

**HB**

**157**

<TARGET><BILL>HB 157</BILL><SUBJECT>HB  
157</SUBJECT><COMM>HTRA27</COMM></TARGET>



# Representative Scott Jiu Wo Kawasaki

Alaska State Legislature

District 9 Fairbanks

## **Sponsor Statement for HB 157 Let There Be Light On Alaska Roads Bill**

House Bill 157 addresses a key goal of the Alaska Highway Safety Office's Strategic Highway Safety Plan. The plan recommends changing state law to require car and truck headlight use at all times. Research shows a decrease in traffic accidents where daytime running lights are used. The Alaska Highway Safety Office has determined enforcements of the headlight law could decrease head-on collisions by five to 15 percent.

The effectiveness of "headlights on" laws can be seen in Alaska on the Seward Highway. In the mid-1990s, signs were installed along the highway from Anchorage to Seward requiring motor vehicles to have headlights on at all times. The Department of Public Safety and the Department of Transportation acknowledge the effectiveness of the headlight usage with instructional signs in saving lives. According to the Department of Transportation, there was a marked decrease in the number of crashes along the Seward Highway.

Similar results have been seen in other countries located in Polar Regions like Alaska. In Sweden, which has similar climate conditions to Alaska, studies have found that the requirement to use headlights at all times reduced crash rates by 20 percent in urban areas and 17 percent in rural areas in winter months.

House Bill 157 will increase the safety on Alaska's roadways by making all vehicles easier to see while traveling, especially during Alaska's long periods of dusk and dawn. Please join me in supporting House Bill 157 and help make Alaska a safer place to drive.

## Alaska Department of Transportation & Public Facilities/ Alaska Highway Safety Office

### Headlights



**Headlights on the Alaska Highway.**

Photo by Joanna Reed, Alaska DOT&PF.



**One of 47 signs installed in 2011 within four Safety Corridors.**

Photo by Brendan Dougherty, Alaska DOT&PF.



**Headlights are ON.**

Photo by Joanna Reed, Alaska DOT&PF.

Headlights are a low-cost method to reduce crashes by increasing vehicle conspicuity and making it easier to detect approaching vehicles from farther away. Nearly all published reports indicate the use of headlights reduce multiple-vehicle daytime crashes, including studies conducted in Scandinavia, Canada, and the United States. Available studies document crash reductions of 5% to 15% due to the use of daytime headlight use.

If you don't have driving running lights, then manually turn on your headlights, if you want to perform one of the easiest tasks to prevent a traffic crash. And the light bell will sound as a reminder to turn them off in some vehicles.

### Why use headlights in Alaska?

For the same reason that northern countries as Canada Finland Sweden Norway Iceland Denmark: to prevent head-on collisions. In our hemisphere, during both summer and winter greater judgment is required because:

- the twilight period is quite long
- the shadows produced by low sun angles in the summer often reduce visibility of vehicles
- vehicles take on a grey tint and become camouflaged against the surrounding grey-tinted sky, mountains, buildings and roads.
- deep shadows can make a car nearly invisible even on the brightest days of the year

### What is the law in Alaska?

Motorists in Alaska must drive with headlights on where a roadway is posted to do so.

### 13 AAC 04.010. When lights are required

(a) Every vehicle traveling on a highway or other vehicular way or area within the state must illuminate lights

(1) between one half hour after sunset and one half hour before sunrise; or

(2) at any other time when, because of insufficient light or other atmospheric conditions, persons or vehicles on the highway are not clearly discernible at a distance of 1000 feet.

(b) Stop lights, turn signals, and other signaling devices must be illuminated as required by this chapter.

(c) Every vehicle traveling on a highway or vehicular way or area must illuminate lights when traveling on any roadway that is posted with signs requiring the use of headlights.

(d) For the purposes of (c) of this section, lights include low intensity headlights and daytime running lamp devices that meet the standards in 49 C.F.R. 571 (revised as of August 29, 1996), if the headlights are not otherwise required under (a)(1) or (2) of this section.

## What is Alaska doing to prevent head-on collisions?

During the summer of 2011, the Department of Transportation and Public Facilities, in consultation with the Department of Public Safety, installed headlight signs along the four designated safety corridors based upon the 2010 Safety Corridor Audit. The Sterling, the Seward, the Parks and the Knik-Goose Bay Roads all have signs along their designated corridors. The purpose is to maximize lives saved at the least public cost on the existing roadway, until such time as significant permanent and lasting road improvements can be made. Centerline rumble strips were installed in Safety Corridors in 2010 in order to reduce head-on collisions by one-quarter or greater, as is often the result in other states.

It is the responsibility of the State of Alaska and all drivers to take as many actions as possible to prevent deaths and major injuries on our highways. In the case of Safety Corridors, the State of Alaska is taking our highest volume, highest risk roadways and increasing the requirement for us all in order to reduce risk and save lives for all residents and visitors.

The State of Alaska is actively engaged in the headlights issue; describing the requirement in media and anywhere signs are posted the Alaska State Troopers are stopping and educating motorists, and if appropriate, writing a \$60.00 2-point citation.

## Will DRLs shorten headlamp bulb life or lower fuel economy?

Running vehicle lights in the daytime does not significantly shorten bulb life. Systems like those on General Motors cars that use high beams are designed to operate at half their normal power during daylight hours, thereby conserving energy and reducing the effect on a vehicle's fuel economy. The National Highway Traffic Safety Administration (NHTSA) estimates that only a fraction of a mile per gallon will be lost, depending on the type of system used. GM estimates the cost to be about \$3 per year for the average driver.

## Are motorcycles required to have DRLs?

Federal law does not require motorcycles to have DRLs, but some states, like Alaska, require motorcyclists to ride with their headlights on at all hours. Since 1979 most manufacturers have equipped their cycles with automatic-on headlamps.

### Publications

NHTSA - An Assessment of the Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs)  259KB

NHTSA - Drivers' Perceptions of Headlight Glare From Oncoming And Following Vehicles  333KB

Department of Transportation & Public Facilities  
PO Box 112500  
3132 Channel Drive  
Juneau, Alaska 99811-2500  
Phone: 907-465-3900 || 907-586-8365 (FAX)  
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### Safety Topics

- » DEC / DRE
- » Distracted Driving
  - Fatality Analysis
  - » Reporting System (FARS)
- » Headlights
  - LEL - Law Enforcement
  - » Liaisons
- » Low Speed Vehicles
- » Media Campaigns
- » Mock Crashes
- » Moose Safety
- » Motorcycle Safety
- » Occupant Protection
- » REDDI
- » Red Light Running
- » Safe Communities
  - DUI Information &
    - » Impaired Driving
      - » State DUI Driver Information
      - » Impaired Driving
- » Safety Corridor
  - » Safety Corridor
  - » Safety Corridor Maps
- » Senior Driving in Alaska

**Mindy O'Neill**

---

**From:** Don and Carol Callahan <caltec@mosquionet.com>  
**Sent:** Sunday, January 22, 2012 9:23 PM  
**To:** Sen. Joe Paskvan; Sen. Joe Thomas  
**Cc:** Rep. David Guttenberg; Rep. Scott Kawasaki; Rep. Tammie Wilson; Rep. Bob Miller  
**Subject:** Driving Safety Bill

Driving in Fairbanks and environs in the ice fog and with limited hours of daylight and cars that are white or silver or shades of gray I think a law that required headlights and tail lights (not just those obnoxious "driving lights or fog lights") be required 24-7 from 1 November until March 1.

Respectfully submitted,

Don Callahan

And following distance requirement should be on the 4 second rule not the 2 second or 3 second...

**Tyler Spaan**

---

**From:** Marie Wagner <dmea@netzero.net>  
**Sent:** Thursday, October 27, 2011 3:28 PM  
**To:** Rep. Scott Kawasaki  
**Subject:** Seward Hiway Safety

Hello Rep. Kawaskai ,

We have lived in Seward, Whittier & Anchorage and have driven the highway for over 30 years. The recent focus on highway safety prompted us to develop a method to both remind and encourage motorists to observe the "headlights on" in the safety corridor and also raise revenue for other highway safety projects.

As one of the authors of the HB 181 requiring headlight use, I know this is an important issue for you too.

I've briefly discussed this proposal with Chief Schofield and Mayor Lunceford of Whittier. Of course, they are both deeply concerned about making the Seward highway as safe as possible.

Please take a moment to look at our website and then I'd like to get your comments.

Thanks,

Marie Wagner, Project Managner

PhotoSolutions

907-703-8890

[info@PhotoSolutions.info](mailto:info@PhotoSolutions.info)

[www.PhotoSolutions.info](http://www.PhotoSolutions.info)

Helping to make our highways safer

## Tyler Spaan

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**From:** elke2144@ptialaska.net  
**Sent:** Wednesday, January 25, 2012 10:44 AM  
**To:** Sen. Joe Thomas; Rep. Scott Kawasaki; Rep. David Guttenberg  
**Subject:** Headlights

Hello Sirs; we've all seen them, the people who don't seem smart enough to turn their headlights on when they are in the fog, blowing snow, have the sun to their back etc. The object is to be seen not to see! I would like to see the State spend some money to make some Public Service announcements to explain why you should turn your headlights on AT ALL TIMES. We have them to tell you to keep back from road equipment (duh!). We have them to tell you to burn dry wood (duh!). I would like to see something like posters in DMV with a car with lights in the fog/snow and without lights. a spot showing the same on TV. A spot on the radio stations, " put your head lights on dummy." It would go a long way in lowering my blood pressure.

While I'm here, how about NOT lowering the taxes on the oil companies! I'm paying \$4.00 a gallon for heating oil, on a fixed income.. The oil companies are making record profits. If the Gov. was serious about long term investment he would leave the oil in the ground and it will accrue in value.. wages and benefits for working for the oil companies have been reduced by at least 25%. IF the oil companies want to leave, don't let the door hit them in the ass on the way out!!!!

Thank you for your service!

Terrence Koltak

B 282  
ester ak 99725

**Mindy O'Neill**

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**From:** Don and Carol Callahan <caltec@mosquitonet.com>  
**Sent:** Sunday, January 22, 2012 9:23 PM  
**To:** Sen. Joe Paskvan; Sen. Joe Thomas  
**Cc:** Rep. David Guttenberg; Rep. Scott Kawasaki; Rep. Tammie Wilson; Rep. Bob Miller  
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Respectfully submitted,

Don Callahan

And following distance requirement should be on the 4 second rule not the 2 second or 3 second...

## Rep. Scott Kawasaki

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**From:** joelkol <joelkol@yahoo.com>  
**Sent:** Tuesday, February 14, 2012 11:03 PM  
**To:** Tyler Spaan  
**Subject:** For headlights

I was so excited to see this being addressed, a small thing that can make a huge difference. I lived off the seaward highway many years ago where headlights are required at all times and noted a significant difference in visibility after relocating here. I would love to see this enacted as I use my headlights at all times because of that past experience.

Thank you for the opportunity to write my support.

Joseph Hogan

Sent from my Samsung Galaxy Tab

## Rep. Scott Kawasaki

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**From:** sue cole <scoleak@gmail.com>  
**Sent:** Tuesday, February 14, 2012 7:01 PM  
**To:** Tyler Spaan  
**Subject:** use of headlight on all vehicles

As a former driving instructor and examiner for the State of Alaska and the Teamsters, I have often observed vehicles that would not otherwise be visible if they hadn't had their headlights/tailights on. I completely support this action.

Also, it doesn't matter what type of day or what the weather is, you just have a better chance of other people seeing you if your lights are on.

Teresa Sue Cole  
420 Eureka Avenue  
Fairbanks, AK 99701  
registered democrat

## Rep. Scott Kawasaki

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From: Marcella Hill <aksally2324@gmail.com>  
Sent: Tuesday, February 14, 2012 6:29 PM  
To: Tyler Spaan  
Subject: HB 157

As an AARP Safe Driving for the past 14 years in Alaska, I have seen the dire need for all motor vehicles to have their lights on while in motion. Judging distances and speed of oncoming traffic in low light as in snow, fog, and rain is very important in aiding drivers in making the right quick decisions. As Alaska's population of older drivers increase, it is imperative to have our roadways as safe as possible. The main way is to have headlights on when driving.

Marcella D. Hill  
1548 Westwood Way  
Fairbanks, 99709

## Tyler Spaan

---

**From:** Nancy Kuhn <motherchukar@gmail.com>  
**Sent:** Tuesday, February 14, 2012 4:19 PM  
**To:** Tyler Spaan  
**Subject:** can you see me yet?

Turn on your headlites so I can see you. Black cars and trucks on black roads with minimal light leads to deaths that are needless. Give me a chance to know you are either coming at me or are in the lane ahead of me, please. All vehicles, bicycles, snow machines and off road vehicles included, need to be outfitted with headlights that work and there should be a penalty for driving without them turned on or burned out. Safety first.

Vote YES for HB 157 "Act relating to the use of headlights when operating a motor vehicle."

## Tyler Spaan

---

**From:** Gretchen Murphy <gretmurphy@gmail.com>  
**Sent:** Tuesday, February 14, 2012 4:23 PM  
**To:** Tyler Spaan  
**Subject:** lights on!!

Driving in our town means the sun shining at low angles which can impede vision or it means driving in the dark. Often I pass cars coming towards me on Chena Pump Road that do not have their headlights on. I do not see them until they are within a very short distance of me. Headlights need to be on at all times for our safety. They are not just for the convenience of the vehicle's driver; they are more important for other drivers to see that vehicle.

Gretchen Murphy  
3504 Kreb Drive  
Fairbanks, AK 99709

--

Gretchen Murphy  
State Math Content Coach  
907-479-8224  
907-799-6138 (GCI cell for travel only)

research on school teachers shows that good instruction requires the ability to make complex decisions about how curriculum can be used to provoke and develop student reasoning. --a math ed researcher  
took a researcher to tell us this.

## Tyler Spaan

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**From:** Don and Carol Callahan <caltec@mosquionet.com>  
**Sent:** Tuesday, February 14, 2012 6:36 PM  
**To:** Tyler Spaan  
**Subject:** Headlight use during winter period

I wrote to a # of legislators about the lack of head and tail lights illuminated on vehicles on the road during the winter months.

I believe that it should be mandatory to have head and tail lights on any time operating a motor vehicle during the winter months from November 1 until March 1 in Alaska.

I keep them on all year around.

Don Callahan  
Fairbanks  
907-388-1658

## Tyler Spaan

---

**From:** Ron Arnold <aefse@gci.net>  
**Sent:** Tuesday, February 14, 2012 8:49 PM  
**To:** Tyler Spaan  
**Subject:** HR 157

Honorable Tyler Spaan,

I wish to state my approval of making safer driving with headlights on at all time in Alaska. I commend you for taking this step for many people will be critical of you and say we don't need more government yet government is needed when it comes to safety of its citizens. It is unfortunate that we are not onboard with safety of our citizens when it comes to health care, how we use our resources in Alaska and the manufactured energy crisis the state is in due to cow towing or our representatives to the lobbyist and not the citizens of the great state of Alaska.

What bills will you present to address these issues of fairness and safety for citizens of Alaska?

Have a day of success,

Ron Arnold

Alaska Yukon River Expedition  
PO Box 74512  
Fairbanks, Alaska 99707  
907 953 2233 – Cell Phone  
[ayre@gci.net](mailto:ayre@gci.net)  
[www.alaskayukonriverexpedition.com](http://www.alaskayukonriverexpedition.com)

There is no understanding when fear is greater than love

## Tyler Spaan

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**From:** Maureen Knutsen <maureen.knutsen@gmail.com>  
**Sent:** Tuesday, February 14, 2012 9:33 PM  
**To:** Tyler Spaan  
**Subject:** HB 157

I am writing to express my support for HB 157. Driving with headlights is not a hardship and I concur that this will improve safety in many conditions.

Thank you for considering my comment.

Maureen Knutsen  
P.O. Box 134  
Naknek, AK 99633

## Tyler Spaan

---

**From:** D. Robbins <d Robbins.r@gmail.com>  
**Sent:** Tuesday, February 14, 2012 11:08 PM  
**To:** Tyler Spaan  
**Subject:** Driving with lights on

I think it is a good safety measure to drive with lights on.

I do not myself have a vehicle so I'm not sure my thoughts should count.

Sincerely,

Doris Robbins

--  
Doris Robbins

(907) 374-0597  
1281 Overhill Dr.  
Fairbanks AK 99709-6753  
[Robbins.r@gmail.com](mailto:Robbins.r@gmail.com)

*Natural Soaps Soothing to the Skin*  
[www.alaskasoaps.com](http://www.alaskasoaps.com)

## Tyler Spaan

---

**From:** Jeanine Griek <jeaninegriek@gmail.com>  
**Sent:** Wednesday, February 15, 2012 10:49 AM  
**To:** Tyler Spaan  
**Subject:** Hb157

I support hb157. There have been too many times that I have seen dangerous situations on the roads because people don't have their headlights on, even when there is thick icefog!

Jeanine Griek  
Fairbanks

Sent from my iPhone

## Tyler Spaan

---

**m:** Janet Halvarson <halvar@alaska.net>  
**Sent:** Wednesday, February 15, 2012 10:11 AM  
**To:** Tyler Spaan  
**Subject:** Daytime headlight use

I fully support the use of headlights on the roads of Alaska and always have. Go for it.  
Stan Halvarson, Fairbanks

## Tyler Spaan

---

**From:** Bob Thomas <bobt38@acsalaska.net>  
**Sent:** Tuesday, February 14, 2012 7:05 PM  
**To:** Tyler Spaan  
**Subject:** headlight safety

I do NOT support HB-257 as a law - If all vehicles were equipped with auto lights would be one thing - but they aren't and - especially in Alaska - we're all going to forget - except for the professional drivers - and they do not need a law to use this safety measure. It's laws like this that drive up the cost of government. Good intentions - but ..... the cost of paying law enforcers to stop, warn, and perhaps tickets and court and collection is just too much to ask of the taxpayers. (Remember, we have a lot of cops and judges on the road or bench BUT for each of these we have two or three in retirement mode for which we still pay retirement.) Oh and by the way I'm a retired Alaskan traffic engineer. Bob Thomas

## Tyler Spaan

---

**From:** Tim Berg <deadman@alaska.net>  
**Sent:** Tuesday, February 14, 2012 7:16 PM  
**To:** Tyler Spaan  
**Subject:** HB 157

Dear Tyler:

Please pass along to my House Rep. Kawasaki; my extreme displeasure, of hearing that the legislator is wasting their time on a bill that they will surely claim is for the good of the citizens! The decision to use head lights, should not be the job of Government! Other than what is currently required!

Sincerely

Tim Berg  
Fairbanks Alaska

**Tyler Spaan**

---

**From:** Pitzer, Ezra S SSgt USAF ANG 168 MXS/MXMTC <ezra.pitzer@ang.af.mil>  
**Sent:** Wednesday, February 15, 2012 6:40 AM  
**To:** Tyler Spaan

Dear Tyler:

Please pass along to my House Rep. Kawasaki; my extreme displeasure, of hearing that the legislator is wasting their time on a bill that they will surely claim is for the good of the citizens! The decision to use head lights, should not be the job of Government! Other than what is currently required!

Sincerely

EZRA PITZER,

NORTH POLE ALASKA

## Tyler Spaan

---

**From:** Jim Pound  
**Sent:** Thursday, February 09, 2012 12:02 PM  
**To:** Rep. Scott Kawasaki; Mindy O'Neill  
**Subject:** FW: HB 181 26th Legis.

**Follow Up Flag:** Follow up  
**Flag Status:** Flagged

I am passing this along for your information on HB 157.

Jim

**From:** Craig Breshears [<mailto:ak-craig@clearwire.net>]  
**Sent:** Thursday, February 09, 2012 8:44 AM  
**To:** Jim Pound  
**Subject:** RE: HB 181 26th Legis.

Thanks for the reply Jim.

I think the bill has merits and could possibly reduce risks for motorists unfortunately for motorcyclists I think it may have dire consequences. As you know motorcyclists are taught to utilize the entire lane broken up into three distinct areas, right-middle-left. Since motorcycles are already required to use headlights at all times I feel that with all roadway users dimming their headlamps that motorcyclists may be lost in depth perception. Oncoming passing traffic may see the larger vehicle behind us and simply see our headlamp as one of the vehicles missing judging their passing distance. Head-on collisions for motorcycles are rarely anything but deadly. If this legislation appears to be able to pass I would like the opportunity to talk with you about additional language or a separate bill that could put motorcycles back on solid ground.

Craig "Blue" Breshears  
Media Chair  
AMSAC  
Alaska Motorcycle Safety Advisory Committee  
(907) 230-9205  
[http://www.dot.state.ak.us/stwdplng/hwysafety/motorcycle\\_safety.shtml](http://www.dot.state.ak.us/stwdplng/hwysafety/motorcycle_safety.shtml)  
Got advice on motorcycle safety??? I'm all ears!!!

**From:** Jim Pound [[mailto:Jim\\_Pound@legis.state.ak.us](mailto:Jim_Pound@legis.state.ak.us)]  
**Sent:** Thursday, February 09, 2012 7:55 AM  
**To:** Blue  
**Subject:** RE: HB 181 26th Legis.

Sorry for the delay. It has been a mess this year. Anyway the bill is now HB 157. It was re-introduced last year but has yet to be heard in Committee. Here is the basic information.

27th Legislature(2011-2012)



U.S. Department  
of Transportation

National Highway  
Traffic Safety  
Administration



---

DOT HS 809 669

October 2003

Technical Report

# DRIVERS' PERCEPTIONS OF HEADLIGHT GLARE FROM ONCOMING AND FOLLOWING VEHICLES

Published By:

**NCSA**

National Center for Statistics and Analysis  
Advanced Research and Analysis

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This document is available to the public from the National Technical Information Service, Springfield, Virginia, VA 22161

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Technical Report Documentation Page

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				6. Performing Organization Code NPO-121 and NVS-322	
7. Author(s) Santokh Singh*Ph. D. and Mike Perel®				8. Performing Organization Report No.	
9. Performing Organization Name and Address  * Rainbow Technology Inc.      @ Crash Avoidance Research Division 17106 Thatcher Court              NHTSA, U.S. Department of Transportation Olney, MD 20832                      400 Seventh Street, S.W., Washington, D.C. 20590				10. Work Unit No. (TRAIS)	
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15. Supplementary Notes  Authors wish to thank reviewers from NHTSA for their useful comments and Mr. Tom Bragan and Ms. Ellin Ramsey for proofreading this report.					
16. Abstract  Recently, U.S. drivers have been expressing concern over the discomfort and reduced visibility that they experience from headlight glare from other vehicles. Drivers have focused their concern on the relatively new high intensity discharge lights, high mounted lights, and various auxiliary lights. In order to better understand this glare problem, the National Highway Traffic Safety Administration collected data on drivers' perception of glare from a representative sample of U.S. drivers. The survey was conducted through Omnibus Survey of the Bureau of Transportation Statistics. The present study is based on the information (data) collected on two types of glare: glare from oncoming and following vehicles.  The survey data were analyzed to find out how U.S. drivers perceive the two types of glare and if glare perception is associated with respondents' age and gender. Contingency analysis was conducted to establish these associations. The statistics showed that a sizeable number of respondents feel that glare was 'disturbing'. The percent frequency distributions were used to better understand the age and gender profiles of drivers who felt disturbed by the nighttime glare. It was found that the age group 35 to 44 had the highest percentage of night drivers as well as among those who felt glare 'disturbing'. In addition, female respondents of this age group were more of the opinion that the glare from oncoming and following vehicles was 'disturbing' as compared with other age groups of their own gender or even of the opposite gender.					
17. Key Words age, association, following glare, gender, oncoming glare, respondents			18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, VA 22161 <a href="http://www.ntis.gov">http://www.ntis.gov</a>		
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## EXECUTIVE SUMMARY

### Background and objectives

In recent years, an increasing number of drivers have complained to the National Highway Traffic Safety Administration (NHTSA) about headlight glare. A number of comments concerned objections to glare from fog lamps and high-mounted headlights on trucks and SUVs. The comments from the public to the NHTSA Docket 01-8885 helped to identify many of the glare concerns of the U.S. driving population. The large number of glare complaints demonstrated the extent to which the public was concerned with the glare from other vehicles. The number of comments was larger than those that NHTSA received on other safety concerns. However, the docket comments may not provide a true assessment of the glare concern of the driving population.

High intensity of headlights may extend the visibility of objects ahead, but it may also increase the discomfort that glare of the headlights may cause to drivers of other vehicles. Glare can also reduce visibility distances by reducing object contrast or causing drivers to avert their eyes from the roadway to avoid discomfort. The challenge for headlight designers and regulators is to maintain an appropriate balance between glare and visibility. While empirical research is often necessary to quantify these tradeoffs, such research can only study a small number of drivers under a limited set of real world conditions. This limits the extent to which findings can be generalized to the entire population of drivers as well as to real world driving conditions.

To help put the docket comments on glare into perspective, NHTSA asked the Bureau of Transportation Statistics (BTS) to include several questions pertinent to this issue in a series of nationwide telephone surveys titled 'Omnibus Survey'. These surveys were conducted monthly (January to December, 2002) with a new sample of subjects each month. However, the questions concerning glare were asked only during the first six months: January to June 2002. The questions pertaining to drivers' perceptions of glare from *oncoming* and *following* vehicles is the subject of this study.

Based on the survey, the primary objective of this study was to obtain a nationally representative assessment of drivers' perceptions of glare. Additionally, the objective was to confirm if drivers' perceptions of glare are associated with their age and gender and bring out the differences that might exist due to gender and age of the respondent.

### Data and methodology

The analyses conducted in this study are based on the 'Omnibus Survey' data that consists of drivers' perceptions of glare expressed as: 'not noticeable', 'barely noticeable', 'noticeable but acceptable', 'disturbing', or 'crash or near miss' due to two types of glare: glare from oncoming and following vehicles.

Descriptive statistics were used to study variations with respect to glare perceptions that exist among drivers due to age and gender. Contingency analysis was used to test hypotheses related to the possible associations between glare ratings and age and gender. Bivariate distributions: Age x Glare perception and Gender x Glare perception were used to obtain a better idea about the glare perception.

### Results and conclusions

The results show that for the majority of respondents (about 54%) glare was 'noticeable but acceptable'. However, the sizeable number of drivers (about 30%) who experienced nighttime glare as 'disturbing' cannot be ignored. The response data of drivers falling into this category was further analyzed to bring

out the differences that might exist due to the type of glare and age and gender of the respondent. In fact, the frequency distributions of the glare-disturbed respondents over age and gender groups, for oncoming and following glare, did not indicate any difference due to the type of glare; the distributions were found in close proximity with each other. There were, however, percentage differences among age and gender groups.

The age-wise comparison highlighted some differences and similarities among age groups. For instance, the distribution of the glare-disturbed respondents over age groups showed that most of the respondents who rated glare 'disturbing' were not old drivers. Also, the ratings of discomfort from glare for old drivers were not significantly different from that for the younger drivers. In general, the percentage of the glare-disturbed respondents was highest for the age groups 35 to 44 and 45 to 54. For oncoming glare, the 55 to 64 year old group had the highest percentage of the glare-disturbed respondents, while for following glare, it was the age group 18 to 24 that contributed most to the this category of drivers.

Through gender-wise comparison of respondents, it was observed that although male and female representation in the population of all respondents was the same, the females, in general, were found more glare-disturbed. Distributions of male and female respondents over age groups showed that among all night-driving and glare-disturbed respondents, 35 to 44 year old had the highest representation, with a higher female representation. Male-female comparison within each age group showed that among the night-driving respondents, males had much higher representation in the age group 75 and above, while in other age groups the differences in male-female representations were small. The gender-wise comparison was also done for the glare-disturbed respondents in each age group. Significant differences in male-female representations were observed within each age group of this category of respondents with much larger differences for the age groups 35 to 44 and 75 and above. It was also found that 35 to 44 year old females had much higher representation as compared with the males of this age group, even though the differences between the two genders of this age group among all respondents was not so large.

The statistics also show that for both oncoming and following glare, as the number of dark hours decreases from January to June, the percentage of 'concerned' respondents decreases. The largest decrease in the percentage of glare-disturbed respondents was observed from March to April. Only a slight change in the percentages of both 'concerned' and 'minimally concerned' respondents was observed in May and June.

## **1. Introduction and background**

In recent years, an increasing number of drivers have complained to the National Highway Traffic Safety Administration (NHTSA) about headlight glare. The complaints are documented in citizen submissions to Docket 01-8885, Notice 1. Since its publication in September 2001, the docket has received about 4,000 comments from all over the United States. A number of comments concerned objections to glare from fog lamps and high-mounted headlights on trucks and SUVs. However, the primary concern was glare from high intensity discharge (HID) lights. HID differ in several respects from more conventional halogen lamps. HIDs have a bluer spectral content, a wider beam pattern, and can have a smaller luminous area. While a few drivers with HID on their vehicles thought that their night visibility improved, the great majority of the comments expressed drivers' complaints about glare from HID-equipped vehicles.

Increasing intensity may extend the visibility of objects ahead but it may also increase the discomfort that glare of the headlights may cause to drivers of other vehicles. Glare can also reduce visibility distances by reducing object contrast or causing drivers to avert their eyes from the roadway to avoid discomfort. The challenge for headlight designers and regulators is to maintain an appropriate balance between glare and visibility. While empirical research is often necessary to quantify these tradeoffs, such research can only study a small number of drivers under a limited set of real world conditions. This limits the extent to which findings can be generalized to the entire population of drivers.

The comments from the public to the NHTSA docket helped to put the glare concerns of the driving population at large into perspective. The large number of glare complaints demonstrated the extent to which the public was concerned with the glare from other vehicles while driving on the roadways. The number of comments was much larger than the number of public comments that NHTSA has received on other safety topics. The drivers' descriptions of their glare problems helped to provide real-world insight into the safety-related problems being experienced on the roadways. For example, many drivers described being "blinded" for a few seconds after exposure to the glare and needed to slow down. The strong feelings of the public about being exposed to glare were also evident in their comments.

Despite the useful information provided by docket comments, they do not necessarily provide a representative assessment of the glare concerns of the U.S. driving population. The comments may be biased because drivers with glare problems are more likely to write as compared with those who have no such issues. It is also likely that many viewpoints were not represented because many drivers did not know about the docket.

To help put the docket comments on glare into perspective, NHTSA asked the Bureau of Transportation Statistics (BTS) to include several questions pertinent to this issue in a series of nationwide telephone surveys titled 'Omnibus Survey'. These surveys were conducted monthly (January to December, 2002) with a new sample of subjects each month. However, the questions concerning glare were asked only during the first six months: January to June 2002. The questions pertaining to drivers' perceptions of glare from oncoming vehicles and glare from the vehicles behind are the subject of this study.

## **2. Overview of the Omnibus survey**

The Omnibus Survey is a stratified random national probability sample conducted monthly by the BTS to monitor expectations of, and satisfaction with, the transportation system, as well as to gather information on specific events and issues, using a Random-Digit-Dialed telephone methodology. Various sampling issues, such as selection of sampling design, sampling weights, precision of estimates, etc., were resolved before the interviews started. The target population of the survey consisted of U. S. non-institutionalized adult population of drivers who were 18 years of age or older. The average (over

six months) final completed sample size was 1,053 cases per month, of which on the average 870 were valid responses. Each respondent who drove at night during the previous twelve months was asked to express his/her perception of nighttime glare from: oncoming and following vehicles by selecting one of the five ratings: 'not noticeable', 'barely noticeable', 'noticeable but acceptable', 'disturbing', or 'caused a crash or near miss'.

The background information of the survey, sampling procedures, data collection, data elements and survey variables, response rates, final weights and standard errors of estimates are provided in the survey documentation of the Omnibus Survey issued by Bureau of Transportation Statistics [1].

### 3. Objective of the study and methodology

A descriptive analysis was conducted to get a comparative idea about different glare ratings. One of the objectives of this study was to confirm if the driver's perception of glare on driving is in any way associated with age and gender of the respondents. Contingency analysis was used to test hypotheses related to the possible association between glare ratings and age and gender. Contingency analysis [2] is one of the useful techniques to study the relation between two variables that can be arranged in a contingency table, such as Table A.1 (Appendix).

Bivariate percent frequency distributions were used to study the differences that exist among respondents of different age and gender groups in perceiving glare. These differences were depicted through percentage histograms and polygons.

### 4. Selection of variables for statistical analysis

As mentioned earlier, the present study is focused on 'glare from oncoming vehicles' and 'glare from following vehicles'. Accordingly, the analyses conducted in this study are based on responses of the interviewed persons to the following two questions:

**Q1.** In the last 12 months, while driving at night, has the glare from the headlights of an **oncoming vehicle** been '*not noticeable*', '*barely noticeable*', '*noticeable but acceptable*', '*disturbing*', or did it cause a '*crash or near miss*'?

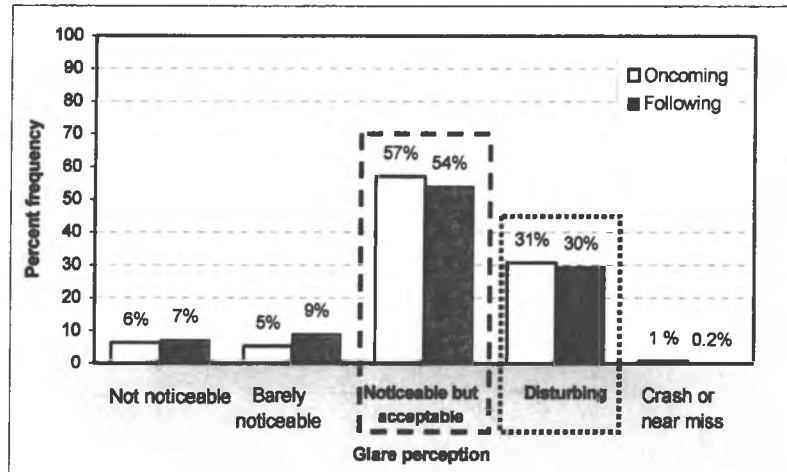
**Q2.** In the last 12 months, while driving at night, has the glare from the headlights of a **vehicle behind** been '*not noticeable*', '*barely noticeable*', '*noticeable but acceptable*', '*disturbing*', or did it cause a '*crash or near miss*'?

The two glare types covered by questions Q1 and Q2 will be referred to, respectively, as oncoming and following glare. It is important to note that the above two questions do not cover the respondents of the survey who did not drive at night during the last twelve months. Such respondents are therefore not subject of this study. In addition, the respondents who 'refused' to answer the two glare questions or responded 'don't know', do not provide any information about the glare issue. Hence, such respondents will also be excluded from the analysis. Thus, the term 'respondent' used henceforth should be understood to mean a survey respondent whose response was one of the five choices. The respondents considered in this study can accordingly be classified in five categories: 'not noticeable', 'barely noticeable', 'noticeable but acceptable', 'disturbing', 'crash or near miss'.

### 5. Overall glare ratings of survey respondents

As a first step, a descriptive analysis was conducted to get an overall picture of how the U.S. drivers, in general, perceive glare from oncoming and following vehicles. Figure 1 presents percent frequencies of

respondents for responses (ratings): not noticeable, barely noticeable, noticeable but acceptable, 'disturbing', crash or near miss, aggregated for the six months (January to June). It can be seen in Figure 1 (box with broken line border) that according to majority of respondents, both oncoming and following glare is 'noticeable but acceptable'; the percent frequencies of respondents with this rating being the highest 57% and 54%, respectively, for the two types of glare.



**Figure 1.** Percent frequency distributions of respondents over five glare ratings for oncoming and following glare (Data source: Omnibus Survey 2002, BTS).

Figure 1 also shows that for small percentages (6% and 7%) of respondents, oncoming and following glare types were 'not noticeable' and so was the case with respondents who rated glare as 'barely noticeable'; the latter formed only 5% and 9%, respectively, for the two types of glare. The respondents who were seriously concerned about glare and had significant representation among respondents were the ones for whom glare was 'disturbing'. About 31% of respondents perceived oncoming glare 'disturbing' and about 30%, following glare. Since temperament plays an important role in perception, the class of respondents who felt disturbed from glare was considered as a special class for further analysis. The following analysis is focused on detecting the differences that might exist in terms of the contribution of different age- and gender-based groups to the class 'disturbing'. These respondents will be referred to as 'glare-disturbed' respondents.

## 6. Association between glare perception and respondent's age and gender

Perception is a process whereby sensory stimulation in humans is translated into organized experience and so is the glare perception. Therefore, in order to get a deeper insight into the glare issue, it is important to investigate if the human attributes: age and gender of the respondents can have influence on his/her perception of the glare. To confirm this, contingency analysis was conducted to test the hypothesis of independence between glare perception and respondent's age as well as between glare perception and respondent's gender for both oncoming and following glare. As the Omnibus survey was based on stratified simple random design, the statistical software SUDAAN® was used for contingency analysis of the survey data, which takes into account the underlying sampling design. The analysis will be supplemented by what is called Ph-coefficient, which measures the strength of association between two categorical variables.

The analysis for testing independence between glare perception and age yielded the value 64.08 of Chi-square with 24 degrees of freedom and p-value 0.000001. These statistics confirm that respondent's age

possibly influences how he/she perceives oncoming glare. The value 0.3 of Phi-coefficient with its lower and upper attainable bounds 0 and 0.9, respectively, shows a strong association between respondent's age and his/her perception of oncoming glare. Similarly, the test statistics: 25.56 of Chi-square with 4 degrees of freedom and p-value 0.00001 show that gender of the respondent, too, has bearing on oncoming glare perception. The value 0.2 of Phi-coefficient with its lower and upper attainable bounds 0 and 0.7, respectively, shows a strong association between respondent's sex and the rating of oncoming glare.

The hypothesis of independence between glare perception and age as well as between glare perception and gender was also tested for following glare. The value 60.38 of Chi-square with 24 degrees of freedom and p-value 0.000001 shows that respondent's age has influence on how he/she perceives following glare. The value 0.3 of Phi-coefficient with its lower and upper attainable bounds 0 and 0.9, respectively, shows a strong association between respondent's age and the rating of following glare. Similarly, the test statistics: 37.97 of Chi-square with 4 degrees of freedom and p-value 0.000001 show that gender of the respondent, too, has bearing on oncoming glare perception. The value 0.2 of Phi-coefficient with its lower and upper attainable bounds 0 and 0.7, respectively, shows a strong association between respondent's sex and the rating of following glare.

It was found in Section 5 that the glare-disturbed respondents formed the second largest category among all respondents in case of both oncoming (31%) and following (30%) glare. These rather large percentages of the glare disturbed respondents and the influence that age and gender can have on glare perception, lead to further investigation as to how these dependencies reflect on the glare perception 'disturbing'. In the subsequent analysis, we bring out differences among different age groups as well as between male and female glare-disturbed respondents for oncoming and following glare.

### 7. Age-wise distribution of respondents with the rating 'disturbing'

The survey data were first analyzed to obtain the distribution of the rating 'disturbing' for each of the two glare types over seven age groups: 18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74 and above 74. The results for glare from oncoming and following vehicles are plotted as percentages and cumulative (in reverse order) percentages, respectively, in Figure 2(a) and Figure 2(b). While interpreting results presented in these figures, it should be noted that the statistics shown at the end of hanging bars are to be read in reference to the x-axis secondary labels, such as the label  $\geq 18$ ,  $\geq 25$  etc. Thus, this figure not only gives an idea about the percentage of respondents of different age

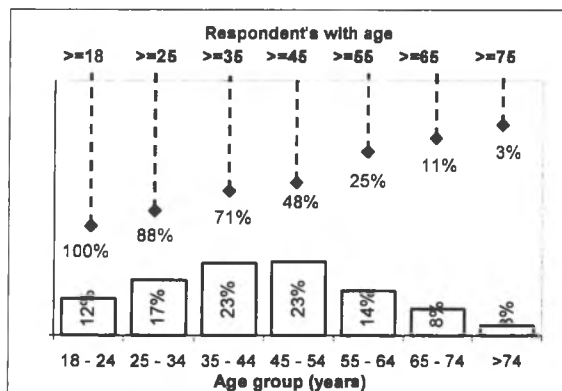


Figure 2(a). Oncoming glare

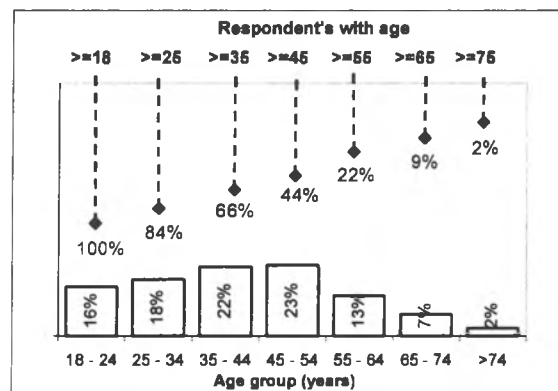


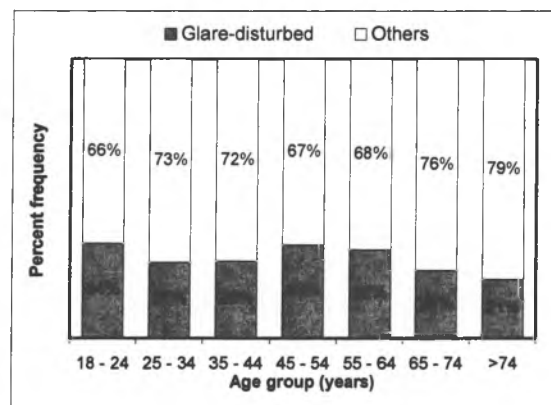
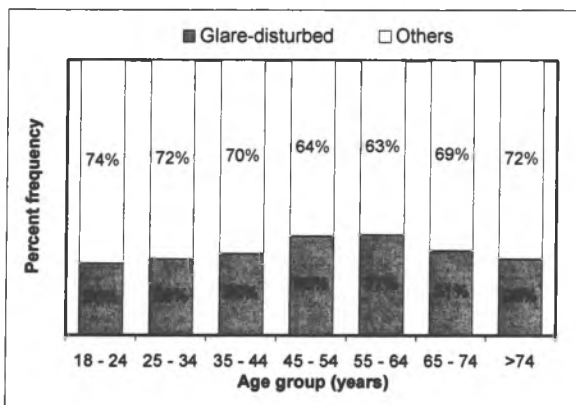
Figure 2(b). Following glare

Figure 2. Percent frequency and cumulative percent frequency (reverse order) distributions of glare-disturbed respondents over seven age groups (Data source: Omnibus Survey 2002, BTS).

groups in the 'disturbing' category, but also shows the percentage of respondents in that category whose age is greater than or equal to 18, 25, 35, 45, 55, 65, or 75. It can be seen in these figures that the frequency distributions of respondents with the perception 'disturbing' for oncoming and following glare are in close proximity with each other. Figure 2(a) shows that most of the people who rated oncoming glare 'disturbing' were not older drivers. In fact, only 11% of respondents who rated oncoming glare 'disturbing' were above 65 as compared with 45% (22 + 23) between 35 and 54. The distribution for glare from following vehicles (Figure 2(b)) shows almost the same statistics: 9% of the respondents with the rating 'disturbing' were above 65 and 46% (23 + 23) between 35 and 54.

Although older drivers eyes are particularly susceptible to the adverse affects of glare on judging distance, it is possible that the effects of glare on driver's discomfort are not age dependent. The results of the current analysis of the survey data supports the findings of several research studies in which it has been noted that the ratings of discomfort from oncoming glare for older drivers (65 and above) are not significantly different from younger drivers (18 to 24); being 11% and 12%, respectively.

In addition to looking at the age profile of glare-disturbed respondents, it is informative to compare different age groups with respect to their rating 'disturbing'. This was done by taking into account the age group sizes and computing percent frequencies relative to these sizes. The results for oncoming and following glare are presented, respectively, in Figure 3(a) and Figure 3(b). These results show that for oncoming glare, 55 to 64 year old respondents had the highest percentage (37%), while for following glare, it was the age group 18 to 24 that contributed most (34%) to the this category of drivers. In general, the percentage of glare-disturbed respondents was highest for age groups: 45 to 54 and 55 to 64 for both types of glare.



RESPONDENT CATEG.	AGE GROUP						
	18-24	25-34	35-44	45-54	55-64	65-74	>=75
Glare-disturbed	26	28	30	36	37	31	28
Others	74	72	70	74	63	69	72
Total	100	100	100	100	100	100	100

RESPONDENT CATEG.	AGE GROUP						
	18-24	25-34	35-44	45-54	55-64	65-74	>=75
Glare-disturbed	34	27	28	33	32	24	21
Others	66	73	72	67	68	76	79
Total	100	100	100	100	100	100	100

Figure 3(a). Oncoming glare.

Figure 3(b). Following glare.

Figure 3. Percent frequencies of glare-disturbed respondents and the rest in each of the seven age groups. (Data source: Omnibus Survey 2002, BTS).

A comparison of Figure 3(a) and Figure 3(b) shows that except for 18 to 24 year old drivers, the percentages of drivers with rating 'disturbing' was higher for oncoming glare as compared with

following glare. The younger drivers were more concerned with glare from following vehicles; 34% of them rated this type of glare as 'disturbing', while 26% rated oncoming glare as 'disturbing'.

Figure 4 gives a comparative picture of the representations of different age groups in the entire population of respondents and in the 'disturbing' category. In case of oncoming glare (Figure 4(a)), all age groups had lower representation in the 'disturbing' category, except for the age groups 45 to 54 and 55 to 64, whose representations in this category were 23% and 14%, respectively, as compared with their respective percentages 20% and 12% in the population. For following glare, the picture was slightly different. In addition to higher representations (23% and 13%, respectively) of these two age groups in the 'disturbing' category, the age group 18 to 24, too, had a higher percentage (16%) in the glare-disturbed category as compared with their representation (14%) in the population of respondents. Figure 4(a) and Figure 4(b) show that except for age group 18 to 24, the distributions respondents over age groups were the same for both oncoming and following glare.

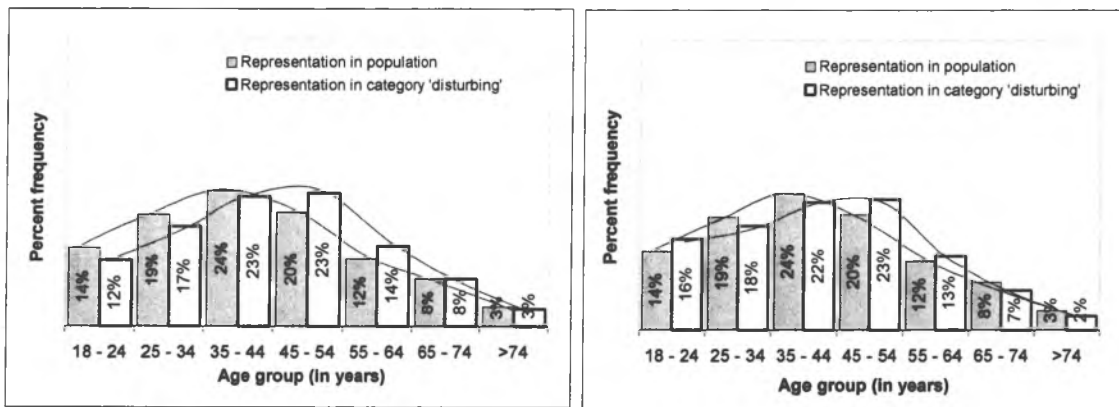


Figure 4(a). Oncoming glare.

Figure 4(b). Following glare.

Figure 4. Percent frequency distributions of glare-disturbed and all respondents over seven age groups. (Data source: Omnibus Survey 2002, BTS).

## 8. Gender-wise distribution of respondents with the rating 'disturbing'

It has been established in Section 6 that the glare perception has dependence on the respondent's gender. It is, therefore, important to see the way in which male and female respondents differ from each other with respect to their glare perception. Figure 5 shows male and female representations in the population of all respondents as well as in the subpopulation of glare-disturbed respondents. The statistics in Figure 5(a) show that for oncoming glare, although the two gender groups had almost the same (50.3% and 49.7%, respectively) representation in the population, the female respondents had a higher representation (55.5%) among the glare-disturbed as compared with 44.5% male respondents. Similarly, in case of following glare, with the same representation of the two gender groups in the population, the female representation in the 'disturbing' category was higher (53.4%) as compared with the male representation (46.6%).

Even though male and female respondents had almost the same representation in the population of respondents (Figure 5), for oncoming glare a higher percentage (33.9%) of female respondents were found glare-disturbed as compared with male respondents, among whom 28.8% were found in the 'disturbing' category. Similarly, for following glare, 33.1% of female respondents were in the 'disturbing' category as compared with 26.2% of male respondents who fell into this category. This leads to the conclusion that females, in general, feel more disturbed from both types of glare. A

comparison of similar statistics related to oncoming (in Figure (a)) and following (in Figure 5(b)) glare perception shows that there is virtually no difference between these two types of glare. Following this observation, in the subsequent sections we will present and discuss the results only for oncoming glare.

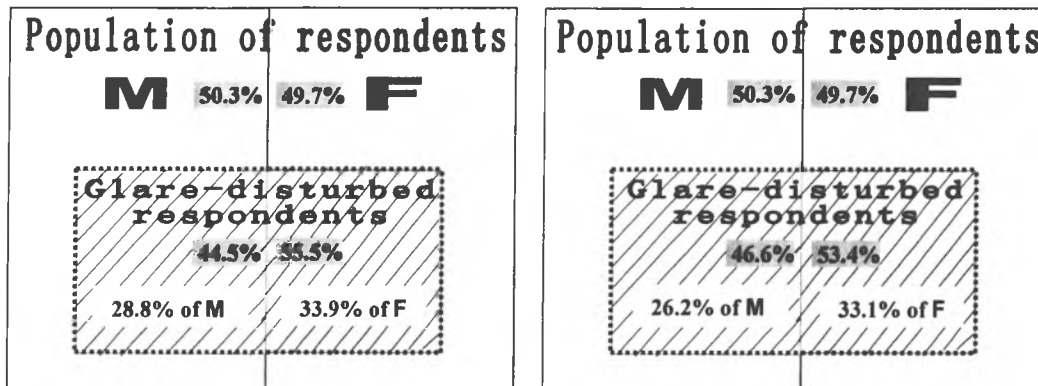


Figure 5(a). Oncoming glare.

Figure 5(b). Following glare.

Figure 5. Venn diagram showing percentages of male and female respondents among oncoming and following glare-disturbed and all respondents. (Data source: Omnibus Survey 2002, BTS).

## 9. Male-female comparison in subpopulations of night-driving and glare-disturbed respondents

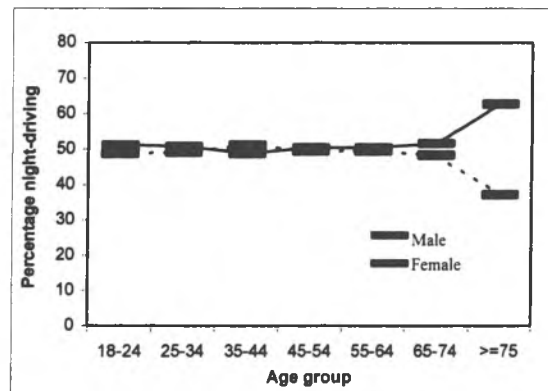
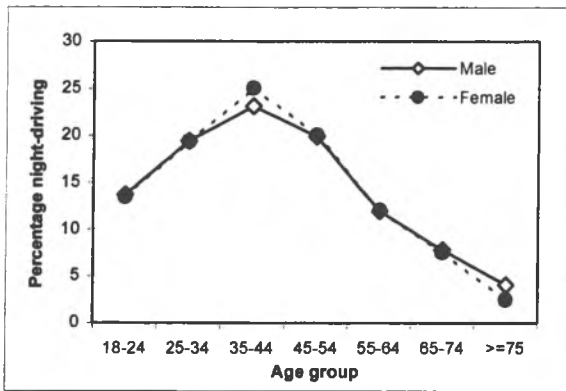
To gain better insight into the glare issue, the differences that have been observed among respondents' glare perception due to age and gender differences must be viewed in comparison with such differences that exist among the night-driving respondents. The following statistical analysis yields statistics that can be used for this purpose.

### 9.1 Male and female night-driving respondents over age groups

Figure 6 (a) presents statistics that show a comparison of male and female subpopulations of night-driving respondents. The same profile can be seen for the two gender groups, over seven age groups (Figure 6(a)). In both cases, the percentages of the night-driving respondents keep increasing until the age group 35 to 44 and starts decreasing thereafter with minimum for the age group 75 and above.

However, there are differences between two genders for some age groups. One difference is that a slightly higher percentage (24.9%) of 35 to 44 year old females drive at night as compared with their male counterparts (23.0%). The difference between the two genders, in terms of night driving, can be seen also for the age group 75 and above, though in this case a higher percentage (3.9%) of males reported driving at night as compared with females (2.7%).

Figure 6(b) shows male-female comparisons within each age group of respondents who drove at night. A slightly higher male percentage was observed for age groups 18 to 24 and 25 to 34. A visible difference (48.9% males and 51.1% females) was observed for the age group 35 to 44. For the rest of the age groups, increasingly higher percentage of male night-driving respondents can be seen with a markedly large difference (60.4% males and 39.6% females) for 75 and above respondents.



GENDER	AGE GROUP							Total
	18-24	25-34	35-44	45-54	55-64	65-74	>=75	
Male	13.3	19.4	23.0	20.3	12.2	7.8	3.9	100
Female	13.4	18.9	24.9	20.3	11.8	8.2	2.7	100

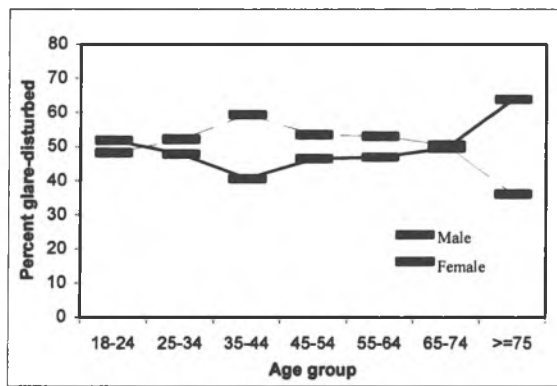
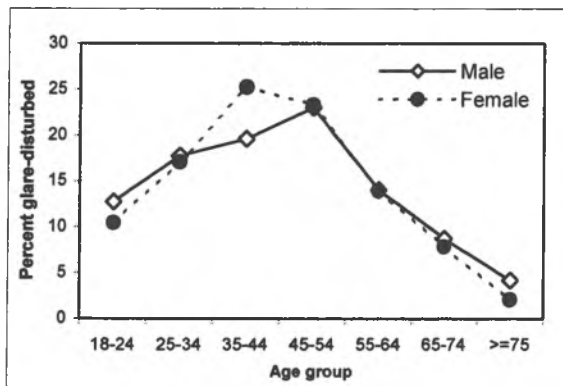
GENDER	AGE GROUP							Total
	18-24	25-34	35-44	45-54	55-64	65-74	>=75	
Male	50.7	51.6	48.9	50.8	51.9	49.5	60.4	100
Female	49.3	48.4	51.1	49.2	48.1	50.5	39.6	100
Total	100	100	100	100	100	100	100	100

Figure 6(a). Percentage frequency distributions for male and female night-driving respondents, over age groups. Figure 6(b). Male and female percentages of night-driving respondents in each of the seven age groups.

Figure 6. Percentage frequency distributions of night-driving respondents (Data source: Omnibus Survey 2002, BTS).

## 9.2 Male and female glare-disturbed respondents over age groups

Unlike the night-driving respondents, the age profiles of male and female glare-disturbed respondents are different. A comparison of male and female subpopulations of glare-disturbed respondents over age groups in Figure 7(a) shows that a higher percentage of males of age groups 18 to 24, 65 to 74, and 75



GENDER	AGE GROUP							Total
	18-24	25-34	35-44	45-54	55-64	65-74	>=75	
Male	12.4	17.1	20.2	23.0	14.3	9.2	3.9	100
Female	11.5	17.3	24.4	23.2	13.6	7.7	2.3	100

GENDER	AGE GROUP							Total
	18-24	25-34	35-44	45-54	55-64	65-74	>=75	
Male	48.3	46.3	41.8	46.2	47.8	50.8	59.9	100
Female	51.7	53.7	58.2	53.8	52.2	49.2	40.1	100
Total	100	100	100	100	100	100	100	100

Figure 7(a). Gender-wise comparison.

Figure 7(b). Age-wise comparison.

Figure 7. Percent distributions of glare-disturbed respondents (Data source: Omnibus Survey 2002, BTS).

and above perceive glare as 'disturbing' as compared with females belonging to these age groups. A shift was observed for the age group 35 to 44 in that a higher percentage (24.4%) of female glare-disturbed respondents was observed as compared with 20.2% of male glare-disturbed respondents. It can also be seen in this figure that the highest percentage (23.0%) of glare-disturbed males was observed for the age group 45 to 54, while that of the glare-disturbed females (24.4%) was for the age group 35 to 44.

Figure 7(b) shows male-female comparison of glare-disturbed respondents within each age group. Higher percentages of female glare-disturbed respondents were observed for age groups 25 to 34, 35 to 44 and 45 to 54 with a maximum difference (41.8% males and 58.2% females) for 35 to 44 year old glare-disturbed respondents. Although, a large difference was also observed for the age group 75 and above, more males (59.9%) were found glare-disturbed as compared with 40.1% females.

### 10. Temporal profile of glare ratings

Glare ratings may be influenced by the length of time that drivers are exposed to vehicle lights. For example, the fewer the number of daylight hours, the greater is the number of hours during which drivers will be exposed to headlight glare at night, i.e., oncoming and following glare. In view of this fact, the temporal variations with respect to glare ratings were studied over six months: January, February, March, April, May, and June.

For that purpose broader categories of glare ratings were considered that were representative of the level of concern of the respondents, defined as:

Level of concern: { Minimally concerned, if response is 'not noticeable',  
'barely noticeable', or 'noticeable but acceptable'.  
Concerned, if response is 'disturbing' or 'crash or near miss'.

Figure 9 shows temporal profiles of 'minimally concerned' (dark dotted line) and 'concerned' (light dotted line) respondents over six months (January to June). In order to obtain an idea about the trend over six months, moving averages were computed. In this figure, these are plotted as a dark solid line for 'minimally concerned' and as a light solid line for 'concerned' respondents.

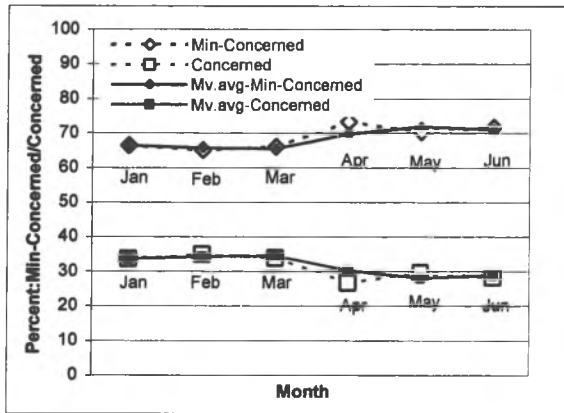


Figure 9(a). Oncoming glare.

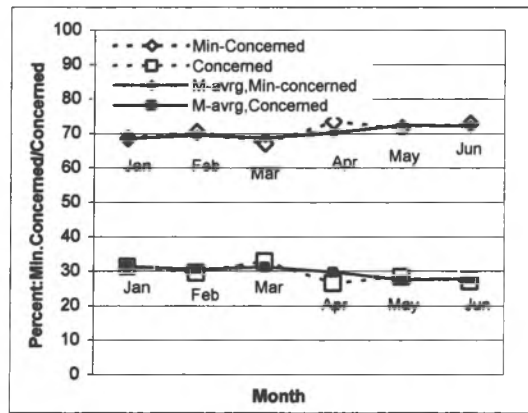


Figure 9(b). Following glare.

Figure 9. Temporal profiles of glare ratings of respondents for oncoming and following glare over six months (January to June) (Data source: Omnibus Survey 2002, BTS).

The two profiles are complementary to each other. The moving average plots in these figures show that for both oncoming and following glare, as the number of daylight hours increases (January to June), the percentage of 'Concerned' respondents decreases (increases for minimally concerned) slightly from January to February, but generally decreases from the darker winter months to the brighter spring and early summer months. The largest decrease (the largest increase for minimally concerned) in the percentage of glare-disturbed respondents was observed from March to April.

## 11. Summary and conclusions

The results show that for the majority of respondents (about 54%) glare was 'noticeable but acceptable'. However, the sizeable number of drivers (about 30%) who experienced nighttime glare as 'disturbing' cannot be ignored. The response data of drivers falling into this category was further analyzed to bring out the differences that might exist due to the type of glare and age and gender of the respondent. In fact, the frequency distributions of the glare-disturbed respondents over age and gender groups, for oncoming and following glare, did not indicate any difference due to the type of glare; the distributions were found in close proximity with each other. There were, however, percentage differences among age and gender groups.

The age-wise comparison highlighted some differences and similarities among age groups. For instance, the distribution of the glare-disturbed respondents over age groups showed that most of the respondents who rated glare 'disturbing' were not old drivers. Also, the ratings of discomfort from glare for old drivers were not significantly different from that for the younger drivers. In general, the percentage of the glare-disturbed respondents was highest for the age groups 35 to 44 and 45 to 54. For oncoming glare, 55 to 64 year old had the highest percentage of the glare-disturbed respondents, while for following glare, it was the age group 18 to 24 that contributed most to the this category of drivers.

Through gender-wise comparison of respondents, it was observed that although male and female representation in the population of all respondents was the same, the females, in general, were found more glare-disturbed. Distributions of male and female respondents over age groups showed that among all night-driving and glare-disturbed respondents, 35 to 44 year old had the highest representation, with a higher female representation. Male-female comparison within each age group showed that among the night-driving respondents, males had much higher representation in the age group 75 and above, while in other age groups the differences in male-female representations were small. The gender-wise comparison was also done for the glare-disturbed respondents in each age group. Significant differences in male-female representations were observed within each age group of this category of respondents with much larger differences for the age groups 35 to 44 and 75 and above. It was also found that 35 to 44 year old females had much higher representation as compared with the males of this age group, even though the differences between the two genders of this age group among all respondents was not so large.

The statistics also show that for both oncoming and following glare, as the number of dark hours decreases from January to June, the percentage of 'concerned' respondents decreases. The largest decrease in the percentage of glare-disturbed respondents was observed from March to April. Only a slight change in the percentages of both 'concerned' and 'minimally concerned' respondents was observed in May and June.

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- [1] Bureau of Transportation Statistics, *Survey Documentation for the Bureau of Transportation Statistics Omnibus Survey Program*, January to May 2002.
- [2] Kendall, M.G. and Stuart A., *The Advanced Theory of Statistics*, Vol. 2, Hafner Publishing Company, New York, 1967.

### 13. Appendix A. Bivariate frequency distributions: Age vs. Glare rating and Gender vs. Glare rating for oncoming and following glare

This section provides statistics that were produced by SUDAAN cross tabulation procedure for oncoming and following glare types.

Table A.1 and Table A.2 present bivariate frequency distribution of age- and sex-based groups of respondents, based on their responses to question Q1, related to perception of glare from oncoming vehicles.

**Table A.1.** Bivariate frequency distribution: Age vs. Oncoming glare rating

Age group	Oncoming glare rating						Total
	Statistic	Not noticeable	Barely noticeable	Noticeable but acceptable	Disturbing	Crash or near miss	
18 to 24	Weighted Size	1567461	1391752	12936571	5948684	123298	21967765
	Sample Size	5	5	43	23	0	76
25 to 34	Weighted Size	2423762	1413269	18612288	8602074	481899	31533292
	Sample Size	12	8	97	45	2	163
35 to 44	Weighted Size	2446880	1889094	22761159	11232660	225161	38554954
	Sample Size	12	11	121	61	1	206
45 to 54	Weighted Size	1579715	1673743	17943060	11546292	250794	32993604
	Sample Size	9	10	102	67	1	189
55 to 64	Weighted Size	1419958	1002579	9994766	6959966	25247	19402515
	Sample Size	8	6	65	42	0	122
65 to 74	Weighted Size	833226	831486	7980846	4200666	0	13846223
	Sample Size	5	5	42	24	0	76
75 and above	Weighted Size	729448	302509	3009410	1501529	29075	5571970
	Sample Size	5	2	17	9	0	33
Total	Weighted Size	11000448	8504433	93238099	49991871	1135472	163870322
	Sample Size	56	46	487	270	5	864

(Data source: Omnibus Survey 2002, BTS)

**Table A.1.** Bivariate frequency distribution: Sex vs. Oncoming glare rating

Sex	Oncoming glare rating						Total
	Statistic	Not noticeable	Barely noticeable	Noticeable but acceptable	Disturbing	Crash or near miss	
Male	Weighted Size	6919885	4458832	48022133	23427247	654746	83482844
	Sample Size	33	22	236	117	3	410
Female	Weighted Size	4107626	4045601	46311448	27130845	480726	82076246
	Sample Size	23	24	255	156	3	460
Total	Weighted Size	11027512	8504433	94333582	50558092	1135472	165559090
	Sample Size	56	46	491	272	5	870

(Data source: Omnibus Survey 2002, BTS)

Table A.3 and Table A.4 present bivariate frequency distribution of age- and sex-based groups of respondents, based on their responses to question Q2, related to perception of glare from oncoming vehicles.

**Table A.3.** Bivariate frequency distribution: Age vs. Following glare rating

Age group	Following glare rating						Total
	Statistic	Not noticeable	Barely noticeable	Noticeable but acceptable	Disturbing	Crash or near miss	
18 to 24	Weighted Size	1842399	2143349	10343279	7638739	0	21967765
	Sample Size	7	7	37	25	0	76
25 to 34	Weighted Size	1803748	2850946	18068017	8601540	270002	31594253
	Sample Size	10	16	94	43	1	164
35 to 44	Weighted Size	2554046	3077828	22510358	10354634	87490	38584356
	Sample Size	14	17	117	58	1	206
45 to 54	Weighted Size	1999600	2687472	18000123	10406958	18130	33112283
	Sample Size	11	15	101	64	0	190
55 to 64	Weighted Size	1596738	1689228	10307519	5993286	0	19586770
	Sample Size	10	11	64	38	0	123
65 to 74	Weighted Size	1564391	1335354	7443577	3513997	0	13857320
	Sample Size	9	7	40	20	0	76
75 and above	Weighted Size	948667	677948	2721257	1196800	0	5544672
	Sample Size	6	4	16	7	0	32
Total	Weighted Size	12309590	14462125	89394129	47705953	375622	164247418
	Sample Size	66	76	468	255	2	866

(Data source: Omnibus Survey 2002, BTS)

**Table A.4.** Bivariate frequency distribution: Sex vs. Following glare rating

Sex	Following glare rating						Total
	Statistic	Not noticeable	Barely noticeable	Noticeable but acceptable	Disturbing	Crash or near miss	
Male	Weighted Size	7101625	8321053	46970149	21286678	80835	83760340
	Sample Size	35	41	229	106	1	411
Female	Weighted Size	5286631	6290957	43203578	27155553	294787	82231505
	Sample Size	31	35	242	152	2	461
Total	Weighted Size	12388255	14612010	90173727	48442231	375622	165991845
	Sample Size	66	76	471	258	2	873

(Data source: Omnibus Survey 2002, BTS)



U.S. Department  
of Transportation  
National Highway  
Traffic Safety  
Administration



DOT HS 809 760

September 2004

Technical Report

# An Assessment of the Crash-Reducing Effectiveness of Passenger Vehicle Daytime Running Lamps (DRLs)

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<p>Abstract</p> <p>This study estimates the effectiveness of passenger vehicle daytime running lights in reducing two-vehicle opposite direction crashes, pedestrian/bicycle crashes, and motorcycle crashes. The authors chose the generalized simple odds, a conventional statistical technique, to analyze the data.</p> <p>Results based on simple odds indicate that from 1995 to 2001:</p> <ul style="list-style-type: none"> <li>• DRLs reduced opposite direction daytime fatal crashes by 5 percent.</li> <li>• DRLs reduced opposite direction/angle daytime non-fatal crashes by 5 percent.</li> <li>• DRLs reduced non-motorists, pedestrians and cyclists, daytime fatalities in single-vehicle crashes by 12 percent.</li> <li>• DRLs reduced daytime opposite direction fatal crashes of a passenger vehicle with a motorcycle by 23 percent.</li> </ul> <p>Reviewers of this paper required the inclusion of results using the odds ratio technique. The estimated the effect of DRLs are -6.3 percent, -7.9 percent, 3.8 percent, and 26 percent, respectively. None of these results were statistically significant.</p>			
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## Executive Summary

This study estimates the effectiveness of passenger vehicle daytime running lights in reducing two-vehicle opposite direction crashes, pedestrian/bicycle crashes, and motorcycle crashes. The authors chose the generalized simple odds, a conventional statistical technique, to analyze the data. The generalized odds ratio attempts to adjust for a variety of exogenous factors other than the presence or absence of DRLs not specifically controlled for within the model.

Significant results of this study show that from 1995 to 2001:

### Simple Odds Results:

- DRLs reduced opposite direction daytime fatal crashes by 5 percent.
- DRLs reduced opposite direction/angle daytime non-fatal crashes by 5 percent.
- DRLs reduced non-motorists, pedestrians and cyclists, daytime fatalities in single-vehicle crashes by 12 percent.
- DRLs reduced daytime opposite direction fatal crashes of a passenger vehicle with a motorcycle by 23 percent.

The reviewers of this paper required the inclusion of an analysis based on odds ratio, which can be found in Appendix B. Like the simple odds, the odds ratio attempts to control for a variety of factors other than the presence or absence of DRLs. The estimated effectiveness of DRLs based on this technique is extremely sensitive to small changes encountered in real world crash data. As a result, reductions in target crashes during the daytime using the odds ratio technique may not be detected over the inherent background noise of the data system. **None** of the results based on the odds ratio are statistically significant.

### Odds Ratio Results:

- DRLs reduced opposite direction daytime fatal crashes by -6.3 percent that is DRLs increase opposite direction daytime fatal crashes by 6.3 percent.
- DRLs reduced opposite direction/angle daytime non-fatal crashes by -7.9 percent that is DRLs increase opposite direction/angle daytime non-fatal crashes by 7.9 percent.
- DRLs reduced non-motorists, pedestrians and cyclists, daytime fatalities in single-vehicle crashes by 3.8 percent.
- DRLs reduced daytime opposite direction fatal crashes of a passenger vehicle with a motorcycle by 26 percent.

## METHODOLOGY:

A case-control method was chosen as the approach for this study, since only specific make-models for each year were equipped with DRLs. The number of crashes for a set of passenger vehicles equipped with DRLs is compared to passenger vehicles manufactured in the same years without DRLs. The groups of vehicles are analyzed by time of day and crash type.

The generalized simple odds method was used to analyze the data. This technique implicitly attempts to control for factors, other than the presence or absence of DRLs, that could be associated with crash occurrences. The effectiveness of DRLs due to differences in passenger vehicle types, namely, passenger cars, SUVs, vans, and light/pickup trucks is addressed explicitly. The simple odds provided useful statistically significant results.

## Background

This is the second NHTSA study on the effectiveness of Daytime Running Lamps (DRLs). The preliminary study was published in June 2000 and is the basis of this research.

Many traffic crashes are the result of the failure of a driver to notice another vehicle. Visual contrast is an essential characteristic that enables a driver to detect vehicles. The purpose of daytime running lamps (DRLs) is to increase the drivers' ability to detect DRL-equipped vehicles, particularly in the peripheral visual field, by increasing visual contrast. Seven countries require the use of DRLs during all daytime periods: Canada, Denmark, Finland, Hungary, Iceland, Norway, and Sweden. Results of DRL studies from these countries consistently, however not conclusively, show that DRLs reduce the number of two-vehicle crashes during daylight, dusk, and dawn. This study examines the effectiveness of first-generation DRLs, using U.S. national data for passenger vehicles.

DRLs come in a variety of configurations. DRLs may be upper beam headlamps at reduced intensity, low-beam headlamps at full or reduced power, turn signals or dedicated lamps. In addition the brightness, color and light dispersion are design features of DRLs. Four manufacturers began equipping selected 1995 model year vehicles, for sale within the U.S., with DRLs. General Motors Corporation produces DRL-equipped vehicles with higher intensity DRLs than those used in Scandinavian countries. In the U.S. the availability of DRL-equipped vehicles has increased with each model year since 1995. Since the cost of DRLs is low, small reductions in the number of crashes would likely be considered cost effective. A partial chronological summary of results from several previous studies of the effectiveness of DRLs follows.

Finland's legislation of 1972 required the use of low-beam headlights in rural areas during winter. The rural multiple-vehicle daytime crash rate decreased by 27 percent as a result.<sup>1</sup>

In 1975, Clayton and Mackay<sup>2</sup>, at Indiana University, found that drivers failing to process information properly caused almost half of all crashes. The most prevalent information processing errors were faulty visual perception, recognition errors and comprehension errors. In addition, it was shown that traffic crashes were due more to inattention and distraction than to poor vision. The crash reduction potential of DRLs lies in their ability to attract attention, especially in the peripheral visual field, thereby enhancing detect ability.

A study conducted by Transport Canada<sup>3</sup> in 1975-1976 examined the crash experience with part of the Canadian defense vehicle fleet equipped with automatic headlights, a version of DRLs. The results

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<sup>1</sup>Andersson, K., Kilsson, G., and Salusjärvi, S. The Effect On Traffic Accidents on the Recommended use of Vehicle Running Lights in the Daytime in Finland. Report No 102. Swedish road and Traffic Research Institute (VTI), 1976.

<sup>2</sup>Claton, A.B. and Mackay, G.M. Aetiology of Traffic Accidents. *Health Bulletin*, 31(4), 277-280, 1972.

<sup>3</sup>Attwood, D.A. The Potential of Daytime Running Lights as a Vehicle Collision Countermeasure. SAE Technical Paper 810190. Society of Automotive Engineers, 1981.

published by Attwood in 1981 showed a 20 percent crash decrease in the specially equipped vehicles compared to the comparison group of unmodified vehicles.

Swedish legislation required the use of DRLs throughout the year starting in October 1977. An 11 percent reduction in daytime crashes was observed. Two-vehicle, head-on crashes were reduced by 10 percent, angle crashes were reduced 9 percent, crashes involving a bicycle or moped were reduced by 21 percent, and crashes involving a pedestrian or a cyclist decreased 17 percent.<sup>4</sup> These results were questioned by Theeuwes and Riemersma in 1995<sup>5</sup>, as the proportion of multi-party crashes was not reduced as a proportion of all crashes.

Hills, in 1980<sup>6</sup>, and more recently Sekuler and Blake,<sup>7</sup> found that increasing the visual contrast of a vehicle increases the ability of other drivers to detect and monitor the vehicle. Low contrast between a vehicle and its background can be quite common during daylight hours. Contrast is reduced by color, rain, clouds and low levels of light that occur at dawn and dusk.

Stein reported in 1985<sup>8</sup> the results of a study by the Insurance Institute for Highway Safety (IIHS), which equipped over 2,000 passenger cars, light trucks and vans with DRLs. Relevant multi-vehicle crashes were 7 percent lower for the DRL-equipped vehicles than the comparison (unmodified) vehicles.

Norway required the installation of DRLs by vehicle manufacturers in January of 1985 and the use of low beam head lights was required on all vehicles in Norway not equipped with DRLs in April of 1988. Elvik reported<sup>9</sup> that a 15 percent reduction in all summertime multi-vehicle daylight crashes was achieved.

Canada required that all new passenger cars, trucks, multi-purpose vehicles, and buses manufactured for sale in Canada be equipped with DRLs after December 1, 1989. In September 1993 Arora, et al.<sup>10</sup>

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<sup>4</sup>Andersson, K. Nilsson, G. The Effects on Accidents of Compulsory Use of Running Lights During Daylight in Sweden. Report No. 208A, Swedish Road and Traffic Research Institute (VRI), 1981.

<sup>5</sup>Theeuwes, J. and Riemersma, J. Daytime Running Lights as a Vehicle Collision Countermeasure: The Swedish Evidence Reconsidered. *Accident Anal. Prevention*. 27:633-642, 1995.

<sup>6</sup>Hills, B.L. Vision, Visibility and Perception in Driving. *Perception*, 9, 183-216, 1980.

<sup>7</sup>Sekuler, R. and Blake, R. *Perception*, (Second Edition) Toronto: McGraw-Hill, 1990.

<sup>8</sup>Stein, H. Fleet Experience with Daytime Running Lights in the United States. SAE Technical Paper 851239. Warrendale, PA, Society of Automotive Engineers, 1985.

<sup>9</sup>Elvik, R. The Effects of Accidents of Compulsory Use of Daytime Running Lights for Cars in Norway. *Accident Analysis and Prevention*. 25(4) 383-398, 1993.

<sup>10</sup>Arora, H. Collard, D. Robbins, G. Welbourne, E.R. White, J.G. *Effectiveness of Daytime Running Lights in Canada*. Report No. TP1298 (E), Transport Canada 1994.

conducted an extensive analysis on the effectiveness of DRLs for Transport Canada. They estimate that relevant crashes were reduced by 11.3 percent, which was statistically significant at  $p < 0.05$ .

In October of 1990, Denmark required universal use of DRLs. No overall effect was reported. However, Hansen identified a statistically significant 37 percent decrease in crashes involving a left turn in 1993<sup>11</sup>.

Hungary has required the use of DRLs on rural roads since March 1993. Hollo studied the crash experience of DRL-equipped vehicles and presented the findings at a conference in the Czech Republic in 1995<sup>12</sup>. Several changes in traffic regulations and enforcement, which includes the reduction of the speed limit, stricter seat belt laws, increases in police patrols, significantly higher fines and a campaign to increase public awareness of traffic-related issues were considered confounding factors, thereby making it difficult to estimate the effect of DRLs. Nonetheless, Hollo estimates that DRLs reduced the number of rural daytime "frontal and cross traffic" crashes by 7 to 8 percent. Hallo further claims that during "good visibility" crashes are reduced 11 to 14 percent.

IIHS' Highway Loss Data Institute (HLDI) in 1997<sup>13</sup> released findings from a study of the personal injury claims for vehicles that added DRLs as a standard feature in 1995 and 1996, compared to the claim frequencies for the same makes and models prior to adding DRL. The number of relative claims was found to have increased slightly after DRLs were introduced. However, HLDI's study was not able to identify a consistent pattern of increases among vehicles. HLDI's study hypothesized that this finding was not surprising, as "...claims for striking vehicles, single-vehicle crashes, and nighttime crashes could not be identified..." and therefore, could not be excluded from the study. Striking vehicle, single-vehicle, and nighttime crashes would not likely be impacted by the presence of DRLs.

Tofflemire and Whitehead<sup>14</sup> re-analyzed the Canadian DRL law in 1997 using a "quasi-experimental comparative posttest design" and found that opposite direction and angle crashes were reduced by 5.3 percent, which was statistically significant at  $p < 0.05$ . The study concluded that the DRL law had a greater effect on opposite direction crashes (15 percent reduction) than angle crashes (2.5 percent reduction).

Each province in Canada was individually analyzed. Only Nova Scotia and New Brunswick

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<sup>11</sup>Hansen, L.K. Daytime Running Lights in Denmark - Evaluation of the Safety Effect. Translated exact.

<sup>12</sup>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.

<sup>13</sup>Highway Loss Data Institute Bulletin Volume 15, Number 1, December 1997.

<sup>14</sup>Tofflemire, T. C., Whitehead, P.C. An Evaluation of the Impact of Daytime Running Lights on Traffic Safety in Canada, Journal of Safety Research, Volume 28, Number 4, 1997.

experienced a statistically significant ( $p < 0.05$ ) reduction in crashes.

While the 1993 and 1997 Canadian studies described above are among the few studies reporting statistically significant results, in most other studies the data sets are small, which can result in nonsignificant statistical results, even when an effect might exist.

Hollo<sup>15</sup> reported that DRLs reduced daylight frontal and crossing vehicle crashes by 4.7 percent to 15.2 percent in Hungary, depending on the statistical technique used and assumptions made.

Tessmer<sup>16</sup> estimated that the effectiveness of DRLs in US fatal two-vehicle opposite-direction crashes ranged from -8 percent to 2 percent. For non-fatal crashes the effectiveness ranged from 5 percent to 7 percent. For pedestrians fatalities in single-vehicle crashes, the estimated effectiveness ranged from 28 percent to 29 percent.

Lau<sup>17</sup> estimates that DRLs reduce multiple vehicle crashes by 5 to 13 percent. Lau even estimates that DRLs reduce multiple vehicle nighttime crashes by 5 percent, which suggests that there may be a confounding lurking variable within the data.

Farmer and Williams<sup>18</sup> demonstrated that DRLs are associated with a 3.2 percent decline in multiple-vehicle daylight crashes.

Thompson<sup>19</sup> in 2003 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 type.

Table 1 summarizes findings from studies of the effectiveness of DRLs in several countries, including the U.S. The individual studies are identified by year, investigator(s), the type of study, i.e., did the study analyze the effects of DRLs on a specific fleet of vehicles, a case controlled study, or the result of a change in the law, applicable country, and the estimated effects of DRLs.

**Table 1**  
**Summary of Findings on DRL Effectiveness\***

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<sup>15</sup>Hollo, P., Changes in the Legislation on the Use of Daytime Running Lights by Motor Vehicles and Their Effect on Road Safety in Hungary, *Accid. Anal. And Prev.*, Volume 30, No.2, pp 183-199, 1998.

<sup>16</sup>Tessmer, J.M., A Preliminary Assessment of the Crash-Reducing Effectiveness of Passenger Car Daytime Running Lamps (DRLs); DOT HS 808 645, June 2000.

<sup>17</sup>Lau, E. Daytime Running Light Effectiveness A Preliminary Evaluation, Presented at a Government/Industry Meeting, June 19-21, 2000 Washington, DC.

<sup>18</sup>Farmer, C.M. and Williams, A.F. Effects of daytime running lights on multiple-vehicle daylight crashes in the United States; *Accid. Anal. And Prev.*, Volume 34, pp 197-203, 2002.

<sup>19</sup>Thompson, P.A., Daytime Running Lamps (DRLs) for Pedestrian Protection SAE Paper 2003-0102072, April 2003.

Year	Investigator(s)	Study Type	Country	Estimated Effects
1972	Anderson et al <sup>1</sup>	Law	Finland	27% reduction rural multi-vehicle
1975	Attwood <sup>3</sup>	Fleet	Canada	20% some defense vehicles
1977	Anderson et al <sup>4</sup>	Law	Sweden	9% to 21% crash type dependent
1985	Stein <sup>8</sup>	Fleet	U.S.	7% reduction selected vehicles
1988	Elvik <sup>9</sup>	Law	Norway	15% reduction summer multi-vehicle
1993	Arora et al <sup>10</sup>	Law	Canada	11.3% reduction 2-vehicle opposite-direction
1993	Hansen <sup>11</sup>	Law	Denmark	up to 37% reduction - crash type dependent
1995	Hollo <sup>12</sup>	Law	Hungary	7% to 14% reduction frontal cross traffic
1997	Tofflemire et al <sup>14</sup>	Law	Canada	5.3% reduction opposite direction/angle crashes
1998	Hollo <sup>15</sup>	Law	Hungary	4.7% to 15.2% reduction frontal cross traffic
2000	Tessmer <sup>16</sup>	CC	U.S.	-8% to 29% crash type dependent
2000	Lau <sup>17</sup>	CC	U. S.	5% to 13% reduction multiple vehicle crashes
2002	Farmer et al <sup>18</sup>	CC	U.S.	3.2% decline in mult. vehicle daylight crashes
2003	Thompson <sup>19</sup>	CC	U.S.	2.3% to 12.4% DRL type dependent

\* See Bibliography for detailed information on published studies.

Several factors could influence the effectiveness of DRLs, e.g., geography and the climate, the mix of rural and urban crashes, traffic conditions, and manner of collision. The approach of this study attempts to limit the influence of such exogenous variables by using comparison groups where the effects should be similar. This study examines the effectiveness of DRLs in the U.S. for vehicles of model years 1995 and later. Two sources of data maintained by the National Highway Safety Traffic Administration (NHTSA) are used to study DRL effectiveness: the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System/ General Estimates System (NASS/GES).

### Methodological Changes from Preliminary Assessment

This study is the second study conducted by NHTSA to determine the effectiveness of Daytime Running Lamps (DRLs). The same basic statistical techniques to evaluate DRLs have been used. However, with the collection of additional data and the knowledge gained from NHTSA's first study, A Preliminary Assessment of the Crash-Reducing Effectiveness of Passenger Car Daytime Running Lamps (DRLs), which appeared in 2000, several improvements have been made. A great deal was learned about using

national traffic crash data to analyze DRLs, which guided our efforts in the current study.

In the original study two comparison groups of fatal crashes were used, single vehicle fatal crashes and 2-vehicle same direction fatal crashes. There are many more single vehicle fatal crashes than 2-vehicle same direction fatal crashes. The results of the analysis based on using the 2-vehicle same direction fatal crashes do not produce sufficient power to reject the null hypothesis. Critics of the earlier study pointed out that in same direction crashes, a potential striking vehicle with DRLs could have the DRLs detected in the rear view mirror of the potentially stuck vehicle, which could then take corrective action. They argue that same direction crashes are not independent of DRLs and using them, as a comparison group would skew the results. For these two reasons, analysis using 2-vehicle same direction fatal comparison crashes has been eliminated from this study.

In the original study, both the simple odds,  $O = TD/(CD+TN+CN)^{20}$ , and the odds ratio,  $? = (TD/CD)/(TN/CN)^1$ , were used in the analysis. The standard error of the odds ratio is much larger than the standard error of the simple odds. To be statistically precise, when using the simple odds, the null hypothesis can be marginally rejected, however, the power of the odds ratio is not sufficient to reject the null hypothesis. Therefore the analysis in the main body of this report was based solely on the simple odds. Several reviewers of the report required publication of the non-statistically significant results, based on the odds ratio. The results based on the odds ratio can be found in Appendix B of this report. Generalized forms of the simple odds and the odds ratio were also used in this study; see the appendices. A generalized form of the ratios allows one to adjust for a variety of identifiable factors such as vehicle type.

Target vehicles with DRLs and the comparison vehicles without DRLs have been partitioned in a different way. In the original study two groups of comparison passenger cars were used. The groups of target and comparison vehicles were identified by make and model. The original study's first comparison group consisted of vehicles of the same make and model prior to the adoption of DRLs. Vehicles in this comparison group were from 1 to 6 years older than the target vehicles equipped with DRLs. To eliminate the potential bias due to age in the original study a second group of comparison vehicles was selected, namely vehicles manufactured by the Ford Motor Company at the same time that the target vehicles were manufactured.

In the current study, the vehicles under analysis have been expanded from passenger cars to passenger vehicles. Both the target and comparison vehicles have been identified by analysis of the vehicle identification number (VIN). Target and comparison vehicles were all manufactured during the same time period. All passenger vehicles that could be classified as having DRLs as standard equipment were classified as target vehicles. All passenger vehicles that did not have DRLs as standard equipment nor as a standard option were included as comparison vehicles.

The effectiveness of DRLs in preventing fatal two-vehicle daytime opposite direction crashes of passenger vehicles with motorcycles was examined.

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<sup>20</sup> See Appendix A, Page 19 for additional details on the simple odds and odds ratios.

Four states, Florida, Maryland, Missouri and Pennsylvania were used to examine the effectiveness of DRLs for non-fatal crashes in the original study. However, one cannot extrapolate the effectiveness of DRLs to the nation. To obtain a national estimate, data from the General Estimates System (GES) was used. Since GES is a survey and not a census of crashes, software for the statistical analysis of correlated data, SUDAAN, was used to obtain credible estimates of statistical significance.

Finally a meta-analysis was used in the original study to attempt to provide an overall estimate of DRL effectiveness. This has been eliminated from the current analysis since the survey data was used to estimate the effects of DRLs for non-fatal crashes. The mixture of survey data and census data in a meta-analysis does not provide reliable results.

### **Data and Methodology**

Previous studies of DRL effectiveness often have used a before vs. after approach. This approach is appropriate, for example, when a law goes into effect at a given point in time and one wishes to determine the effect of that law on traffic crashes. A case-control method was chosen as the approach for this study, since only specific make-models for each year were equipped with DRLs. A case-control method attempts to control for factors, other than the presence or absence of DRLs that could be associated with crash occurrence. In this study, the number of crashes for a fleet of vehicles equipped with DRLs is compared to a fleet of vehicles without DRLs produced in the same years. Both groups of vehicles are analyzed by time of day and crash type. Analysis of the Vehicle Identification Number (VIN) was used to partition passenger cars, vans, pickups/light trucks, and sport utility vehicles (SUVs) into a fleet of vehicles that did and did not have DRLs. Passenger vehicles that permitted DRLs as a standard option were removed from the analysis, since one could not analyze the VIN to determine if the specific vehicle was or was not equipped with DRLs.

Data from FARS<sup>21</sup> for calendar years 1995 - 2001 were used to examine DRL effectiveness for fatal two-vehicle opposite-direction crashes and for single-vehicle pedestrian/cyclist crashes. NASS/GES<sup>22</sup> data for calendar years 1995 - 2001 were used to examine DRL effectiveness for non-fatal two-vehicle opposite-direction crashes.

The analysis focused on the possible effect of DRLs in reducing crashes during daylight or twilight hours, as opposed to nighttime hours, when traditional lighting would be in use by all drivers. Therefore, the

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<sup>21</sup> Fatal crash data are from NHTSA's *Fatality Analysis Reporting System (FARS)*. FARS contains data on a census of fatal traffic crashes within the United States and Puerto Rico. A crash must involve a motor vehicle traveling on a public roadway and must result in the death of an occupant of a vehicle or a non-motorist within 30 days of the crash to be included in FARS.

<sup>22</sup> Non-fatal crash data are from NHTSA's *National Automotive Sampling System/General Estimates System (NASS/GES)*. NASS/GES contains data from a survey of approximately 55,000 weighted traffic crashes across the United States. Both injury crashes and property damage only crashes are included.

target time period is daytime, including dawn and dusk, and the comparison time period is night<sup>23</sup>.

Target crashes and comparison crashes are defined by the crash configuration. Ideally, the only difference between daytime target crashes and daytime comparison crashes is that the set of daytime target crashes consists of crashes that could be affected by DRLs, while the set of daytime comparison crashes consists of crashes that would not be affected by DRLs. A target crash is a crash where the DRLs can be seen by the driver of the other crash involved vehicle. A comparison crash is a crash involving a single vehicle, where the visibility of DRLs is not relevant.

Neither the FARS nor the NASS/GES databases have a variable that partitions the data exactly into target and comparison crashes. Both data sets have variables, which permit one to approximate the desired partition. Therefore, it is possible that the partition of target crashes and comparison crashes may not be perfect. For example, the geometry of an angle crash might prevent a driver from seeing the DRLs of the other vehicle. If angle crashes that cannot be affected by DRLs are included in the set of target crashes, the estimated effect of DRLs, using FARS may be underestimated. Since the effectiveness is expected to be small, fatal target crashes have been limited to head-on crashes and sideswipe opposite direction crashes. Although the glare from DRLs may contribute to a single vehicle crash, this is unlikely. However, the data do not have the fidelity to identify such crashes. At night, one assumes neither the target crashes nor the comparison crashes should be affected by DRLs. This assumption, like all assumptions can be challenged. For example, if a driver of a DRL-equipped vehicle does not turn on his head/tail lights at night a crash may result. Again this unlikely set of events is within the realm of possibility; however, the available data do not permit one to identify or analyze such crashes. Two-vehicle target crashes were further distinguished, for the purposes of this study, by focusing on those involving crashes in which the two vehicles were traveling in opposite-directions.

The FARS and NASS/GES target crashes include head-on and sideswipe opposite direction crashes<sup>24</sup>.

The set of single-vehicle crashes is used as a set of comparison crashes. The comparison groups of crashes, ideally, would represent those crashes, which would not be affected by the presence or absence of DRLs. In the case of nighttime crashes, it has been pointed out that the use of DRLs may cause headlamps to burn out more frequently, contributing to an increase in nighttime crashes. However, only early Volkswagen and Volvo vehicles use full intensity lower beam headlamps for DRLs. In addition, all vehicles equipped with DRLs are relatively new, model year 1995 and later, so the potential problem of burned out headlamps should be minimal. Hauer (1995) pointed out that single-vehicle crashes might also be affected by DRLs. Namely, two-vehicles on a collision course may detect each other earlier due to DRLs. In such a situation, a multi-vehicle crash may be avoided and a single-

<sup>23</sup> An alternative partition of the light condition would be to exclude all dawn and dusk crashes from the analysis. A preliminary analysis to calculate the point estimate of DRL effectiveness during dawn and dusk was made. The result showed a larger value of DRL effectiveness during dawn and dusk than during the day. However, due to the limited number of dawn and dusk crashes, the result was not statistically significant.

<sup>24</sup> Sideswipe opposite direction crashes are two-vehicle crashes with the vehicles moving in opposite directions. The initial engagement does not overlap the corner of either vehicle by more than four inches, so that there is no significant involvement of the front or rear surface areas. In addition, there is no pocketing of the impact in the suspension areas. The impact swipes along the surface of the vehicles parallel to the direction of travel. There is low retardation of the force along the surface of the vehicles.

vehicle crash may result. Thus, the two comparison groups, nighttime crashes and single-vehicle crashes may not be statistically independent of DRLs, a required theoretical assumption for the analysis performed here. However, from a practical point of view, these two groups are as statistically independent from the target as is reasonably possible. That is, in general, a two-vehicle opposite-direction crash does not cause, nor does it prevent, a single vehicle crash. Likewise, a single-vehicle crash does not cause, nor does it prevent, a two-vehicle crash.

Two-vehicle crashes involving the rear end of one or more vehicles and sideswipe same-direction crashes have been eliminated from the study. Two-vehicle rear-end and sideswipe same-direction crashes might be meaningful choices for comparison crashes because they share similar vision-related causal factors as the target crashes, even though DRLs could play a role as a countermeasure in rear end crashes. One problem is that the number of such crashes is much smaller than single vehicle crashes and the results would not have enough power to reject the null hypothesis. However, there is another argument that although rear-end and same-direction sideswipe crashes are not the intended target of DRLs, they are relevant since they draw attention to following vehicles – particularly tailgating vehicles – where drivers may respond with actions that potentially can increase or decrease the risk of a crash. If this is the case, design issues of location, brightness and color may be relevant.

Crashes of three or more vehicles were eliminated from the analysis. The crash geometry can become quite complex and vague for crashes of three or more vehicles and the number of such crashes is small. It is easy to misclassify such a crash. Therefore, to reduce the possibility of contamination of the analysis, all crashes involving three or more vehicles have been eliminated.

Another possible source of contamination, albeit a small one, is crashes involving parked vehicles in a fatal crash. To insure a vehicle involved in the crash was not parked, the requirement that a driver was present or that the driver had left the scene, was imposed.

The vehicles in the analysis were restricted to passenger vehicles of model year 1995 and later. Passenger vehicles include passenger cars, SUVs, light trucks, and vans. The target group of vehicles with daytime running lamps and the comparison group of vehicles without daytime running lamps were identified by analysis of the Vehicle Identification Number, VIN. Analysis of the VIN partitioned vehicles into 4 distinct groups: 1) vehicles that had DRLs as standard equipment, 2) vehicles that did not have DRLs as standard equipment nor as a standard option, 3) vehicles that have DRLs as a standard option, and 4) other vehicles including vehicles where the VIN was not reported or could not be decoded.

The target group of vehicles was the group of vehicles with DRLs as standard equipment. The comparison group of vehicles was the group of vehicles without DRLs, which did not have DRLs as a standard option. Vehicles with DRLs as a standard option and the vehicles in the “other” category were eliminated from the analysis.

### **Caveats**

To analyze the effect of a new vehicle safety device one needs to compare it to vehicles that do not have the device and in situations that should and should not be affected by the device. One attempts to assure that the respective partition of vehicles and crashes eliminates any lurking variables, but this can never be fully guaranteed. The selection and partition of vehicles and crashes were based on the analytic judgment.

### **DRL Effectiveness in Fatal Two-Vehicle Crashes**

The target crashes are two-vehicle crashes where the vehicles are traveling in opposite-directions. The target crashes include head-on, and sideswipe opposite direction crashes. Single-vehicle crashes are the comparison crashes.

Table 2 shows the cross tabulation of the target and single-vehicle crashes under daytime and nighttime conditions for vehicles equipped with DRLs.

**Table 2**  
**DRL-Equipped Vehicles in Target and**  
**Single-Vehicle Fatal Crashes, FARS 1995-2001**

Time of Day	Target Crashes	Single-Vehicle Crashes	Total
Daytime	2,117	3,360	5,477
Nighttime	1,047	4,573	5,620
Total	3,164	7,933	11,097
Source: NHTSA, NCSA, FARS			

Table 3 shows the cross tabulation of the target and single-vehicle crashes under daytime and nighttime conditions for the comparison group of vehicles without DRLs.

**Table 3**  
**Vehicles w/o DRL in Target and**  
**Single-Vehicle Fatal Crashes, FARS 1995-2001**

Time of Day	Target Crashes	Single-Vehicle Crashes	Total
Daytime	6,699	10,058	16,757
Nighttime	3,450	13,413	16,863
Total	10,149	23,471	33,620
Source: NHTSA, NCSA, FARS			

#### **DRL Effectiveness in Fatal Two-Vehicle Crashes - Results**

The effectiveness, based on the simple odds, of DRLs in preventing two-vehicle opposite direction fatal crashes during daylight is estimated to be **5.3** percent with ( $p = 0.052$ ).

Passenger vehicle type may influence the effectiveness of DRLs. To examine this issue, vehicle types were included in the logistic fit of the data. The results are similar. The effectiveness, based on the simple odds, of DRLs in preventing two-vehicle opposite direction crashes during daylight is estimated to be **5.1** percent with ( $p = 0.061$ ) when adjusting for vehicle type.

#### **DRL Effectiveness in Non-Fatal Two-Vehicle Crashes**

The target crashes are two-vehicle crashes where the vehicles are traveling in opposite-directions. Single-vehicle crashes are the comparison crashes.

Table 4 shows the cross tabulation of the target and single-vehicle non-fatal crashes under daytime and nighttime conditions for vehicles equipped with DRLs. Since NASS/GES is a complex sample survey a program such as SUDAAN must be used to estimate the level of significance of the parameters.

**Table 4**  
**DRL-Equipped Vehicles in Target and**  
**Single -Vehicle Non-Fatal Crashes, NASS/GES 1995-2001**

Time of Day	Target Crashes	Single-Vehicle Crashes	Total
Daytime	972,000	248,000	1,220,000
Nighttime	215,000	216,000	432,000
Total <sup>25</sup>	1,188,000	464,000	1,652,000
Source: NHTSA, NCSA, NASS/GES			

Table 5 shows the cross tabulation of the target and single-vehicle non-fatal crashes under daytime and nighttime conditions for the comparison group of vehicles without DRLs.

**Table 5**  
**Vehicles w/o DRL in Target and**  
**Single-Vehicle Non-Fatal Crashes, NASS/GES 1995-2001**

Time of Day	Target Crashes	Single-Vehicle Crashes	Total
Daytime	3,074,000	737,000	3,812,000
Nighttime	695,000	608,000	1,303,000
Total <sup>24</sup>	3,770,000	1,345,000	5,115,000
Source: NHTSA, NCSA, NASS/GES			

### **DRL Effectiveness in Non-Fatal Two-Vehicle Crashes - Results**

The effectiveness, based on the simple odds, of DRLs in preventing two-vehicle opposite direction non-fatal crashes during daylight is estimated to be **5.2** percent with ( $p = 0.075$ ).

Passenger vehicle type may influence the effectiveness of DRLs. To examine this issue, vehicle types were included in the logistic fit of the data. The results are similar. The effectiveness of DRLs in preventing two-vehicle opposite direction non-fatal crashes during daylight is estimated to be **4.4** percent with ( $p = 0.133$ ) when adjusting for vehicle type. Since the value of  $p$  is greater than 0.1, the null hypothesis cannot be rejected. However, since this estimate of effectiveness is similar to the significantly significant value calculated without adjusting for vehicle type, with ( $p = 0.075$ ) one could interpret this estimate as a weak confirmation of the previous result.

<sup>25</sup> Totals may not add due to rounding.

## DRL Effectiveness in Fatal Single-Vehicle Pedestrian/Cyclist Crashes

As daytime running lamps reduce two-vehicle opposite-direction crashes, daytime running lamps may also reduce single-vehicle crashes with pedestrians or cyclists. To answer that question, one can modify the approach used above. FARS, 1995 to 2001, can again be used for this analysis. However, the analysis is performed at the person level, rather than the vehicle level<sup>26</sup>. The target group of persons is fatally injured pedestrians and cyclists in single vehicle crashes; the comparison group of persons is fatally injured occupants in single vehicle crashes. The target time period is daytime, including dawn and dusk and the comparison time period is night. The results follow:

**Table 6**  
**Single-vehicle Pedestrian and Cyclist Fatalities FARS 1995-2001**  
**Vehicles Equipped with DRLs**

Time of Day	Pedestrian and Cyclist Deaths	Occupant Deaths	Total
Daytime	710	6,288	6,998
Nighttime	1,153	8,136	9,289
Total	1,863	14,424	16,287
Source: NHTSA, NCSA, FARS			

**Table 7**  
**Single-vehicle Pedestrian and Cyclist Fatalities FARS 1995-2001**  
**Vehicles Not Equipped with DRLs**

Time of Day	Pedestrian and Cyclist Deaths	Occupant Deaths	Total
Daytime	2,515	19,540	22,055
Nighttime	3,876	24,946	28,822
Total	6,391	44,486	50,877
Source: NHTSA, NCSA, FARS			

<sup>26</sup> It is possible for a pedestrian fatality and an occupant fatality to occur in the same crash. In this case, both the pedestrian and cyclist death cell and occupant death cell are incremented. To avoid potential single vehicle crashes involving a pedestrian/cyclist death and an occupant death from confounding the data, this analysis is performed at the person level, not the crash level.

### **DRL Effectiveness in Fatal Single-Vehicle Pedestrian/Cyclist Crashes - Results**

The effectiveness, based on the simple odds, of DRLs in preventing single-vehicle pedestrian/cyclist fatalities during daylight is estimated to be **12.4** percent with ( $p = 0.002$ ).

Passenger vehicle type may influence the effectiveness of DRLs. To examine this issue, vehicle types were included in the logistic fit of the data. The results are similar. The effectiveness, based on the simple odds, of DRLs in preventing single-vehicle pedestrian/cyclist fatal crashes during daylight is estimated to be **12.9** percent with ( $p = 0.002$ ) when adjusting for vehicle type.

### **DRL Effectiveness in Fatal Crashes of a Passenger Vehicle with a Motorcycle**

Target crashes are two-vehicle opposite direction crashes between a passenger vehicle and a motorcycle. Comparison crashes are single vehicle crashes. In the analysis that follows, the DRL status of the passenger vehicle involved in a two-vehicle crash with a motorcycle determined if the crash was a DRL equipped crash or a non-DRL equipped crash.

Table 8 shows the cross tabulation of the target and single passenger vehicle crashes under daytime and nighttime conditions for passenger vehicles equipped with DRLs.

**Table 8**  
**Passenger Vehicles with DRLs Involved in Fatal 2-Vehicle Crashes of a Motorcycle and a Single Passenger Vehicle, FARS 1995-2001**

Time of Day	Target 2-Vehicle Motorcycle Crashes	Single Passenger Vehicle Crashes	Total
Daytime	62	3,360	3,422
Nighttime	30	4,573	4,603
Total	92	7,933	8,025

Source: NHTSA, NCSA, FARS

Table 9 shows the cross tabulation of the target and single passenger vehicle crashes under daytime and nighttime conditions for the comparison group of passenger vehicles without DRLs.

**Table 9**  
**Passenger Vehicles w/o DRLs Involved in Fatal 2-Vehicle Crashes of a Motorcycle and a Single Passenger Vehicle, FARS 1995-2001**

Time of Day	Target 2-Vehicle Motorcycle Crashes	Single Passenger Vehicle Crashes	Total
Daytime	239	10,058	10,297
Nighttime	86	13,413	13,499
Total	325	23,471	23,796
Source: NHTSA, NCSA, FARS			

#### **DRL Effectiveness in Fatal Crashes of a Passenger Vehicle with a Motorcycle - Results**

The effectiveness, based on the simple odds, of DRLs in preventing two-vehicle opposite direction crashes between a passenger vehicle and a motorcycle during daylight is estimated to be **23.2** percent with ( $p = 0.065$ ).

Passenger vehicle type may influence the effectiveness of DRLs. To examine this issue, vehicle types were included in the logistic fit of the data. The results are similar. The effectiveness, based on the simple odds, of DRLs in preventing two-vehicle opposite direction crashes between a passenger vehicle and a motorcycle during daylight is estimated to be **22.6** percent with ( $p = 0.074$ ) when adjusting for vehicle type.

#### **Conclusions**

The effectiveness of daytime running lamps, based on the simple odds, was analyzed in the preceding sections using data from FARS and NASS/GES from calendar years 1995 to 2001. FARS and NASS/GES data show that during the period of the study 1995 to 2001, DRLs reduced daylight two passenger vehicle opposite-direction crashes by about 5 percent. DRLs have also been shown to reduce fatal opposite direction crashes between a motorcycle and a passenger vehicle by 23 percent. The results for two-vehicle daytime opposite-direction crashes are statistically significant at the  $p < 0.10$  level, although one would prefer a statistical level of  $p < 0.05$ .

FARS data were also used to estimate the effectiveness, based on the simple odds, of DRLs in reducing pedestrian/cyclist fatalities in single-vehicle fatal crashes. The analysis shows that DRLs reduced pedestrian/cyclist fatalities by more than 12 percent. These results are highly significant at a statistical level of  $p = 0.002$ .

This analysis is based on US historical data and does not reflect what will happen in the future. The techniques used do not predict the crash reducing effectiveness of DRLs if the entire fleet is equipped with DRLs nor if drivers become habituated to DRLs. These are limitations of historical crash data.

As additional data become available it may be appropriate to further investigate the effectiveness of DRLs in a variety of crash configurations including pedestrian and motorcycle crashes.

## Appendix A

### Analytic Approach

The primary analytic approach used to estimate the effectiveness,  $E$ , of daytime running lamps is based on the generalized simple odds. The effectiveness, based on the simple odds approach, is defined as:

$$E = 1 - e^{-\beta}$$

Where  $\beta$  is the coefficient of the following equation:

$$TC\_DT = \beta * DRL + \sum_i \beta_i * X_i + \text{error}$$

Where:  $TC\_DT = 1$  if the crash is a target crash that occurred during the day, 0 otherwise and  $DRL = 0$  if the vehicle has DRLs, otherwise 1. A bivariate logistic fit of the data is calculated using a maximum likelihood estimate. FARS data can be analyzed using SAS<sup>®</sup>, however, since NASS/GES data come from a complex survey rather than a census, SUDAAN had to be used to estimate the variance and significance of the estimated coefficients.

In the event that one does not need to control for variables such as vehicle type, the  $X_i$  terms are zero and an arithmetic approach to calculate the effectiveness exists. In this case, the effectiveness,  $E$  is equivalent to:

$$E = 1 - (O_{DRL} / O_{CMP})$$

Where

$$O = TD / (CD + TN + CN)$$

and is evaluated for both the vehicles equipped with DRLs,  $O_{DRL}$ , and the vehicles in the comparison group without DRLs,  $O_{CMP}$ .

TD is the number of vehicles/persons in Targeted crashes during Daylight.

CD is the number of vehicles/persons in Comparison crashes during Daylight.

TN is the number of vehicles/persons in Targeted crashes at Night.

CN is the number of vehicles/persons in Comparison crashes at Night.

In this simplified case, for FARS data, the variance of  $\ln(1-E)$ , can be estimated as the sum of the squared of the reciprocals of the four groups of observations. That is:

$$\text{VAR} [\ln(1-E)] \sim [1/\text{TD}_{\text{DRL}}]^2 + [1/(\text{CD}_{\text{DRL}} + \text{TN}_{\text{DRL}} + \text{CN}_{\text{DRL}})]^2 + [1/\text{TD}_{\text{CMP}}]^2 + [1/(\text{CD}_{\text{CMP}} + \text{TN}_{\text{CMP}} + \text{CN}_{\text{CMP}})]^2$$

This technique to estimate the variance of the  $\ln(1-E)$  does not apply to weighted survey data, which requires complex software such as SUDAAN.

### Logistic Regression Estimates Using the Simple Odds

Note that, with the exception of Table A-4, the value of  $p$  for the coefficient of DRL is  $< 0.1$ .

<b>Table A-1</b>					
<b>DRL Effectiveness in Fatal Two-Vehicle Crashes Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	1.4450	0.0242	3,577.07	<0.0001
DRL	0.947	-0.0541	0.0278	3.79	0.0515

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

<b>Table A-2</b>					
<b>DRL Effectiveness in Fatal Two-Vehicle Crashes / Adjusted for Vehicle Type Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	1.4902	0.0270	3,053.61	< 0.0001
DRL	0.949	-0.0523	0.0279	3.52	0.0606
Sport Utility	1.211	0.1917	0.0356	29.01	<0.0001
Van	0.475	-0.2938	0.0442	44.11	<0.0001
Light Trucks	0.817	-0.2025	0.0283	51.10	<0.0001

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

<b>Table A-3</b>					
<b>DRL Effectiveness in Non-Fatal Two-Vehicle Crashes Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	-0.3579	0.05	3.33	0.0751
DRL	0.948	-0.0529	0.03	3.33	0.0751

Source: NHTSA, NCSA, NASS/GES, SUDAAN

<b>Table A-4</b>					
<b>DRL Effectiveness in Non-Fatal Two-Vehicle Crashes / Adjusted for Vehicle Type Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	-0.3779	0.13	3.74	0.0017
DRL	0.956	-0.0445	0.03	2.34	0.1333
Sport Utility	1.099	0.0941	0.05	4.30	0.0441
Van	0.826	-0.1906	0.08	6.13	0.0173
Light Trucks	1.089	0.0856	0.05	3.53	0.0672

Source: NHTSA, NCSA, NASS/GES, SUDAAN

<b>Table A-5</b>					
<b>DRL Effectiveness in Fatal Single-Vehicle – Pedestrian/Cyclist Crashes Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	3.0883	0.0384	6,476.45	<0.0001
DRL	0.876	-0.1318	0.0435	9.19	0.0024

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

<b>Table A-6</b>					
<b>DRL Effectiveness in Fatal Single-Vehicle – Pedestrian/Cyclist Crashes Adjusted for Vehicle Type Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	3.1449	0.0427	5,424.56	<0.0001
DRL	0.871	-0.1377	0.0437	9.94	0.0016
Sport Utility	1.231	0.2082	0.0527	15.58	<0.0001
Van	0.812	-0.2086	0.0586	12.69	0.0004

Light Trucks	0.752	-0.2853	0.0445	41.08	<0.0001
Source: NHTSA, NCSA, FARS, SAS <sup>®</sup>					
<b>Table A-7</b>					
<b>DRL Effectiveness for Two-Vehicle Fatal Crashes</b>					
<b>Involving a Motorcycle and a Passenger Vehicle Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	4.8552	0.1275	1,450.52	<0.0001
DRL	0.768	-0.2645	0.1431	3.42	0.0645
Source: NHTSA, NCSA, FARS, SAS <sup>®</sup>					

<b>Table A-8</b>					
<b>DRL Effectiveness for Two-Vehicle Fatal Crashes</b>					
<b>Involving a Motorcycle and a Passenger Vehicle Adjusted for Vehicle Type</b>					
<b>Based on Simple Odds</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	5.1603	0.1478	1,224.38	<0.0001
DRL	.0774	-0.2564	0.1436	3.19	0.0741
Sport Utility	0.627	-0.4664	0.1572	8.80	0.0030
Van	0.499	-0.6960	0.2044	11.60	0.0007
Light Trucks	0.557	-0.5846	0.1408	17.25	<0.0001
Source: NHTSA, NCSA, FARS, SAS <sup>®</sup>					

## Appendix B

### Alternate Analytic Approach

This section is included at the request of the reviewers of the paper. The odds ratio is easier to understand for inexperienced analysts than the simple odds and, like the simple odds, attempts to control for a variety of factors other than the presence or absence of DRLs. Unfortunately, when using the odds ratio, the estimated effectiveness of DRLs is extremely sensitive to small changes encountered in real world crash data and none of the results were statistically significant. This does not mean that DRLs do not reduce target crashes during the daytime. It just means that the odds ratio technique does not detect these changes over the inherent background noise of the data system.

The effectiveness, based on the odds ratio, is defined as:

$$E = 1 - e^{\beta}$$

Where  $\beta$  is the coefficient of the following equation:

$$\text{LIGHT} = \beta * (\text{DRL} \times \text{CRASH}) + a_1 * \text{DRL} + a_2 * \text{CRASH} + \sum_i \beta_i * X_i + \text{error}$$

Where: LIGHT = 1 if the crash occurred during the day, 0 otherwise  
DRL = 0 if the vehicle has DRLs, otherwise 1.  
CRASH = 1 if the crash is a target crash, and 0 if the crash is a comparison crash.

A bivariate logistic fit of the data is calculated using a maximum likelihood estimate. FARS data can be analyzed using SAS<sup>®</sup>, however, since NASS/GES data come from a complex survey rather than a census, SUDAAN had to be used to estimate the variance and significance of the estimated coefficients.

In the event that one does not need to control for variables such as vehicle type, the  $X_i$  terms are zero and an arithmetic approach to calculate the effectiveness exists. In this case, the effectiveness,  $E$  is equivalent to:

$$E = 1 - \left( \frac{\text{DRL}}{\text{CMP}} \right)$$

Where

$$\left( \frac{\text{DRL}}{\text{CMP}} \right) = \frac{(\text{TD}/\text{CD})}{(\text{TN}/\text{CN})}$$

and is evaluated for both the vehicles equipped with DRLs,  $\left( \frac{\text{DRL}}{\text{CMP}} \right)$ , and the vehicles in the comparison group without DRLs,  $\left( \frac{\text{DRL}}{\text{CMP}} \right)$ .

In this simplified case, for FARS data, the variance of  $\ln(1-E)$ , can be estimated as the sum of the squares of the reciprocals of the eight groups of observations. That is:

$$\text{VAR} [\ln(1-E)] \sim [1/\text{TD}_{\text{DRL}}]^2 + [1/\text{CD}_{\text{DRL}}]^2 + [1/\text{TN}_{\text{DRL}}]^2 + [1/\text{CN}_{\text{DRL}}]^2 + [1/\text{TD}_{\text{CMP}}]^2 + [1/\text{CD}_{\text{CMP}}]^2 + [1/\text{TN}_{\text{CMP}}]^2 + [1/\text{CN}_{\text{CMP}}]^2$$

Note that VAR [ln(1-E)] is much larger for the odds ratio than for the simple odds. As a result, the values of p, for each of the evaluated crash types in this study, are larger than 0.1, therefore the null hypothesis cannot be rejected and there is no reason to believe that the results, based on the odds ratio, did not occur by chance.

Using the data of Tables 2 and 3, the estimates of effectiveness of DRLs are calculated using the odds ratio. The result for two-vehicle opposite direction fatal crashes is -6.3 percent with (p=0.229). When adjusting for vehicle type, the result is -6.3 percent with (p=0.235). The values of p in both cases are larger than 0.1, therefore the null hypothesis cannot be rejected and there is no reason to believe that the results, based on the odds ratio, did not occur by chance.

Using the data of Tables 4 and 5, the estimates of effectiveness of DRLs are calculated using the odds ratio. The result for two-vehicle opposite direction non-fatal crashes is -7.9 percent with (p=0.186). When adjusting for vehicle type, the result is -7.6 percent with (p=0.202). The values of p in both cases are larger than 0.1, therefore the null hypothesis cannot be rejected and there is no reason to believe that the results, based on the odds ratio, did not occur by chance.

Using the data of Tables 6 and 7, the estimates of effectiveness of DRLs are calculated using the odds ratio. The result for fatal single-vehicle pedestrian/cyclist crashes is 3.8 percent with (p=0.498). When adjusting for vehicle type, the result is 4.6 percent with (p=0.415). The values of p in both cases are larger than 0.1, therefore the null hypothesis cannot be rejected and there is no reason to believe that these results, based on the odds ratio, did not occur by chance.

Using the data of Tables 8 and 9, the estimates of effectiveness of DRLs are calculated using the odds ratio. The result for crashes of a passenger vehicle with a motorcycle is 26.0 percent with (p=0.284). When adjusting for vehicle type, the result is 22.0 percent with (p=0.335). The values of p in both cases are larger than 0.1, therefore the null hypothesis cannot be rejected and there is no reason to believe that the results, based on the odds ratio, did not occur by chance.

## Logistic Regression Estimates Using the Odds Ratio

Note that the value of  $p$  for the coefficient of DRLxCRASH is always larger than 0.1. Therefore the null hypothesis cannot be rejected and the estimates, based on the odds ratio, do not improve our understanding of the effectiveness of DRLs. However, if the estimate of effectiveness is larger than 20 percent, the estimates, based on the odds ratio, are similar to the estimates calculated using the simple odds, albeit not statistically significant.

Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.3082	0.227	184.01	<0.0001
DRLxCRASH	1.063	0.0608	0.0506	1.45	0.2291
DRL	0.980	-0.0204	0.0263	0.60	0.4381
CRASH	0.363	0.3082	0.0441	527.08	<0.0001

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.4052	0.0247	269.55	< 0.0001
DRLxCRASH	1.063	0.0606	0.0507	1.43	0.2315
DRL	0.998	-0.0019	0.0264	0.01	0.9435
CRASH	0.361	-1.0193	0.0442	531.82	<0.0001
Sport Utility	0.738	-0.3036	0.0273	123.75	<0.0001
Van	0.604	-0.5044	0.0689	167.83	<0.0001
Light Trucks	0.920	-0.0836	0.0237	12.43	<0.0004

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

<b>Table B-3</b>					
<b>DRL Effectiveness in Non-Fatal Two-Vehicle Crashes Based on Odds Ratio</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	-0.1343	0.08	222.88	<0.0001
DRLxCRASH	1.079	0.0763	0.06	1.81	0.1259
DRL	0.944	-0.0574	0.05	1.56	0.2184
CRASH	0.253	-1.3725	0.07	383.31	<0.0001

Source: NHTSA, NCSA, NASS/GES, SUDAAN

<b>Table B-4</b>					
<b>DRL Effectiveness in Non-Fatal Two-Vehicle Crashes / Adjusted for Vehicle Type Based on Odds Ratio</b>					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	-0.0957	0.08	141.85	<0.0000
DRLxCRASH	1.076	0.0735	0.06	1.68	0.2024
DRL	-0.954	-0.0467	0.05	0.97	0.3294
CRASH	0.253	-1.3728	0.07	387.03	<0.0000
Sport Utility	0.921	-0.0825	0.04	5.20	0.0276
Van	0.718	-0.3320	0.06	33.31	<0.0000
Light Trucks	1.089	0.0856	0.03	5.05	0.0237

Source: NHTSA, NCSA, NASS/GES, SUDAAN

**Table B-5**  
**DRL Effectiveness in Fatal Single-Vehicle – Pedestrian/Cyclist Crashes**  
**Based on Odds Ratio**

Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.2577	0.0168	235.46	<0.0001
DRLxPERSON	0.962	-0.0389	0.0575	0.46	0.4984
DRL	0.987	-0.0134	0.0193	0.42	0.4877
PERSON	0.876	-0.1318	0.0435	9.19	0.0024

Source: NHTSA, NCSA, FARS, SAS®

**Table B-6**  
**DRL Effectiveness in Fatal Single-Vehicle – Pedestrian/Cyclist Crashes**  
**Adjusted for Vehicle Type Based on Odds Ratio**

Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.4387	0.0186	554.10	<0.0001
DRLxPERSON	0.954	-0.0472	0.0579	0.66	0.4153
DRL	1.031	0.0309	0.0195	2.51	0.1133
PERSON	1.238	0.2137	0.0509	17.62	<0.0001
Sport Utility	0.619	-0.4790	0.0208	532.62	<0.0001
Van	0.461	-0.7749	0.0269	831.38	<0.0001
Light Trucks	0.846	-0.1667	0.0206	65.46	<0.0001

Source: NHTSA, NCSA, FARS, SAS®

Table B-7					
DRL Effectiveness for Two-Vehicle Fatal Crashes					
Involving a Motorcycle and a Passenger Vehicle Based on Odds Ratio					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.3082	0.0227	184.01	<0.0001
DRLxCRASH	0.760	-0.2851	0.2568	1.15	0.2842
DRL	0.980	-0.0204	0.0263	0.60	0.4381
CRASH	0.356	-1.0341	0.2236	21.40	<0.0001

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

Table B-8					
DRL Effectiveness for Two-Vehicle Fatal Crashes					
Involving a Motorcycle and a Passenger Vehicle Adjusted for Vehicle Type					
Based on Odds Ratio					
Parameter	Odds Ratio	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq p
Intercept	N/A	0.4268	0.0254	282.23	<0.0001
DRLxCRASH	0.780	-0.2485	0.2577	0.93	0.3349
DRL	1.003	0.0030	0.0264	0.01	0.9087
CRASH	0.355	-1.0363	0.2242	21.36	<0.0001
Sport Utility	0.691	-0.3695	0.0309	143.26	<0.0001
Van	0.529	-0.6362	0.0460	190.93	<0.0001
Light Trucks	0.905	-0.0993	0.0283	12.27	0.0005

Source: NHTSA, NCSA, FARS, SAS<sup>®</sup>

## Appendix C

The following SAS<sup>®</sup> code was used to partition FARS 1996 vehicle crashes. The code for the NASS/GES is similar.

```
/* COMPARISON CRASHES SINGLE VEHICLE CRASHES */

LIBNAME FARS96 'L:\FARSSAS\FARS96';

DATA CRASH;
  SET FARS96.ACCIDENT(KEEP = ST_CASE LGT_COND VE_FORMS MAN_COLL
  WEATHER);

LENGTH TGT_CRSH $8;

* IF TWO VEHICLES CRASH AND;
* HEAD-ON OR SIDESWIPE DIFFERENT DIRECTIONS;

IF (VE_FORMS EQ 2) AND
  ((2 EQ MAN_COLL) OR (6 EQ MAN_COLL))
  THEN TGT_CRSH ='MUL TGT';

/* ELSE SINGLE VEHICLE CRASHES */
ELSE IF (VE_FORMS EQ 1) THEN TGT_CRSH = 'SINGLE';
ELSE DELETE;

*DEFINE THE DICHOTOMOUS VARIABLE D_CRASH;

IF (VE_FORMS EQ 2) AND
  ((2 EQ MAN_COLL) OR (6 EQ MAN_COLL))
  THEN D_CRASH = 1;

/* ELSE SINGLE VEHICLE CRASHES */
ELSE IF (VE_FORMS EQ 1) THEN D_CRASH = 0;
ELSE DELETE;

LENGTH LIGHT $7;

*IF DAYLIGHT DAWN OR DUSK;
IF (LGT_COND EQ 1 OR 4 LE LGT_COND LE 5) THEN LIGHT = 'DAYTIME';

*IF DARK OR DARK AND LIGHTED;
ELSE IF (2 LE LGT_COND LE 3) THEN LIGHT = 'NIGHT';
```

ELSE DELETE;

\* DEFINE THE DICHOTOMOUS VARIABLE D\_LIGHT;  
IF (LGT\_COND EQ 1 OR 4 LE LGT\_COND LE 5) THEN D\_LIGHT = 1;  
ELSE IF (2 LE LGT\_COND LE 3) THEN D\_LIGHT = 0;

\* DEFINE THE DICHOTOMOUS VARIABLE MUL\_DAY;  
\* THIS IS FOR THE SIMPLE ODDS CALCULATION;

IF (D\_CRASH = 1 AND D\_LIGHT = 1) THEN MUL\_DAY = 1;  
ELSE MUL\_DAY = 0;

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