
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	79	65	64	49	143	114
Nighttime	30	27	11	11	41	38
Single-PV-to-Motorcycle (3)						
Daytime	31	25	28	10	59	35
Nighttime	1	7	3	3	4	10
All Target Crashes (1) + (2) + (3)						
Daytime	3,225	2,848	1,771	1,577	4,996	4,425
Nighttime	882	815	422	359	1,304	1,174

PV: passenger vehicle
Source: State Data System

Table 3-41
All Crash Severity Levels Excluding Dawn and Dusk
Wisconsin (2000-2004)

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	1,991	2,124	1,086	971	3,077	3,095
Nighttime	2,397	2,532	1,273	1,258	3,670	3,790
Target Two-PV (1)						
Daytime	9,607	9,740	4,351	4,351	13,958	14,091
Nighttime	2,658	2,753	1,143	1,046	3,801	3,799
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	112	160	69	59	181	219
Nighttime	53	67	35	26	88	93
Single-PV-to-Motorcycle (3)						
Daytime	116	111	47	51	163	162
Nighttime	26	22	8	13	34	35
All Target Crashes (1) + (2) + (3)						
Daytime	9,835	10,011	4,467	4,461	14,302	14,472
Nighttime	2,737	2,842	1,186	1,085	3,923	3,927

PV: passenger vehicle
Source: State Data System

Table 3-42
All Crash Severity Levels Excluding Dawn and Dusk
Nine States Combined Total

Crash Type	Passenger Cars		Light Trucks/Vans		Combined	
	DRL	No DRL	DRL	No DRL	DRL	No DRL
Single-PV, Excluding Pedestrian/Pedalcyclist						
Daytime	18,479	16,769	7,589	6,855	26,068	23,624
Nighttime	22,119	19,404	10,157	9,096	32,276	28,500
Target Two-PV (1)						
Daytime	91,473	84,140	34,123	32,258	125,596	116,398
Nighttime	27,100	24,706	9,574	8,566	36,674	33,272
Single-PV-to-Pedestrian/Pedalcyclist (2)						
Daytime	2,172	2,112	817	746	2,989	2,858
Nighttime	794	764	274	287	1,068	1,051
Single-PV-to-Motorcycle (3)						
Daytime	947	845	362	304	1,309	1,149
Nighttime	267	233	86	84	353	317
All Target Crashes (1) + (2) + (3)						
Daytime	94,592	87,097	35,302	33,308	129,894	120,405
Nighttime	28,161	25,703	9,934	8,937	38,095	34,640

PV: passenger vehicle
Source: State Data System

3.3 Descriptive Characteristics

This section presents vehicle age, driver age, and driver gender characteristics of the crash samples by DRL status and vehicle type. This section also examines any differences that existed for these characteristics between FARS and CDS samples. Mean vehicle age, mean driver age, and the percentage of male drivers were used to describe these characteristics. As mentioned earlier, the number of crashes that occurred during dawn and dusk conditions were relatively small. Excluding these crashes did not influence these statistics. The statistics for crashes including dawn and dusk were almost identical to those for crashes when dawn and dusk were excluded. Therefore, statistics only for crashes including dawn and dusk are presented in this section.

Vehicle Age

Table 3-43 shows the mean vehicle age by vehicle type, DRL status, and data source. For PCs, the mean vehicle age[38] of the DRL-equipped vehicle sample in FARS was 6.6 years old with a standard deviation of 2.0 years (SE=2.0 years). The mean age for non-DRL vehicles is 8.4 years old (SE=2.0). These are very similar to the mean vehicle ages of 6.3 (SE=1.9) and 8.1 years old (SE=1.9) derived from the State data.

For LTVs, the mean vehicle ages for the FARS sample were 7.0 and 8.9 years old for DRL-equipped and non-DRL vehicles, respectively. The corresponding mean vehicle ages for the State samples were 6.8 and 8.7 years old. All four statistics had an SE of 1.8 years.

[38] The analysis used the PROC MEAN procedure in the Statistical Analysis System (SAS) to derive mean ages. SAS is a software system developed by SAS institute in North Carolina.

Table 3-43
Mean Vehicle Age by DRL Status, Vehicle Type, and Data Source

Passenger Cars	DRL-Vehicles	Non-DRL Vehicles
FARS	6.6	8.4
State Data	6.3	8.1
Light Trucks/Vans		
FARS	7.0	8.9
State Data	6.8	8.7

Driver Age

Table 3-44 shows the mean driver age by vehicle type, DRL status, and data source. For PCs, the mean age of drivers of the DRL-equipped vehicles in FARS was 39.5 years old (SE=21.4 years). The mean age for drivers of the non-DRL vehicles was 38.1 years old (SE=20.3). These are very similar to the mean drivers' ages of 36.1 (SE=19.8) and 35.4 years old (SE=19.5) derived from the State data. However, the age gap between FARS and State data was larger for PCs than that for LTVs.

For LTVs, the mean drivers' age of the DRL-equipped vehicles in FARS was 37.3 years old (SE=16.1 years). The mean age for drivers of the non-DRL vehicles was 38.2 years old (SE=16.3). These are very similar to the mean drivers' ages of 36.7 (SE=16.2) and 36.6 years old (SE=16.3) derived from the State data.

Table 3-44
Mean Driver Age by DRL Status, Vehicle Type, and Data Source

Passenger Cars	DRL-Vehicles	Non-DRL Vehicles
FARS	39.5	38.1
State Data	36.1	35.4
Light Trucks/Vans		
FARS	37.3	38.2
State Data	36.7	36.6

Driver Gender

Table 3-45 shows the male driver percentage by vehicle type, DRL status, and data source. For PCs, male drivers comprised about 60.3 percent of drivers in DRL-equipped vehicles in FARS and 61.3 percent of drivers in non-DRL vehicles. These are higher than the male percentages derived from the State Data. The corresponding percentages from State Data were 45.4 and 48.0, respectively.

For LTVs, male drivers comprised a relatively larger proportion of the drivers compared to passenger car drivers. As shown in Table 3-45, based on FARS, 76.7 percent of drivers in DRL-equipped LTVs and 80.3 percent in non-DRL LTVs were males. Based on State Data, 70.1 percent of drivers in DRL-equipped LTVs and 73.2 percent in non-DRL LTVs were males.

As shown, LTV samples had more male drivers than did PC samples. For both PCs and LTVs, male drivers comprised a higher percentage in fatal crash samples (FARS) than in all crash samples (State Data). However, the difference in male driver percentage between FARS and State Data is greater for PCs than for LTVs.

Table 3-45
Percent of Male Drivers by DRL Status, Vehicle Type, and Data Source

Passenger Cars	DRL-Vehicles	Non-DRL Vehicles
FARS	60.3	61.3
State Data	45.4	48.0
Light Trucks/Vans		
FARS	76.7	80.3
State Data	70.1	73.2

CHAPTER 4. EFFECTIVENESS

Crashes presented in Chapter 3 were used in this chapter to derive the effectiveness of DRLs. The estimated DRL effects are also organized into two sections that correspond to the baseline crashes presented in Chapter 3. For each section (based on daytime classification), DRL effectiveness was computed for three types of daytime target crashes (Two-PV, Single-PV-to-PED/CYC, and Single-PV-to-Motorcycle); three crash severities (fatal crashes, injury crashes, and all crashes); and two vehicle types (PCs and LTVs). The control crashes were single passenger vehicle crashes excluding pedestrian/pedalcyclist.

To start, control and target crashes were rearranged to form two 2x2 contingency tables as described in the methodology chapter. The eight crash frequencies shown in these 2x2 contingency tables were used to derive odds ratios and subsequently the effectiveness and standard error. Table 4-1 uses fatal Two-PV crashes as an example to illustrate the process of estimating DRL effectiveness.

Table 4-1
DRL Effectiveness Against Daytime Target Fatal Two-Passenger Vehicle Crashes*
For Passenger Cars (Including Dawn and Dusk)

DRL-Equipped Vehicles	Target Two-Passenger Vehicle Crashes	Single Vehicle Excluding Pedestrian/Pedalcyclist	
Daytime	1,695	928	
Nighttime	777	1,394	
		Odds Ratio (R_1)	3.2769
Non DRL Vehicles			
Daytime	1,722	993	
Nighttime	795	1,380	
		Odds Ratio (R_2)	3.0102
	Ratio of Odds Ratios (R)		1.0890
	Effectiveness (E) in %		-8.9%

*Excluding rear-end crashes.

As shown, Odds ratio for DRL-equipped vehicles (R_1) is computed as:

$$R_1 = \frac{1{,}695 * 1{,}394}{777 * 928} = 3.2769$$

Odds ratio for non-DRL vehicles (R_2) is computed as:

$$R_2 = \frac{1{,}722 * 1{,}380}{795 * 993} = 3.0102$$

The ratio of these two odds ratios (R) is

$$R = \frac{3.2769}{3.0102} = 1.0890$$

The effectiveness of DRLs against daytime target Two-PV fatal crashes for PCs is derived by using the formula 100*(1- R), i.e.,

E = 100*(1-1.0890) = -8.9%

The estimated effectiveness of -8.9 percent indicates that DRLs in PCs increased daytime target Two-PV fatal crashes by 8.9 percent. Statistical estimates were commonly associated with a degree of uncertainty. The 95-percent confidence interval was chosen to ascertain the range of the true effect and the likelihood that the true effect would be in this range.

The next is to calculate a 95-percent confidence interval of E using the log-transformation process. The confidence limits of the interval are derived from the following formula:

$$1 - e^{\ln(R) \pm 1.96 * \sigma_{\ln(R)}}.$$

Within the formula, ln(R), the natural log of the sample ratio of odds ratios equals ln(1.10890) = 0.0853 and $\sigma_{\ln(R)}$, its standard error equals

$$\sigma_{\ln(R)} = \sqrt{\frac{1}{1{,}695} + \frac{1}{777} + \frac{1}{928} + \frac{1}{1{,}394} + \frac{1}{1{,}722} + \frac{1}{795} + \frac{1}{993} + \frac{1}{1{,}380}}$$
$$= 0.0851$$

The 95-percent confidence limits for the ln(R) equal $-0.0853 \pm 1.96 * (0.0851)$, or (-0.2521, -0.0815). The 95-percent corresponding confidence limits of R can be represented as:

$$\left[e^{-0.2521}, e^{0.0815}\right] = (0.922, 1.287).$$

Therefore, the 95-percent confidence bounds in percent for the effectiveness estimate, E, is:

$$\left[(1-1.287)*100, (1-0.922)*100\right] = \text{(-28.7 percent, 7.8 percent)}.$$

The confidence interval includes the 0 percent (no effects), signaling that the estimated DRLs effect was not statistically significant at the 0.05 level.

Similarly, applying the calculation processes to other pairs of the control-target (or comparison) crashes derives the DRL effectiveness against that specific daytime target crashes. For injury crashes and all crashes, DRL effects were estimated both for individual States and nine States combined. The combined State effects were based on crashes pooled together from all the baseline cases from the nine States. As expected, large States or States that produced large crash cases had significant influence on the estimated outcomes. When all target crashes were aggregated into one sample, the effects of DRLs were mostly driven by the target Two-PV crashes because of its large sample size.

Bold faced figures shown in the following tables indicate that the results were statistically significant at the 0.05 level. If one of the eight frequencies used to derive DRL effectiveness is less than 10, the result was not presented. Crash cases less than 10 contributed the most to standard error and produced a wide confidence interval. A wide confidence interval infers that the estimated effects were imprecise. This problem is especially acute for the measured DRL effects against target motorcycle crashes.

4.1 Including Dawn and Dusk

Target Two Passenger-Vehicle Crashes (target Two-PV)

Table 4-2 shows the effectiveness of DRLs against daytime target Two-PV crashes (i.e., Two-PV crashes excluding rear-end crashes). As shown, the vast majority of these estimated effects were not statistically significant at the 0.05 level.

For fatal crashes, DRLs in PCs seemed to increase the likelihood of a PC's involvement in daytime target Two-PV fatal crashes by 8.9 percent. In contrast, DRLs in LTVs would reduce LTV involvement in target Two-PV fatal crashes by 13.8 percent. Overall, DRLs would almost have no impact (effectiveness = 0.7) on the target Two-PV fatal crashes. All these estimated effects were not statistically significant.

For injury crashes, the DRL effect for PCs in Maryland was statistically significant. In Maryland, DRLs would reduce PC involvement in target Two-PV injury crashes by 26.0 percent. However, the remaining individual State and combined estimates for PCs were not statistically significant. Results for PCs from individual States fluctuated between positive and negative (5 out 9 were negative). This indicated that no definitive trend can be detected to show whether DRLs would increase or reduce PC involvement in target Two-PV crashes.

For LTVs, Florida and Wisconsin showed statistically significant DRL effects. In Florida, DRLs in LTVs would reduce 21.0 percent of the target Two-PV injury crashes that involved an LTV. In Wisconsin, DRLs in LTVs would reduce 34.3 percent of the target Two-PV injury crashes that involved an LTV. DRL effects for LTVs for the remaining seven States as well as the combined effect were not statistically significant. Although, similar to PCs, DRL effects for LTVs from individual States fluctuated between positive and negative, more (6 out of 9) States showed that DRLs would reduce LTV involvement in target Two-PV injury crashes.

When the State data were pooled together as one crash sample, DRLs seemed to reduce daytime target Two-PV injury crashes by 2.3 and 8.2 percent for PCs and LTVs, respectively. These estimates were not statistically significant. Altogether, for injury crashes, DRLs seemed to reduce daytime target Two-PV injury crashes by 3.9 percent. This effect was not statistically significant either.

For all crashes, all estimates for PCs were not statistically significant. However, eight States and the combined results showed that DRL had a negative impact for PCs. For LTVs, Wisconsin is the only State that produced a statistically significant effect. In Wisconsin, DRLs reduced the LTV involvements in Two-PV crashes by 17.9 percent. The combined State effect of 5.7 percent was also statistically significant which indicated that DRLs reduced the target Two-PV injury crashes by 5.7 percent. However, the individual and combined State DRL effects for PCs and LTVs were moving in opposite directions. When all PVs and the nine States were pooled together, DRLs almost had no effect on target Two-PV crashes.

Table 4-2
DRL Effectiveness Against the Target Two-Passenger-Vehicle Crashes*
Including Dawn and Dusk

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-8.9	-28.7	7.8	13.8	-5.6	29.6	0.7	-13.0	12.7
Injury Crashes									
Florida	7.7	-6.8	20.2	**21.0**	1.0	37.0	**11.9**	0.5	22.0
Illinois	-4.0	-21.5	11.0	2.1	-26.5	24.2	-2.9	-17.5	9.9
Maryland	**26.0**	2.7	43.7	-73.9	-252.3	14.2	16.3	-8.0	35.1
Michigan	13.5	-6.8	29.9	-11.3	-53.2	19.1	6.6	-11.4	21.7
Missouri	6.8	-8.9	20.3	8.0	-16.7	27.5	7.4	-5.5	18.7
Nebraska	-25.0	-69.0	7.6	25.9	-16.0	52.7	-7.5	-38.0	16.2
Pennsylvania	-1.9	-16.0	10.5	-7.1	-36.7	16.1	-3.1	-15.6	8.0
Utah	-11.0	-54.0	20.0	11.9	-39.3	44.3	-2.6	-33.9	21.4
Wisconsin	-8.4	-28.8	8.8	**34.3**	14.7	49.4	5.4	-9.2	18.0
States Combined	2.3	-3.6	7.8	8.2	-1.0	16.5	3.9	-1.0	8.6
All Crashes									
Florida	-0.5	-12.5	10.2	9.4	-8.1	24.1	2.6	-7.1	11.4
Illinois	-4.6	-12.4	2.7	3.0	-8.5	13.3	-2.4	-8.8	3.6
Maryland	12.4	-2.6	25.2	0.4	-45.0	31.6	10.2	-3.9	22.4
Michigan	-1.2	-10.9	7.6	-0.6	-14.6	11.7	-1.0	-8.8	6.3
Missouri	-2.1	-11.9	6.8	8.2	-5.5	20.2	1.3	-6.5	8.6
Nebraska	-1.8	-19.9	13.6	12.6	-9.7	30.4	2.3	-11.5	14.4
Pennsylvania	-2.5	-12.8	6.9	6.0	-12.7	21.6	-0.7	-9.6	7.5
Utah	-15.5	-39.7	4.5	14.4	-11.5	34.3	-4.2	-21.6	10.7
Wisconsin	-2.8	-13.6	7.0	**17.9**	5.0	29.1	4.1	-4.1	11.7
States Combined	-2.0	-5.5	1.4	**5.7**	0.6	10.5	0.3	-2.6	3.1

* Excluding rear-end crashes.
E: effectiveness; CI: confidence interval
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist (Single-PV-to-PED/CYC) Crashes

Table 4-3 shows the effectiveness of DRLs in Single-PV-to-PED/CYC crashes. None of these effects were statistically significant. Note the analysis does not report any results that were derived from the contingency tables that had one of the frequencies less than 10.

For fatal crashes, DRLs in PCs reduced fatal Single-PC-to-PED/CYC crashes by 19.1 percent. DRLs in LTVs, contrarily, seemed to increase Single-LTV-to-PED/CYC crashes by 2.3 percent. These effects were not statistically significant at the 0.05 level. Overall, DRLs seemed to have no impact on fatal Single-LTV-to-PED/CYC crashes.

For injury crashes, none of the DRL effects for PCs and LTVs were statistically significant. The direction of DRL effects on injury crashes was consistent to that on fatal crashes (i.e., DRLs seemed to reduce Single-PC-to-PED/CYC injury crashes but increase Single-LTV-to-PED/CYC crashes). Overall, DRLs seemed to increase Single-PV-to-PED/CYC injury crashes by 1.7 percent. The effect was not statistically significant.

For all crashes, similar to injury crashes, none of the estimates were statistically significant. Based on the combined State data, DRLs seemed to increase Single-PC-to-PED/CYC crashes and Single-LTV-to-PED/CYC crashes. Overall, DRLs seemed to increase Single-PV-to-PED/CYC crashes by 4.3 percent.

Table 4-3
DRL Effectiveness Against
Daytime Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist Crashes
Including Dawn and Dusk

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	19.1	-6.8	38.7	-2.3	-40.7	25.6	0.1	-0.1	0.3
Injury Crashes									
Florida	4.1	-25.4	26.7	9.6	-35.3	39.6	5.6	-18.0	24.5
Illinois	-2.9	-37.0	22.7	-24.5	-104.5	24.2	-8.6	-39.1	15.2
Maryland	25.7	-31.4	58.0	--	--	--	21.3	-34.2	53.8
Michigan	34.9	-5.6	59.8	-71.7	-299.9	26.3	16.5	-26.6	44.9
Missouri	25.0	-20.5	53.3	-81.3	-286.8	15.0	3.2	-43.6	34.8
Nebraska	-82.2	-327.3	22.3	--	--	--	-34.2	-167.7	32.7
Pennsylvania	-13.3	-50.4	14.6	-5.4	-82.1	39.0	-11.7	-43.6	13.1
Utah	-20.8	-138.6	38.8	-0.5	-174.1	63.1	-13.7	-98.8	35.0
Wisconsin	5.8	-48.5	40.2	21.5	-50.0	58.9	11.6	-28.0	38.9
States Combined	2.0	-11.3	13.7	-13.1	-39.5	8.3	-1.7	-13.4	8.8
All Crashes									
Florida	-5.6	-35.9	18.0	2.6	-42.8	33.6	-3.4	-27.6	16.2
Illinois	-4.8	-35.5	18.9	-9.0	-70.8	30.4	-5.9	-32.3	15.2
Maryland	11.0	-46.3	45.9	--	--	--	11.9	-39.4	44.3
Michigan	30.6	-7.6	55.2	-49.0	-217.3	30.0	15.3	-23.5	41.9
Missouri	20.7	-24.4	49.5	-84.1	-278.7	10.5	-1.8	-48.0	30.0
Nebraska	-63.9	-264.9	26.4	--	--	--	-28.9	-148.0	33.0
Pennsylvania	-17.6	-54.7	10.6	-5.9	-79.7	37.6	-15.4	-47.2	9.5
Utah	-18.2	-121.0	36.8	-19.0	-201.7	53.1	-18.4	-98.0	29.2
Wisconsin	10.0	-39.3	41.9	25.8	-38.1	60.1	16.3	-19.4	41.3
States Combined	-1.6	-14.4	9.7	-12.8	-37.2	7.3	-4.3	-15.4	5.7

E: effectiveness; CI: confidence interval
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

Single-Passenger-Vehicle-to-Motorcycle (Single-PV-to-Motorcycle) Crashes

Table 4-4 shows the effectiveness of DRLs against daytime Single-PV-to-Motorcycle crashes. Overall, target motorcycle crashes especially for LTVs obtained from individual States were small. Thus, there is great uncertainty surrounding these estimates.

For fatal crashes, although, not statistically significant, DRLs for both PCs and LTVs seemed to increase target motorcycle crashes by 4.4 and 15.1 percent, respectively. Overall, DRLs seemed to increase fatal Single-PV-to-Motorcycle crashes by 7.5 percent. The overall effect on fatal crashes also was not statistically significant.

For injury crashes, individual State results and the combined results were not statistically significant. Based on the combined effects, DRLs in PCs seemed to reduce daytime Single-PC-to-Motorcycle injury crashes. However, DRLs in LTVs had a negative effect on target motorcycle crashes. Although, not statistically significant, the relatively large negative effect of DRLs on Single-LTV-to-Motorcycle crashes cannot be totally ignored. Overall, DRLs had almost no effect on Single-PV-to-Motorcycle injury crashes.

For all crashes, the statistical conclusions were similar to that for injury crashes since the majority of single-vehicle crashes involving motorcycles were injury crashes. Based on the combined statistics, DRLs seemed to reduce daytime Single-PC-to-Motorcycle crashes by 1.2 percent. By contrast, DRLs in LTVs seemed to increase daytime Single-LTV-to-Motorcycle crashes by 12.2 percent. Overall, DRLs seemed to increase daytime Single-LTV-to-Motorcycle crashes by 1.9 percent. None of these effects were statistically significant.

Table 4-4
DRL Effectiveness Against Daytime Single-Passenger-Vehicle-to-Motorcycle Crashes Including Dawn and Dusk

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-4.4	-66.2	34.4	-15.1	-97.7	33.0	-7.5	-52.8	24.4
Injury Crashes									
Florida	13.1	-24.7	39.4	-11.1	-108.0	40.7	8.8	-24.6	33.2
Illinois	-11.9	-98.3	36.9	--	--	--	-25.7	-107.5	23.9
Maryland	--	--	--	--	--	--	--	--	--
Michigan	--	--	--	--	--	--	22.1	-79.2	66.1
Missouri	--	--	--	--	--	--	-28.0	-148.1	34.0
Nebraska	--	--	--	--	--	--	--	--	--
Pennsylvania	37.5	-17.9	66.9	--	--	--	36.6	-10.5	63.6
Utah	--	--	--	--	--	--	--	--	--
Wisconsin	27.7	-49.2	65.0	--	--	--	23.1	-42.0	58.4
States Combined	5.8	-17.8	24.7	-22.6	-80.6	16.8	-0.5	-22.0	17.2
All Crashes									
Florida	7.6	-29.2	33.9	-12.9	-101.8	36.8	3.7	-28.7	27.9
Illinois	-6.8	-68.8	32.4	-5.7	-134.6	52.4	-7.4	-59.3	27.6
Maryland	--	--	--	--	--	--	--	--	--
Michigan	-8.2	-168.9	56.5	--	--	--	-2.0	-116.5	51.9
Missouri	-25.6	-152.9	37.6	--	--	--	-22.0	-122.1	33.0
Nebraska	--	--	--	--	--	--	--	--	--
Pennsylvania	22.5	-41.2	57.5	--	--	--	24.5	-27.7	55.4
Utah	--	--	--	--	--	--	--	--	--
Wisconsin	10.7	-67.3	52.3	--	--	--	-1.3	-70.7	39.9
States Combined	1.2	-20.6	19.1	-12.2	-57.3	20.0	-1.9	-21.0	14.2

E: effectiveness; CI: confidence interval
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

All Target Crashes Combined

Table 4-5 shows the effectiveness of DRLs against all daytime target crashes combined. The effects presented in this table and statistical conclusions are similar to those presented for the target Two-PV crashes since the target Two-PV crashes comprised over 90 percent of the combined sample.

For fatal crashes, DRLs seemed to increase the daytime target crashes by 2.1 percent for PCs. In contrast, DRLs seemed to reduce daytime target crashes by 9.7 percent for LTVs. For PCs and LTVs combined, DRLs would reduce target fatal crashes by 2.9 percent. However, these three effects were not statistically significant at the 0.05 level.

For injury crashes, Maryland showed a statistically significant effect for DRLs in PCs. In Maryland, DRLs would reduce daytime target injury crashes that involved a PC by 25.1 percent. The remaining estimates for PCs were not statistically significant. Further, the effects derived from the individual States fluctuated between positive and negative. Altogether, there was no clear pattern indicating the direction of the DRL effects. For LTVs, only Wisconsin showed statistically significant DRL effects. In Wisconsin, DRLs in LTVs reduced 33.2 percent of daytime target crashes that involved an LTV. The remaining DRL effects for LTVs were not statistically significant.

When all the State data were pooled together, DRLs seemed to reduce the daytime target crashes by 2.3 and 6.1 percent for PCs and LTVs, respectively. Overall, DRLs seemed to reduce the daytime target crashes by 3.3 percent. All these estimates were not statistically significant.

For all crashes, all the individual State estimates were not statistically significant except for Wisconsin and only for LTVs. In Wisconsin, DRLs reduced the LTV involvements in daytime target crashes that involved a LTV by 17.8 percent. The combined result for LTVs was borderline statistically significant as defined when one of the confidence limits was rounded to 0.0. DRLs would reduce LTV involvement in daytime target crashes that involved an LTV by 5.1 percent. However, based on the combined PC and LTV results, DRLs seemed to have no overall effect on daytime target crashes.

Table 4-5
DRL Effectiveness Against All Daytime Target Crashes Including Dawn and Dusk

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-2.1	-19.1	12.5	9.7	-8.8	25.0	2.9	-9.3	13.8
Injury Crashes									
Florida	7.6	-6.7	20.0	18.8	-1.4	35.0	11.2	-0.2	21.3
Illinois	-4.0	-21.2	10.8	-1.0	-30.0	21.5	-3.8	-18.3	8.9
Maryland	**25.1**	1.8	42.9	-72.9	-248.3	14.2	15.6	-8.6	34.4
Michigan	15.4	-4.1	31.3	-13.6	-55.7	17.1	7.6	-9.9	22.3
Missouri	7.4	-8.0	20.6	3.6	-21.9	23.7	6.6	-6.2	17.9
Nebraska	-27.1	-71.3	5.7	25.7	-15.6	52.2	-8.7	-39.1	15.1
Pennsylvania	-2.1	-15.9	10.0	-5.7	-34.1	16.7	-3.0	-15.2	7.9
Utah	-12.9	-56.0	18.3	7.8	-44.8	41.3	-5.3	-36.9	19.0
Wisconsin	-7.3	-27.1	9.4	**33.2**	13.8	48.2	5.8	-8.4	18.1
States Combined	2.3	-3.5	7.8	6.1	-3.1	14.5	3.3	-1.5	7.9
All Crashes									
Florida	-0.4	-12.3	10.2	8.5	-9.0	23.2	2.3	-7.3	11.1
Illinois	-4.7	-12.5	2.6	2.8	-8.7	13.1	-2.5	-8.9	3.5
Maryland	12.3	-2.6	25.1	0.5	-44.6	31.5	10.2	-3.8	22.3
Michigan	-0.5	-10.1	8.2	-1.2	-15.2	11.1	-0.7	-8.5	6.5
Missouri	-1.7	-11.4	7.2	6.7	-7.2	18.8	1.1	-6.7	8.4
Nebraska	-2.9	-21.1	12.6	13.1	-8.9	30.7	1.8	-12.0	13.9
Pennsylvania	-3.0	-13.2	6.2	5.9	-12.5	21.3	-1.2	-10.0	6.9
Utah	-16.4	-40.6	3.6	12.6	-13.6	32.8	-5.5	-23.0	9.5
Wisconsin	-2.7	-13.5	7.0	**17.8**	5.0	28.9	4.1	-4.1	11.7
States Combined	-2.0	-5.5	1.4	5.1	0.0	9.9	0.1	-2.8	2.9

E: effectiveness; CI: confidence interval
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data
Bold faced figures were statistical significant at the 0.1 level.

4.2 Excluding Dawn and Dusk

Tables 4-6 to 4-9 shows the effectiveness rates of DRLs that correspond to those presented in the previous section except that these effects were derived for daytime conditions that excluded dawn and dusk. As expected, the exclusion of dawn and dusk conditions had a negligible influence on the DRL effectiveness. Consequently, the results and statistical conclusions were very similarly to those represented in the previous section.

A vast majority of these effects were not statistically significant. Furthermore, there were no discernable trends as to whether the exclusion of dawn and dusk conditions diminished the overall DRL effects.

The Target Two Passenger-Vehicle (Target Two-PV) Crashes

Table 4-6 shows the effectiveness of DRLs against the daytime target Two-PV crashes. As shown, the vast majority of these estimated effects were not statistically significant at the 0.05 level.

For fatal crashes, DRLs in PCs seemed to increase the likelihood of a PC's involvement in daytime target Two-PV fatal crashes by 9.3 percent. In contrast, DRLs in LTVs seemed to reduce LTV involvement in Two-PV crashes by 15.2 percent. Overall, DRLs would reduce the target Two-PV fatal crashes by 1.2 percent. However, all these estimated effects were not statistically significant.

For injury crashes, the DRL effect for PCs in Maryland was statistically significant. In Maryland, DRLs in PCs would reduce 26.4 percent of the target Two-PV injury crashes that involved a PC. For LTVs, Wisconsin showed statistically significant DRL effects. In Wisconsin, DRLs in LTVs would reduce target Two-PV injury crashes that involved an LTV by 35.7 percent. DRL effects for LTVs for the remaining seven States as well as the combined effect were not statistically significant.

When the State data were pooled together as one crash sample, DRLs seemed to reduce the daytime target Two-PV injury crashes by 2.7 and 8.7 percent for PCs and LTVs, respectively. These estimates were not statistically significant. Altogether, for injury crashes, DRLs seemed to reduce the daytime target Two-PV injury crashes by 4.4 percent. This effect was also not statistically significant.

For all crashes, all estimates for PCs were not statistically significant. For LTVs, Wisconsin is the only State that produced a statistically significant effect. In Wisconsin, DRLs reduced LTV involvement in target Two-PV crashes by 17.2 percent. The combined State effect indicated that DRLs reduced the target Two-PV injury crashes that involved an LTV by 4.5 percent. However, the individual and combined State DRL effects for PCs and LTVs were generally moving in opposite directions. When all the PVs and nine States were pooled together, DRLs had almost no effect on target Two-PV crashes.

Table 4-6
DRL Effectiveness Against The Target Daytime Two Passenger-Vehicle Crashes Excluding Dawn and Dusk*

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-9.3	-29.6	7.8	15.2	-4.3	31.1	1.2	-12.7	13.4
Injury Crashes									
Florida	7.4	-7.4	20.1	20.2	-0.5	36.6	11.5	-0.2	21.8
Illinois	-5.4	-23.6	10.1	7.7	-20.1	29.1	-2.3	-17.2	10.7
Maryland	**26.4**	3.1	44.1	-80.3	-266.1	11.2	16.3	-8.0	35.2
Michigan	15.5	-4.8	31.9	-9.4	-51.5	21.0	8.6	-9.4	23.6
Missouri	6.8	-8.9	20.3	8.0	-16.7	27.5	7.4	-5.5	18.7
Nebraska	-22.7	-67.2	10.0	20.1	-26.7	49.6	-8.7	-40.4	15.9
Pennsylvania	0.0	-14.0	12.3	-9.2	-39.8	14.7	-2.0	-14.5	9.1
Utah	-17.8	-64.6	15.7	16.8	-32.6	47.8	-4.3	-36.8	20.5
Wisconsin	-8.6	-29.4	8.9	**35.7**	16.1	50.7	5.9	-8.9	18.7
States Combined	2.7	-3.2	8.3	8.7	-0.6	17.1	4.4	-0.5	9.1
All Crashes									
Florida	-1.0	-13.3	10.0	8.4	-9.8	23.6	1.8	-8.2	10.9
Illinois	-5.7	-13.9	2.0	0.9	-11.7	12.1	-3.7	-10.5	2.7
Maryland	12.1	-3.0	25.0	-0.5	-46.5	31.0	9.9	-4.3	22.1
Michigan	-2.6	-12.9	6.7	0.4	-14.2	13.1	-1.6	-9.8	6.0
Missouri	-2.1	-11.9	6.8	8.2	-5.5	20.2	1.3	-6.5	8.6
Nebraska	-1.7	-20.3	14.0	10.6	-12.9	29.2	1.4	-12.9	13.9
Pennsylvania	-2.1	-12.5	7.3	4.3	-15.0	20.4	-0.8	-9.8	7.5
Utah	-15.6	-40.6	4.9	14.0	-12.8	34.4	-4.4	-22.4	10.9
Wisconsin	-3.2	-14.3	6.8	**17.2**	3.8	28.7	3.6	-4.9	11.4
States Combined	-2.5	-6.1	1.0	4.5	-0.8	9.5	-0.5	-3.5	2.4

E: effectiveness; CI: confidence interval
*Same as those reported in the "Including Dawn and Dusk" section.
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist (Single-PV-to-PED/CYC) Crashes

Table 4-7 shows the effectiveness of DRLs against Single-PV-to-PED/CYC crashes. Excluding dawn and dusk conditions further reduced the available sample size and created more uncertainty about the estimates. None of these effects were statistically significant at the 0.05 level.

For fatal crashes, DRLs in PCs reduced fatal Single-PC-to-PED/CYC crashes by 16.4 percent. DRLs in LTVs, contrarily, seemed to increase Single-LTV-to-PED/CYC crashes by 3.4 percent. Both effects were not statistically significant at the 0.05 level. Overall, DRLs seemed to have no effect on fatal Single-PV-to-PED/CYC crashes.

For injury crashes, none of the estimates for individual States or for all States combined were statistically significant. Similar to the direction of the DRL effects derived from FARS, DRLs would reduce injury Single-PC-to-PED/CYC crashes but increase Single-LTV-to-PED/CYC crashes. Overall, DRLs seemed to increase injury Single-PV-to-PED/CYC crashes by 2.0 percent.

For all crashes, again the estimates were not statistically significant. However, based on the combined State data, DRL effects for both PCs and LTVs were negative. Overall, DRLs seemed to increase Single-PV-to-PED/CYC crashes by 5.6 percent.

Table 4-7
DRL Effectiveness Against
Daytime Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist Crashes
Excluding Dawn and Dusk*

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	16.4	-11.7	37.4	-3.4	-44.0	25.8	0.1	-0.1	0.3
Injury Crashes									
Florida	4.6	-25.3	27.3	2.3	-47.1	35.1	3.8	-20.7	23.3
Illinois	-5.7	-41.4	21.0	-21.3	-100.8	26.7	-9.9	-41.3	14.5
Maryland	25.6	-31.6	58.0	--	--	--	20.8	-35.1	53.6
Michigan	32.0	-11.0	58.3	-65.9	-288.4	29.1	14.7	-30.0	44.0
Missouri	25.0	-20.5	53.3	-81.3	-286.8	15.0	3.2	-43.6	34.8
Nebraska	-80.7	-326.3	23.4	--	--	--	-35.6	-171.7	32.3
Pennsylvania	-9.7	-46.0	17.6	-0.8	-75.0	41.9	-7.9	-39.0	16.3
Utah	-33.7	-167.2	33.1	4.0	-164.8	65.2	-19.2	-110.1	32.4
Wisconsin	6.9	-47.5	41.2	19.1	-55.5	57.9	11.2	-29.0	38.9
States Combined	1.9	-11.5	13.7	-14.1	-41.0	7.7	-2.0	-13.8	8.6
All Crashes									
Florida	-4.4	-34.9	19.2	-4.9	-54.6	28.9	-4.8	-29.8	15.4
Illinois	-7.3	-39.2	17.3	-12.6	-77.6	28.6	-8.7	-36.2	13.2
Maryland	10.1	-47.8	45.3	--	--	--	11.0	-40.9	43.8
Michigan	27.1	-13.7	53.2	-45.5	-211.1	32.0	12.8	-27.6	40.4
Missouri	20.7	-24.4	49.5	-84.1	-278.7	10.5	-1.8	-48.0	30.0
Nebraska	-65.5	-270.0	26.0	--	--	--	-30.0	-150.9	32.6
Pennsylvania	-16.0	-52.9	12.0	-2.3	-74.4	40.0	-13.1	-44.5	11.5
Utah	-22.0	-130.4	35.4	-20.1	-207.7	53.1	-21.1	-104.1	28.1
Wisconsin	10.6	-39.0	42.5	21.4	-47.0	58.0	14.9	-21.8	40.5
States Combined	-2.4	-15.4	9.1	-15.7	-41.0	5.1	-5.6	-17.0	4.7

E: effectiveness; CI: confidence interval
*Same as those reported in the "Including Dawn and Dusk" section.
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

Single-Passenger-Vehicle-to-Motorcycle (Single-PV-to-Motorcycle) Crashes

Table 4-8 shows the effectiveness of DRLs against daytime target motorcycle crashes. The effects of DRLs on the target motorcycles had the most uncertainty due to the small overall sample and insufficient cases for individual States.

For fatal crashes, although not statistically significant, DRLs for both PCs and LTVs seemed to increase target motorcycle crashes by 9.4 and 17.3 percent, respectively. Overall, DRLs seemed to increase fatal Single-PV-to-Motorcycle crashes by 11.4 percent. The effect also was not statistically significant. These relatively large effects need to be treated with caution.

For injury crashes, all individual State results and the combined results were not statistically significant. Based on the combined effects, DRLs in PCs would reduce daytime Single-PC-to-Motorcycle injury crashes by 3.7 percent. However, DRLs in LTVs had a negative effect on target motorcycle crashes. Although not statistically significant, the relatively large negative DRL effect on Single-LTV-to-Motorcycle crashes cannot be totally ignored. Overall, DRLs seemed to increase Single-PV-to-Motorcycle injury crashes by 2.5 percent.

For all crashes, based on the combined statistics, DRLs seemed to increase daytime Single-PV-to-Motorcycle crashes by 1.2 and 17.3 percent for PCs and LTVs, respectively. Overall, DRLs seemed to increase daytime Single-PV-to-Motorcycle crashes by 5.0 percent. None of these effects were statistically significant.

Table 4-8
DRL Effectiveness Against Daytime Single-Passenger-Vehicle-to-Motorcycle Crashes Excluding Dawn and Dusk*

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-9.4	-75.2	31.7	-17.3	-102.8	32.1	-11.4	-59.0	21.9
Injury Crashes									
Florida	7.5	-33.4	35.9	-15.9	-118.2	38.4	3.4	-32.5	29.6
* Illinois	-14.5	-103.8	35.7	--	--	--	-27.3	-111.0	23.2
Maryland	--	--	--	--	--	--	--	--	--
Michigan	--	--	--	--	--	--	23.0	-78.0	66.7
Missouri	-32.2	-185.2	38.7	--	--	--	-28.0	-148.1	34.0
Nebraska	--	--	--	--	--	--	--	--	--
Pennsylvania	37.4	-18.4	66.9	--	--	--	36.1	-11.6	63.4
Utah	--	--	--	--	--	--	--	--	--
Wisconsin	27.7	-49.6	65.1	--	--	--	24.3	-40.1	59.1
States Combined	3.7	-20.6	23.1	-24.5	-83.7	15.6	-2.5	-24.5	15.6
All Crashes									
Florida	1.1	-39.0	29.6	-17.5	-111.0	34.6	-2.3	-37.2	23.7
Illinois	-8.8	-72.4	31.3	-10.5	-146.6	50.5	-10.1	-63.7	25.9
Maryland	--	--	--	--	--	--	--	--	--
Michigan	-8.3	-170.4	56.6	--	--	--	-5.1	-123.9	50.7
Missouri	-25.6	-152.9	37.6	--	--	--	-22.0	-122.1	33.0
Nebraska	--	--	--	--	--	--	--	--	--
Pennsylvania	20.5	-45.2	56.5	--	--	--	22.3	-31.7	54.1
Utah	--	--	--	--	--	--	--	--	--
Wisconsin	10.7	-67.7	52.4	--	--	--	-0.9	-70.4	40.3
States Combined	-1.2	-23.7	17.2	-17.3	-64.8	16.5	-5.0	-24.8	11.7

E: effectiveness; CI: confidence interval
*Same as those reported in the "Including Dawn and Dusk" section.
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.1 level.

All Target Crashes Combined

Table 4-9 shows the effectiveness of DRLs against all daytime target crashes combined. For fatal crashes, DRLs seemed to increase the daytime target crashes by 3.1 percent for PCs. In contrast, DRLs seemed to reduce the daytime target crashes by 10.8 percent for LTVs. When combining PCs and LTVs together, DRLs seemed to reduce target fatal crashes by 2.8 percent. However, none of these effects were statistically significant at the 0.05 level. For injury crashes, Maryland showed a statistically significant effect for DRLs in PCs. In Maryland, DRLs would reduce the daytime target injury crashes that involved a PC by 25.4 percent. The remaining estimates for PCs were not statistically significant. Furthermore, the effects derived from the individual States fluctuated between positive and negative. Altogether, there is no consistent pattern indicating the direction of the DRL effects. For LTVs, only Wisconsin showed statistically significant DRL effects. In Wisconsin, DRLs in LTVs reduced daytime target crashes that involved an LTV by 34.5 percent. The remaining DRL effects for LTVs were not statistically significant.

When all State data were pooled together, DRLs seemed to reduce daytime target injury crashes by 2.6 and 6.5 percent for PCs and LTVs, respectively. Overall, DRLs seemed to reduce the daytime target crashes by 3.7 percent. However, none of these estimates were statistically significant.

For all crashes, all the individual State estimates were not statistically significant except for Wisconsin and only for LTVs. In Wisconsin, DRLs reduced LTV involvement in daytime target crashes that involved an LTV by 17.1 percent. Based on the combined PC and LTV results, DRLs seemed to have no overall impacts on daytime target crashes.

Table 4-9
DRL Effectiveness Against All Daytime Target Crashes
Excluding Dawn and Dusk*

Crash Severity	Passenger Cars			Light Trucks/Vans			Combined		
	E (%)	95% CI		E (%)	95% CI		E (%)	95% CI	
		Low	High		Low	High		Low	High
Fatal Crashes	-3.1	-20.7	12.0	10.8	-7.9	26.3	2.8	-9.8	13.9
Injury Crashes									
Florida	7.2	-7.4	19.8	17.5	-3.5	34.3	10.5	-1.2	20.8
Illinois	-5.6	-23.6	9.8	4.4	-23.9	26.2	-3.3	-18.2	9.7
Maryland	25.4	2.2	43.1	-79.2	-261.8	11.3	15.5	-8.8	34.3
Michigan	17.0	-2.6	32.9	-11.7	-54.0	19.0	9.3	-8.3	24.0
Missouri	7.4	-8.0	20.6	3.6	-21.9	23.7	6.6	-6.2	17.9
Nebraska	-24.6	-69.2	8.3	19.9	-26.2	49.2	-9.9	-41.6	14.7
Pennsylvania	-0.1	-13.8	11.9	-7.3	-36.6	15.7	-1.7	-13.9	9.2
Utah	-20.5	-67.7	13.4	12.7	-38.2	44.9	-7.6	-40.7	17.7
Wisconsin	-7.5	-27.7	9.5	**34.5**	15.1	49.5	6.3	-8.1	18.8
States Combined	2.6	-3.2	8.1	6.5	-2.8	15.0	3.7	-1.2	8.4
All Crashes									
Florida	-1.1	-13.3	9.8	7.0	-11.3	22.3	1.4	-8.6	10.5
Illinois	-5.7	-13.9	1.9	0.6	-12.0	11.8	-3.9	-10.7	2.5
Maryland	12.1	-2.9	24.9	-0.3	-45.9	31.1	9.8	-4.3	22.0
Michigan	-2.0	-12.2	7.2	-0.2	-14.8	12.5	-1.3	-9.5	6.3
Missouri	-1.7	-11.4	7.2	6.7	-7.2	18.8	1.1	-6.7	8.4
Nebraska	-2.7	-21.3	13.1	11.1	-12.1	29.5	0.9	-13.4	13.4
Pennsylvania	-2.6	-12.9	6.7	4.5	-14.5	20.3	-1.1	-10.0	7.1
Utah	-16.7	-41.8	3.9	12.1	-15.1	32.9	-5.9	-24.0	9.5
Wisconsin	-3.0	-14.1	7.0	**17.1**	3.8	28.5	3.6	-4.8	11.4
States Combined	-2.5	-6.1	1.0	3.8	-1.5	8.8	-0.7	-3.7	2.2

E: effectiveness; CI: confidence interval
*Same as those reported in the "Including Dawn and Dusk" section.
-- Small sample
Data sources: 2000-2005 FARS and available 2000-2005 State Data System
Bold faced figures were statistical significant at the 0.05 level.

4.3 Summary of Results

The following summarizes the effectiveness of DRLs against daytime fatal crashes and the combined effects against daytime injury and all crashes. The 95-percent confidence intervals of these effects were also presented. Note that GM vehicles comprised the majority of the vehicles selected for this analysis. Thus, the vehicle sample might not be representative of all on-road DRL-equipped passenger vehicles. Also, results among States were different and sometimes contradicted each other. Therefore, DRL effects based on an assessment of nine States might not be applicable to or inferable to the national level.

<u>Including Dawn and Dusk</u>

The Target Two-Passenger-Vehicle Crashes

- The following shows the effectiveness of DRLs against target Two-PV crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-8.9 (-28.7, 7.8)	13.8 (-5.6, 29.6)	0.7 (-13.0, 12.7)
Injury Crashes	2.3 (-3.6, 7.8)	8.2 (-1.0, 16.5)	3.9 (-1.0, 8.6)
All Crashes	-2.0 (-5.5, 1.4)	**5.7** (0.6, 10.5)	0.3 (-2.6, 3.1)

- DRLs significantly reduced LTV involvement in daytime target Two-PV crashes by 5.7 percent at the 0.05 level.
- The remaining results were not statistically significant at the 0.05 level.
- For PCs, there was no consistent pattern indicating whether DRLs would reduce PC involvement in daytime target Two-PV crashes. As shown, DRLs seemed to reduce PC involvement in target Two-PV injury crashes, but increase PC involvement in target Two-PV fatal crashes and all crashes.
- For LTVs, DRL effects were progressively higher with crash severity and the effects were all positive. It seems that DRLs were more likely to reduce LTV involvement in daytime target Two-PV crashes.
- For PCs and LTVs combined, DRLs would reduce target Two-PV injury crashes by 3.9 percent. Overall, DRLs had almost no effect on daytime target Two-PV fatal crashes and all crashes. These estimated effects were not statistically significant.

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist Crashes

- The following shows the effectiveness of DRLs against Single-PV-to-PED/ CYC crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	19.1 (-6.8, 38.7)	-2.3 (-40.7, 25.6)	0.1 (-0.1, 0.3)
Injury Crashes	2.0 (-11.3, 13.7)	-13.1 (-39.5, 8.3)	-1.7 (-13.4, 8.8)
All Crashes	-1.6 (-14.4, 9.7)	-12.8 (-37.2, 7.3)	-4.3 (-15.4, 5.7)

- None of the results were statistically significant at the 0.05 level.
- Although not statistically significant, DRLs in cars were more likely to reduce daytime Single-PC-to-PED/CYC fatal and injury crashes. In contrast, DRLs in LTVs seemed to have an unintended consequence against single-LTV crashes involving pedestrians and pedalcyclists. The large negative effects cannot be completely ignored.
- For PCs and LTVs combined, DRLs seemed to have no effect on Single-PV-to-PED/CYC fatal crashes. However, DRLs seemed to have a negative impact on single-vehicle injury and all crashes involving pedestrians and pedalcyclists.

Single-Passenger-Vehicle-to-Motorcycle Crashes

- The following shows the effectiveness of DRLs against Single-PV-to-Motorcycle crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-4.4 (-66.2, 34.4)	-15.1 (-97.7, 33.0)	-7.5 (-52.8, 24.4)
Injury Crashes	5.8 (-17.8, 24.7)	-22.6 (-80.6, 16.8)	-0.5 (-22.0, 17.2)
All Crashes	1.2 (-20.6, 19.1)	-12.2 (-57.3, 20.0)	-1.9 (-21.0, 14.2)

- All the results were not statistically significant.
- There was greater degree of uncertainty in the effects of DRLs on daytime Single-PV-to-Motorcycle crashes since the crash sizes were relatively small compared to other target crashes.
- For fatal crashes, effectiveness of DRLs for both PCs and LTVs were negative. It seemed that DRLs were more likely to increase daytime fatal target motorcycle crashes.
- For PCs, DRLs seemed to reduce daytime Single-PC-to-Motorcycle crashes. However, for LTVs, DRLs seemed to have adverse effects on daytime Single-LTV-to-Motorcycle crashes. These negative effects were not statistically significant. However, these effects were relatively large and raised concerns regarding potential adverse effects on motorcycle drivers.
- Overall, DRLs seemed to increase daytime Single-PV-to-Motorcycle crashes.

All Target Crashes Combined

- The following shows the effectiveness of DRLs against all three daytime target crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-2.1 (-19.1, 12.5)	9.7 (-8.8, 25.0)	2.9 (-9.3, 13.8)
Injury Crashes	2.3 (-3.5, 7.8)	6.1 (-3.1, 14.5)	3.3 (-1.5, 7.9)
All Crashes	-2.0 (-5.5, 1.4)	5.1 (0.0, 9.9)	0.1 (-2.8, 2.9)

- Target Two-PV crashes comprised the vast majority of the combined crash sample. Thus, the effects of DRLs for the combined target crashes and related statistical conclusions were similar to those presented for the target Two-PV crashes.
- DRLs more likely reduced LTV involvement in daytime target crashes by 5.1 percent. The effect was borderline significant at the 0.05 level.
- The remaining results were not statistically significant at the 0.05 level.
- DRLs seemed more likely to reduce daytime target fatal and injury crashes.
- However, DRLs would have no overall effects on all daytime target crashes. All crashes included fatal, injury, and property-damage-only (PDO) crashes.

Excluding Dawn and Dusk
Target Two-Passenger-Vehicle Crashes

- The following shows the effectiveness of DRLs against the target Two-PV crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-9.3 (-29.6, 7.8)	15.2 (-4.3, 31.1)	1.2 (-12.7, 13.4)
Injury Crashes	2.7 (-3.2, 8.3)	8.7 (-0.6, 17.1)	4.4 (-0.5, 9.1)
All Crashes	-2.5 (-6.1, 1.0)	4.5 (-0.8, 9.5)	-0.5 (-3.5, 2.4)

- None of the results were statistically significant.
- Overall, DRLs seemed to reduce daytime target Two-PV fatal and injury crashes. However, DRLs seemed to have no effect on daytime target Two-PV crashes.

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist Crashes

- The following shows the effectiveness of DRLs against Single-PV-to-PED/CYC crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	16.4 (-11.7, 37.4)	-3.4 (-44.0, 25.8)	0.1 (-0.1, 0.3)
Injury Crashes	1.9 (-11.5, 13.7)	-14.1 (-41.0, 7.7)	-2.0 (-13.8, 8.6)
All Crashes	-2.4 (-15.4, 9.1)	-15.7 (-41.0, 5.1)	-5.6 (-17.0, 4.7)

- None of the results were statistically significant.

Single-Passenger-Vehicle-to-Motorcycle Crashes

- The following shows the effectiveness of DRLs against daytime Single-PV-to-Motorcycle crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-9.4 (-75.2, 31.7)	-17.3 (-102.8, 32.1)	-11.4 (-59.0, 21.9)
Injury Crashes	3.7 (-20.6, 23.1)	-24.5 (-83.7, 15.6)	-2.5 (-24.5, 15.6)
All Crashes	-1.2 (-23.7, 17.2)	-17.3 (-64.8, 16.5)	-5.0 (-24.8, 11.7)

- None of the results were statistically significant.

All Target Crashes Combined

- The following shows the effectiveness of DRLs against all three daytime target crashes:

Crash Severity	Effectiveness of DRL (%)		
	Passenger Cars	Light Trucks/Vans	Combined
Fatal Crashes	-3.1 (-20.7, 12.0)	10.8 (-7.9, 26.3)	2.8 (-9.8, 13.9)
Injury Crashes	2.6 (-3.2, 8.1)	6.5 (-2.8, 15.0)	3.7 (-1.2, 8.4)
All Crashes	-2.5 (-6.1, 1.0)	3.8 (-1.5, 8.8)	-0.7 (-3.7, 2.2)

- None of the results were statistically significant.
- Overall, DRLs seemed to reduce the daytime target fatal and injury crashes but the effects were not statistically significant. However, DRLs seemed to have no effect on daytime target Two-PV crashes.

Chapter 5. DISCUSSION

The analysis applied a control-comparison technique to evaluate the effects of DRLs on three daytime target crashes: Two-PV, Single-PV-to-PED/CYC, and Single-PV-to-Motorcycle crashes. The ratio of odds ratios statistic was used to estimate the effects. Based on this measurement, a majority of the derived effects were not statistically significant. Although some estimated effects were statistically significant, these results often contradicted each other.

Of these three target crashes, the target Two-PV crash samples obtained from FARS and individual States were generally sufficient for analysis. DRLs seemed to reduce daytime Two-PV injury crashes. The effect was not statistically significant. However, when all crashes were considered, DRLs seemed to have no effects on daytime target Two-PV crashes.

The other two target crash samples were generally small. The estimated effects had a relatively wide confidence interval indicating that the estimated results were quite imprecise even for the statistically significant effects. Particularly, Single-PV-to-Motorcycle crashes obtained from several States were too small to render any meaningful results.

The combined State data for each set of target crashes were considered to be relatively more reliable than the individual State results. However, none of these combined results were statistically significant. Further, there were no discernable trends among the individual States that could be used to infer a likely direction (positive or negative) of the combined effects.

For all target crashes combined, the estimated effects and statistical conclusions were similar to those presented for the target Two-PV crashes. This is not surprising given that the target Two-PV crashes comprised the vast majority of the sample.

Studies have validated the sensitivity of the DRL effects on the statistic chosen to measure the effects. Each statistic controls confounding factors differently. Roadway design, vehicle configuration, DRL technologies, weather patterns, the environment, driver behavior, driver demographics, etc. would also affect the DRL effective outcomes. The ratio of odds ratios has a stronger confounding-factor-control ability and produces relatively more conservative statistical results than simple odds do. The derived estimates based on ratio of odds ratios, if found statistically significant, would be more defendable. Therefore, we selected the ratio of odds ratios over simple odds.

Given the uncertainties around the estimated DRL effects and the magnitude of the effects, several statistical-process and data-related factors would affect the outcomes of the analysis:

(1) The DRL-equipped vehicles used in the analysis were mostly 1995 to 1999 model years for PCs and 1995 to 1998 model years for LTVs. DRLs in these vehicles might not represent the current state-of-the-art of DRL technologies.

(2) GM vehicles comprised the majority of the vehicles selected for this analysis. Thus, the vehicle sample might not be representative of all on-road DRL-equipped passenger vehicles.

(3) Results among States were different and sometimes contradicted each other. Therefore, the DRL effects based on an assessment of nine States might not be applicable to or inferable to the national level.

Additionally, since DRLs come with different configurations, this analysis primarily focused on the overall DRL effects and did not attempt to estimate the DRL effects by individual DRL configurations. Furthermore, this analysis has several limitations such as, but not limited to, no estimates by latitude, roadway, and weather conditions. However, further expanding this analysis would reduce crash cases and most likely produce less defendable results.

Finally, the report does not estimate the novelty and intrinsic effects of DRLs to determine whether the increase in DRLs on the road would gradually diminish the DRL effects or impair the conspicuity of pedestrians, pedalcyclists, and motorcyclists. Concerns have been raised about DRLs obscuring the conspicuity of motorcyclists (whose motorcycle lights are on all the time). A timeline trend analysis would be more appropriate for this type of analysis. It is beyond the scope of this analysis.

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APPENDIX A. CRASH DEFINITION

The Appendix lists the data variables and coding schemas in FARS and the State data that were used to define several critical parameters in the analysis: DRL status, ABS status, vehicle type, light condition, crash severity, and target crashes. Of these parameters, DRL status, ABS status, and vehicle type were decoded directly from VIN using a set of VIN-decoding programs. Variables representing these three parameters and the corresponding coding schemas were standardized across FARS and the State data. However, variables and the coding schemas used to define light condition and target crashes were initially reported in FARS and the State data. They varied among these crash data sources. But, in general, the analysis was able to establish a comparable definition for these parameters by mapping State variables closed to those in the FARS.

Common Variables Used Across FARS and State Data

Common variables used across FARS and State data are:
- DRLIGHTS representing DRL status.
- ABS representing ABS status, and
- TRKTYP representing vehicle type.

DRL status was classified into "DRL" and "No-DRL" to identify DRL-equipped vehicles and non-DRL-equipped vehicles. DRL-equipped vehicles included vehicles with the DRLIGHTS variable coded as 'S' (standard equipment). Non-DRL-equipped vehicles included vehicles with the DRLIGHTS variable coded as 'N'. Vehicles that had DRLs as optional equipment were excluded from the analysis.

Similarly, ABS status was classified into "ABS" and "No-ABS" to segregate ABS-equipped and Non-ABS-equipped vehicles. ABS-equipped vehicles included vehicles that had 4-wheel, rear-wheel, or unknown type of ABS as standard equipment. The ABS parameter was used to check whether DRL-equipped vehicles and Non-DRL-eqipped vehicles had a different ABS installation status. Both DRLIGHTS and ABS were created by the PC VINA software developed by R. L. Polk.

TRKTYP was created by the 10-VIN decoding programs developed by NHTSA. The variable was used to identify passenger cars and various types of light trucks and vans (e.g., small SUVs, large vans, etc.). The following is a list of these common variables and the corresponding coding definitions:

Classification	Definition For Both FARS and State Data
DRL Status	DRLIGHTS
DRL	= 'S' (standard equipment)
No-DRL	= 'N' (not equipped)
ABS Status	ABS
ABS	= 2 (4-wheel standard) or
	= 3 (Rear only standard), or
	= 4 (Standard, wheel unknown)

No-ABS	= 0 (Not applicable), or = 1 (Not available)
Vehicle Type Passenger Cars Light Trucks/Vans	TRKTYP = 0 (Cars) = 1-8 & 10-12(Light trucks/vans)

Variables Used to Define Light Condition, Crash Severity, and Crash Type

The following lists the variables and coding schema used to define light condition, crash severity, and crash type. The light conditions at the time of the crash were classified into "daytime" and "nighttime." The basic analysis compared daytime to nighttime. "Daytime" conditions include daylight, dawn, and dusk. "Nighttime" conditions include dark, dark with streetlights, dark with no streetlights, or dark with unknown lights. Note that for the second set of analyses, dawn and dusk were excluded form the "daytime" category. However, Missouri did not have codes for dawn and dusk. Therefore, the "daytime" definition did not change for Missouri throughout the analysis.

Crash severity was classified into "injury" and "PDO" crashes. Injury crashes included police-reported possible injury, non-incapacitating, incapacitating, and fatal crashes (or equivalent injury definitions). This classification was used primarily to identify injury crashes for examining the DRL effects on injury crashes. Thus, this classification was applicable only to the State data.

The remaining classifications were used as the building blocks for defining crash types:

- "Number of Vehicles" was used to identify single- or two-vehicle crashes.
- "Pedestrian/pedalcyclist" was used to identify pedestrian/pedalcylist crashes.
- "Motorcycle" was used to identify motorcycle crashes.
- "Special Use Vehicles" was used to identify the involvement of police vehicles, ambulances, and fire trucks. Crashes that involved these special vehicles were excluded from analysis.
- "Vehicle Defects" included brake, tire, engine, steering, and suspension defects. Crashes that involved a vehicle having these defects coded as a contribution factor were excluded.

These classifications and the vehicle type classification were combined to define the control and target comparison crashes. For example, fatal single passenger-car-to-pedestrian/pedalcylist crashes was defined using the combination of (1) number of vehicles involved (VE_FORMS=1); (2) vehicle type (passenger car, TRKTYP=0); and (3) pedestrian/pedalcylist (PED/CYC=1).

Classification	Definition	
	FARS	**Florida**
Light Condition Daytime Nighttime	LGT_COND (N) = 1 (Daylight) or = 4 (Dawn) or = 5 (Dusk) = 2 (Dark), or = 3 (Dark but lighted)	LIGHT (C) = 1 (Daylight) or = 2 (Dawn) or = 3 (Dusk) = 4 (Dark, street light) or = 5 (Dark, no street light)
Crash Severity Injury Crashes PDO Crashes	N.A. (all fatal crashes)	SEVERITY (C) = 02 (Possible injury) = 03 (Non-incapacitating) = 04 (Incapacitating) = 05 (Fatal) = 01 (Not injured)
Number of Vehicles	VE_FROMS	
Pedestrian/Pedalcyclist PED/CYC = 1 (Yes)	HARM_EV = 08 (Pedestrian) or = 09 (Pedalcyclist)	VENENT1 (C) (as EVENT1 in 2000-2001) = 10 (Collision with pedestrian) = 11 (Collision with bicycle) = 12 (Collision with bicycle-bike lane)
Motorcycles Motorcycle = 1 (Yes)	BODY_TYPE 80<=BODY_TYP<=89	VEH_TYPE (C) = 10 (Motorcycle, 2000-2001) = 11 (Motorcycle, 2002-2005)
Special Use Vehicle Special_Use = 1 (Yes)	SPEC_USE (N) = 5 (Police) or = 6 (Ambulance) or = 7 (Fire truck)	SPEC_VEH (C) = 07 (Ambulance) or = 08 (Law enforcement) or = 09 (Fire/rescue)
Vehicle Defects Defect = 1 (Yes)	VEH_CF1 (N) = 01 (Tire) = 02 (Brake system) = 03 (Steering system) = 04 (Suspension)	VEHCOND1 (C) = 02 (Defective brake) or = 03 (Worn/smooth tires or = 05 (Puncture/blowout), or = 06 (Steering mechanism)

Classification	Definition	
	Illinois*	**Maryland**
Light Condition Daytime Nighttime	LIGHT (C) = 1 (Daylight) = 2 (Dawn) = 3 (Dusk) = 4 (Darkness) = 5 (Darkness, lighted)	LIGHT (C) = 1 (Daylight) or = 2 (Dawn/Dusk) = 4 (Dark, lights on) or = 5 (Dark, no lights)
Crash Severity Injury Crashes PDO Crashes	SEVERITY (C) = 1 (Fatal) = 2 (Injury) = 3 (Property damage)	SEVERITY (C) = 02 (Possible injury) = 03 (Non-incapacitating) = 04 (Incapacitating) = 05 (Fatal) = 01 (Not injured)
Number of Vehicles	NUM_VEH	NUM_VEH
Pedestrian/Pedalcyclist PED/CYC = 1 (Yes)	EVENT1 = 01 (Pedestrian) or = 02 (Pedalcyclist)	ENENT1 (C) = 03 (Pedestrian) = 14 (Bicycle) = 05 (Other pedalcycle) = 06 (Non-motorized conveyance)
Motorcycles Motorcycle = 1 (Yes)	VEH_TYPE (C) = 10 (Motorcycle over 150 cc) = 11 (Motorcycle)	VEH_TYPE (C) = 01 (Motorcycle) = 19 (Moped)
Special Use Vehicle Special_Use = 1 (Yes)	SPEC_USE (N) = 1 (Police) or = 2 (Ambulance) or = 4 (Emergency Other) or = 26 (Fire truck)	VEH_TYPE (C) = 13 (Ambulance/emergency) or = 14 (Ambulance/non-emergency) = 15 (Fire vehicle/emergency) or = 16 (Fir vehicle/non-emergency) = 17 (Police/emergency) = 18 (Police/non-emergency)
Vehicle Defects Defect = 1 (Yes)	VEHCOND1 (C) = 02 (Defective brake) or = 03 (Steering) or = 04 (Engine motor) = 05 (Suspension), or = 06 (Tire)	CON_CIR1 (C) = 51 (Brake) or = 52 (Tires) or = 53 (Steering), or = 59 (Engine)

<table>
<tr><th rowspan="2">Classification</th><th colspan="2">Definition</th></tr>
<tr><th>Michigan</th><th>Missouri</th></tr>
<tr><td>Light Condition
Daytime

Nighttime</td><td>LIGHT (C)
= 1 (Daylight)
= 2 (Dawn)
= 3 (Dusk)

= 4 (Darkness, street lights)
= 5 (Darkness, no street lights)</td><td>= 1 (Daylight)

= 2 (Dark, street lights on)
= 3 (Dark, street lights off)
= 4 (Dark, no street lights)</td></tr>
<tr><td>Crash Severity

Injury Crashes

PDO Crashes</td><td>INJURY and FATAL
INJURY = 1 (Injuries, no deaths) or
FATAL = 1 (Fatal crashes)

INJURY = 0 (No injuries)</td><td>SEVERITY (C)
= 1 (Fatal)
= 2 (Injury)

= 3 (Property damage)</td></tr>
<tr><td>Number of Vehicles</td><td>NUM_VEH</td><td>NUM_VEH</td></tr>
<tr><td>Pedestrian/Pedalcyclist
PED/CYC = 1 (Yes)</td><td>PED_IND and BIC_IND
PED_INC = 1 (Pedestrian)
BIC_IND = 1 (Bicycle)</td><td>PED_IND and BIC_IND
PED_INC = 1 (Pedestrian)
BIC_IND = 1 (Bicycle)</td></tr>
<tr><td>Motorcycles
Motorcycle = 1 (Yes)</td><td>MTRCYCLE (C)
= 1 (Motorcycle)</td><td>VEH_TYPE (2000 – 2001)
= 08 (Motorcycle)
= 10 (Moped)
= 21-23 (Motorcycle, 3+ wheel)
= 24 (Motorcycle, unknown # wheel)

2002 – later
10 = (Motorcycle)
12 = (Motorized bicycle)</td></tr>
<tr><td>Special Use Vehicle
Special_Use = 1 (Yes)</td><td>EMER_VEH
= 1 (Yes)</td><td>SPEC_USE
= 1 (Police)
= 2 (Fire) or
= 3 (Ambulance)</td></tr>
<tr><td>Vehicle Defects
Defect = 1 (Yes)</td><td>VEHCOND1
= 02 (Brakes)
= 03 (Steering)
= 04 (Tires/Wheels)</td><td>CONTFACT
= 01 (Vehicle defect)</td></tr>
</table>

Classification	Definition: Nebraska	Definition: Pennsylvania
Light Condition Daytime Nighttime	LIGHT = 06 (Daylight) = 05 (Dawn/dusk) = 04 (Dawn) (2002) = 07 (Dusk) (2002) = 01 (Dark, lighted roadway) = 02 (Dark, not lighted) = 03 (Dark, unknown lighting) (2002)	LIGHT = 02 (Daylight) = 01 (Dawn) = 05 (Dusk) = 03 (Dark, street lights on) = 04 (Dark, no lights on)
Crash Severity Injury Crashes PDO Crashes	SEVERITY = 03 (Possible injury) = 04 (Visible injury) = 05 (Disabling injury) = 06 (Fatal) = 02 (Property damage only)	SEVERITY = 1 (Fatal) = 2 (Major injury) = 3 (Moderate injury) = 4 (Minor injury) = 6 (No injury)
Number of Vehicles	NUM_VEH	NUM_VEH
Pedestrian/Pedalcyclist PED/CYC = 1 (Yes)	EVENT1 = 2 (Bicycle, pedalcycle) = 31 (Pedestrian)	EVENT1 = 20 (Struck a pedestrian) BODYTYPE = 90 (Uni-, bi-, tricycle) = 91 (Other pedalcycle) = 92 (Unknown pedalcycle)
Motorcycles Motorcycle = 1 (Yes)	MCYCLE (C) = ‘Y’ (Motorcycle)	BODYTYPE = 20 (Motorcycle) = 21 (Moped) = 27 (3-wheel motorcycle) = 28 (Other motorcycle) = 29 (Unknown motorcycle)
Special Use Vehicle Special_Use = 1 (Yes)	SPEC_USE = ‘Y’ (yes)	SPEC_VEH = 2 (Fire) = 3 (Ambulance) = 4 (Other emergency) = 5 (Police)
Vehicle Defects Defect = 1 (Yes)	CONTFACT = 12 (Defective equipment) (only 2002 to present)	CAUSE1 = ‘O3’ (Blowout) = ‘O5’ (Wheel failure) = ‘P1’ (Total brake failure) = ‘P4’ (Brake locked) = ‘P8’ (Other brake failure) = ‘Q1’ (Steering system) = ‘Q2’ (Suspension failure) = ‘Q5’ (Engineer failure)

Classification	Definition: Utah	Definition: Wisconsin
Light Condition Daytime Nighttime	LIGHT = 01 (Daylight) = 02 (Dawn) = 05 (Dusk) = 03 (Dark, no streetlights) = 04 (Dark, streetlights)	LIGHT = 1 (Daylight) = 4 (Dawn) = 5 (Dusk) = 2 (Dark, unlit) = 3 (Dark, lighted)
Crash Severity Injury Crashes PDO Crashes	SEVERITY (C) = 2 (Possible injury) = 3 (Non-incapacitating) = 4 (Incapacitating) = 5 (Fatal) = 1 (Property damage only)	SEVERITY = 1 (Fatal) = 2 (Injury) = 3 (Property damage)
Number of Vehicles	NUM_VEH	NUM_VEH
Pedestrian/Pedalcyclist PED/CYC = 1 (Yes)	EVENT1 = 1 (MV- pedestrian) = 4 (MV- bicycle)	PED_IND = 'Y' (Pedestrian crash) BIC_IND = 'Y' (Bicycle crash)
Motorcycles Motorcycle = 1 (Yes)	VEH_TYPE = 19 (Motorcycle) = 20 (Motorcycle – public owned) = 21 (Motor driven bicycle, scooter, or moped)	MOPED = 'Y' (Moped crash) MTRCYCLE ='Y' (Motorcycle crashes)
Special Use Vehicle Special_Use = 1 (Yes)	VEH_TYPE = 22 (Ambulance, not emergency) = 23 (Ambulance, emergency) = 24 (Ambulance, public own)	VEH_TYPE = 2 (Police, emergency) = 9 (Ambulance, emergency) = 10 (Fire truck, emergency) = 24 (Fire fighter, emergency)
Vehicle Defects Defect = 1 (Yes)	CONTFACT1 = 19 (Brake defective) = 23 (Steering mechanism defective) = 24 (Tire defective)	VCC1 = 1 (Brakes) = 2 (Tires) = 3 (Steering) = 11 (Suspension) = 'P8' (Other brake failure) = 'Q1' (Steering system) = 'Q2' (Suspension failure) = 'Q5' (Engineer failure)

APPENDIX B. CRASH TABULATIONS BY VEHICLE MODEL YEARS

This Appendix tabulates crash samples by crash data sources (FARS and State data), DRL status (DRL and no-DRL), and vehicle model years. The purpose of presenting this alternative tabulation is to examine the spread of vehicle model years by different data sources and to compare the mean vehicle ages. Therefore only fatal crash and all crash samples are shown in here. Tables B-1 and B-2 show the crash samples for daytime that included daylight, dawn, and dusk for PCs and LTVs, respectively. Tables B-3 and B-4 show the same information but for daytime that excluded dawn and dusk.

As shown in these tables, due to the vehicle selection criteria, it is not surprising that for PCs, the majority of DRL-equipped vehicles were 1996 to 1998 model year vehicles. Their non-DRL-equipped counterparts were mostly 1994 to 1996 model year vehicles. For LTVs, the majority of DRL-equipped vehicles were 1996 and 1997 model year vehicles and non-DRL-equipped vehicles were mostly 1994 and 1995 model year vehicles.

Including Dawn and Dusk

Table B-1
Sample Size by State, Vehicle Model Years Including Dawn and Dusk
Passenger Cars

		MY								
FARS		1993	1994	1995	1996	1997	1998	1999	2000	All
	DRL			345	1,539	2,163	1,000	295	189	5,531
	No DRL	232	1,450	2,388	1,086	304	78	51		5,589
State										
FL	DRL			875	5,302	6,515	3,817	2,429	905	19,843
	No DRL	604	4,781	5,576	3,923	2,061	571	48		17,564
IL	DRL			2,401	13,439	18,624	8,329	2,743	1,228	46,764
	No DRL	1,729	13,097	15,284	8,535	2,852	852	171		42,520
MD	DRL			795	3,100	3,475	1,793	1,179	504	10,846
	No DRL	302	2,697	2,915	1,742	1,037	309	127		9,129
MI	DRL			923	5,615	8,986	3,860	516	281	20,181
	No DRL	430	5,057	8,597	3,380	629	126	108		18,327
MO	DRL			1,229	7,291	10,235	4,000	858	480	24,093
	No DRL	894	6,678	7,743	4,145	1,031	219	67		20,777
NE	DRL			313	2,246	3,111	1,197	220	104	7,191
	No DRL	318	2,238	2,441	1,448	283	75	32		6,835
PA	DRL			1,573	5,805	6,509	2,377	731	606	17,601
	No DRL	792	5,286	6,500	2,519	911	252	297		16,557
UT	DRL			453	1,906	1,958	824	326	244	5,711
	No DRL	329	1,673	1,598	852	354	73	149		5,028
WI	DRL			1,235	5,689	7,206	2,599	629	330	17,688
	No DRL	897	5,571	7,764	2,869	831	134	140		18,206
State	DRL			9,797	50,393	66,619	28,796	9,631	4,682	169,918
All	No DRL	6,295	47,078	58,418	29,413	9,989	2,611	1,139		154,943

Table B-2
Sample Size by State, Vehicle Model Years Including Dawn and Dusk
Light Trucks/Vans

		MY						
FARS		1993	1994	1995	1996	1997	1998	All
	DRL			292	1,614	1,674	164	3,744
	No DRL	234	1,709	1,823	118			3,884
State								
FL	DRL			797	3,093	2,747	499	7,136
	No DRL	632	3,018	2,679	412			6,741
IL	DRL			1,166	7,080	7,393	1,310	16,949
	No DRL	906	6,484	6,360	1,070			14,820
MD	DRL			246	723	850	311	2,130
	No DRL	173	689	796	185			1,843
MI	DRL			723	4,035	4,431	697	9,886
	No DRL	435	3,582	4,400	623			9,040
MO	DRL			797	4,418	4,351	433	9,999
	No DRL	641	4,514	3,742	397			9,294
NE	DRL			161	1,716	1,773	127	3,777
	No DRL	185	1,755	1,325	114			3,379
PA	DRL			327	2,190	1,928	228	4,673
	No DRL	299	2,169	2,425	169			5,062
UT	DRL			165	1,409	1,388	137	3,099
	No DRL	105	1,251	1,210	114			2,680
WI	DRL			768	3,496	3,638	463	8,365
	No DRL	476	3,561	3,651	424			8,112
State	DRL			5,150	28,160	28,499	4,205	66,014
All	No DRL	3,852	27,023	26,588	3,508			60,971

Excluding Dawn and Dusk

Table B-3
Sample Size by State, Vehicle Model Years Excluding Dawn and Dusk
Passenger Cars

		MY								
FARS		1993	1994	1995	1996	1997	1998	1999	2000	All
	DRL			331	1,469	2,076	970	285	182	5,313
	No DRL	219	1,388	2,289	1,041	290	73	50		5,350
State										
FL	DRL			840	5,083	6,257	3,677	2,348	875	19,080
	No DRL	586	4,588	5,324	3,738	1,973	553	47		16,809
IL	DRL			2,278	12,752	17,665	7,895	2,617	1,170	44,377
	No DRL	1,621	12,445	14,521	8,137	2,709	812	162		40,407
MD	DRL			791	3,069	3,445	1,775	1,169	500	10,749
	No DRL	298	2,666	2,886	1,721	1,024	307	124		9,026
MI	DRL			856	5,263	8,387	3,597	489	261	18,853
	No DRL	415	4,778	8,061	3,163	584	120	99		17,220
MO	DRL			1,229	7,291	10,235	4,000	858	480	24,093
	No DRL	894	6,678	7,743	4,145	1,031	219	67		20,777
NE	DRL			292	2,144	2,958	1,130	216	101	6,841
	No DRL	307	2,128	2,297	1,373	273	75	30		6,483
PA	DRL			1,507	5,619	6,278	2,306	715	579	17,004
	No DRL	755	5,099	6,296	2,433	882	245	290		16,000
UT	DRL			427	1,805	1,841	778	313	230	5,394
	No DRL	307	1,578	1,509	810	328	70	140		4,742
WI	DRL			1,182	5,458	6,890	2,505	606	319	16,960
	No DRL	877	5,350	7,447	2,769	799	131	136		17,509
State	DRL			9,402	48,484	63,956	27,663	9,331	4,515	163,351
All	No DRL	6,060	45,310	56,084	28,289	9,603	2,532	1,095		148,973

Table B-4
Sample Size by State, Vehicle Model Years Excluding Dawn and Dusk
Light Trucks/Vans

		MY						
FARS		1993	1994	1995	1996	1997	1998	All
	DRL			274	1,540	1,608	159	3,581
	No DRL	226	1,626	1,737	116			3,705
State								
FL	DRL			766	2,972	2,613	482	6,833
	No DRL	602	2,878	2,550	401			6,431
IL	DRL			1,088	6,661	6,943	1,254	15,946
	No DRL	850	6,092	6,003	1,013			13,958
MD	DRL			244	709	841	307	2,101
	No DRL	170	678	791	185			1,824
MI	DRL			662	3,704	4,126	647	9,139
	No DRL	414	3,329	4,072	584			8,399
MO	DRL			797	4,418	4,351	433	9,999
	No DRL	641	4,514	3,742	397			9,294
NE	DRL			148	1,615	1,658	119	3,540
	No DRL	176	1,655	1,240	105			3,176
PA	DRL			312	2,111	1,853	219	4,495
	No DRL	288	2,072	2,311	164			4,835
UT	DRL			149	1,319	1,318	131	2,917
	No DRL	95	1,168	1,132	109			2,504
WI	DRL			736	3,360	3,465	451	8,012
	No DRL	458	3,401	3,503	413			7,775
State All	DRL			4,902	26,869	27,168	4,043	62,982
	No DRL	3,694	25,787	25,344	3,371			58,196

APPENDIX C. SIMPLE ODDS[39]

This Appendix presents the DRL effects derived from the simple odds (SO). The Appendix also compares these effects to the ones derived from the ratio of odds ratios that are presented in the main body of the report. The study design for SO is also a control-comparison method. However, the fundamental design difference between these two statistics is how the control and target crashes were defined. For comparison purposes, the notations for the contingency tables introduced in Chapter II are used in this Appendix to describe SO and standard error calculations.

As described in Chapter II, to derive the ratio of odds ratios, the control and target crashes are first tabulated into two 2x2 contingency tables as follows:

DRL-equipped Vehicles

Light Condition	Target Crashes	Control Crashes
Daytime	N_1	N_2
Nighttime	N_3	N_4

Non-DRL Vehicles

Light Condition	Target Crashes	Control Crashes
Daytime	N_5	N_6
Nighttime	N_7	N_8

Each of the 2x2 contingency tables segregates crashes by light condition (daytime and nighttime) and crash type (control and target). The segregation is designed to control confounding factors which are associated with crash types (i.e., more young drivers in single-vehicle crashes than two-vehicle crashes) and light conditions (e.g., more alcohol use in nighttime hours). DRLs were designed to affect only the daytime crashes. Therefore, the separation of daytime and nighttime is considered to be critical to the analyses for DRL type of countermeasures.

In contrast, the control crashes for SO include the control crashes as initially defined in the above contingency tables and the "nighttime" target crashes (i.e., N_2 and N_6). The theory for this categorization contends that all nighttime crashes would not be affected by DRLs and thus should be considered as control crashes. This enlarged control crash group is called "big control crashes" in this Appendix. In other words, the "big control" crashes include three subgroups of crashes: nighttime target crashes, daytime control crashes, and nighttime control crashes. For this categorization, the above two 2x2 contingency tables essentially are consolidated into one 2x2 contingency table as shown below:

[39] In response to Dr. Farmer's comments.

DRL Status	Target Crashes	Big Control Crashes
DRL Vehicles	N_1	$N_2 + N_3 + N_4$
Non-DRL Vehicles	N_5	$N_6 + N_7 + N_8$

SO is defined as the odds of DRL-equipped vehicles' involvement in the target crashes verses the odds of the non-DRL-equipped vehicles' involvement. SO can be noted as:

$$SO = \frac{N_1}{N_2 + N_3 + N_4} \Big/ \frac{N_5}{N_6 + N_7 + N_8}$$

The effectiveness is defined as 1 – SO.

For SO, the calculations of standard error and 95-percent confidence interval of E are similar to those for the ratio of odds ratios. The standard error for the natural logarithm of SO ($\sigma_{\ln(SO)}$) is derived fist using the following formula:

$$\text{Standard Error of } \ln(SO) = \sigma_{\ln(SO)} = \sqrt{\frac{1}{N_1} + \frac{1}{N_2 + N_3 + N_4} + \frac{1}{N_5} + \frac{1}{N_6 + N_7 + N_8}}$$

Then, the standard error of E is equal to

$$1 - e^{\ln(SO) \pm 1.96 * \sigma_{\ln(SO)}}$$, where, e is the exponential function.

Tables C-1 and C-2 summarize the overall combined effectiveness derived from SO by crash severity. Table C-1 is for crashes that included dawn and dusk. Table C-2 is for crashes that excluded dawn and dusk. Results derived from the ratio of odds ratios are also presented in both tables. Bold faced figures indicate statistically significant results at the 0.05 level.

As shown in Table C-1, DRLs would reduce overall daytime target two-PV crashes (rear-end crashes were excluded) by 3.2 percent based on the SO statistic. The effect was statistically significant. Based on the ratio of odds ratios, the effect became 0.3 percent and it was not statistically significant. For injury and fatal target two-PV crashes, the DRL effects derived from either statistic were not statistically significant.

Based on SO, DRLs would reduce PV-to-PED/CYC crashes by 7.2 percent. The effect was statistically significant. In contrast, the effect derived from the ratio of odds ratios not only was not statistically significant, it was also negative indicating an increase of Single-PV-to-PED/CYC crashes. Though not statistically significant, DRL effects derived from SO were contrary to those derived from the ratio of odds ratios for injury and all Single-PV-to-PED/CYC crashes.

For PV-to-Motorcycle crashes, none of the estimated results, either based on SO or the ratio of odds ratios, were statistically significant.

Not surprising, for all target crashes combined, the effectiveness estimates were similar to those of target Two-PV crashes. DRLs would reduce the overall target daytime crashes by 3.2 percent based on SO. The effect was statistically significant. The corresponding DRL effect was 0.1 percent based on the ratio of odds ratios and the effect was not statistically significant. The DRL effects for injury and fatal target crashes were not statistically significant regardless of which statistic was used.

Table C-1. DRL Effectiveness
Including Dawn and Dusk

Two-Passenger-Vehicle Crashes, Excluding Rear-End Crashes

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	4.2	0.7
Injury Crashes	0.9	3.9
All Crashes	**3.2**	0.3

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist

	Effectiveness of DRL (%)	
Crash Severity	SO	Ratio of Odds Ratios
Fatal Crashes	6.8	0.1
Injury Crashes	2.3	-1.7
All Crash Severity	**7.2**	-4.3

Single-Passenger-Vehicle-to-Motorcycle

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	0.8	-7.5
Injury Crashes	-6.0	-0.5
All Crashes	0.8	-1.9

All Target Crashes Combined

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	5.3	2.9
Injury Crashes	0.9	3.3
All Crashes	**3.2**	0.1

Table C-2. DRL Effectiveness
Excluding Dawn and Dusk

Two-Passenger-Vehicle Crashes, Excluding Rear-End Crashes

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	4.7	1.2
Injury Crashes	1.1	4.4
All Crashes	**3.0**	-0.5

Single-Passenger-Vehicle-to-Pedestrian/Pedalcyclist

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	4.7	0.1
Injury Crashes	1.7	-2.0
All Crashes	**6.4**	-5.6

Single-Passenger-Vehicle-to-Motorcycle

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	-2.7	-11.4
Injury Crashes	-8.4	-2.5
All Crashes	-1.8	-5.0

All Target Crashes Combined

	Effectiveness of DRL (%)	
Crash Severity	Simple Odds	Ratio of Odds Ratios
Fatal Crashes	5.3	2.8
Injury Crashes	0.9	3.7
All Crashes	**2.9**	-0.7

As shown in the two tables above, the effects derived from the ratio of odds ratios are not consistently smaller than those derived from SO. Therefore, the use of ratio of odds ratios would not necessarily underestimate the effects of DRLs. However, as shown in the 2x2 contingency table, the "big control crashes" for SO included three subgroups with different crash types occurring under different light conditions. This methodology design does not process a vigorous control for variations among the crash groups. Furthermore, by the natural of mathematical process, the standard error for SO would always be smaller than that of the ratio of odds ratios even though both statistics were based on the same number of DRL and non-DRL crashes and the same number of daytime and nighttime crashes. Also, when any of the subgroups in the "big control crashes" was relatively smaller than the remaining groups, this group would contribute much less to the standard error. Contrarily, this group would contribute significantly more to the standard error when the ratio of odds ratios was used. Consequently, SO would be more likely to produce statistically significant results than the ratio of odds ratios as demonstrated in Tables C-1 and C-2.

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