Daytime Running Lights in America

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Introduction

Daytime running lights are presently required equipment on all automobiles sold or imported into Canada. The stated rationale behind this legislation is that daytime running lights increase vehicle visibility during the day, particularly during adverse weather conditions, by creating contrast between the vehicle and the environment (Krajicek & Schears, 2009) and improving detectability in the central and peripheral fields of view (Williams and Lancaster, 1995). Despite the evidence of improved safety, daytime running lights are not required on automobiles sold in the United States. Reasons for the lack of legislation in the United States are oriented around other research either finding no difference or targeting the quality of other research. While studies on daytime running lights do vary in quality, a common criticism of them, the results consistently indicate a reduction in incidence of head-on and side crashes during the daytime (Sparks, et al, 1993).

As of December 1, 1989 all new vehicles sold in or imported into Canada have been required to come standard with daytime running light systems (Sparks, et al, 1993). Daytime running light systems can mean a few different things, though the three most typical types are a low-beam headlight, standard-brightness headlight, or parking lights, each of which is activated upon starting the automobile. Despite the demonstrated benefits of daytime running lights in Canada, mandated use of them is a contested issue in the United States. In addition to Canada, other countries including Denmark, Finland, Hungary, Iceland, Norway, and Sweden currently require daytime running lights (MnDOT, 2011).

When considering the role of daytime running lights in the United States, it is critical to note that they were not such a contentious issue regarding motorcycles. Daytime running lights are presently required on all motorcycles in the United States. As daytime running lights became mandatory for motorcycles, the incidence of fatal motorcycle crashes fell by thirteen percent (Sparks, et al, 1993).

Required use of daytime headlights also appears in different ways in different states. For example, on its “Safety Corridors” in California use of daytime headlights is required, in Pennsylvania headlights are required in work zones, and in West Virginia headlights are required at any point windshield wipers are in use. Other states, including Minnesota, have considered the possibility of requiring motorists to turn on their headlights 24-hours per day, a so-called “behavioral option” (MnDOT, 2011). One state, Illinois, also attempted to pass a state law requiring daytime running lights in both 2009 and 2010, but neither iteration of the law passed (MnDOT, 2011). Essentially, these findings indicate daytime running lights are incrementally creeping into use in various incarnations presently.

The primary basis of disagreement regarding daytime running lights is the potential costs and added emissions of the daytime running light systems (MnDOT, 2011). The other primary sources of argument have been based in differences of opinion regarding methodology in the published research.

This research takes three approaches to evaluating the issue of daytime running lights in the United States. The first approach identifies where the dialogue on daytime running lights is presently in the United States through reviewing published research and government documents. The second approach identifies the potential acceptability of daytime running lights in the United States if they are mandated. The simplest way to complete this goal is observing traffic and note how many passenger cars utilize lights during the day. The third approach describes a potential framework to evaluate the effects of potential legislation pertaining to daytime running lights in the United States. Ultimately, this paper seeks to compile the information to make an informed policy decision regarding the implementation of daytime running lights in the United States.

Literature Review

Some states, particularly Minnesota, have identified the benefit of daytime running lights. This is indicative of most of the government research conducted on the use of daytime running lights in the United States. Research is typically conducted at a state level. A report the Minnesota Department of Transportation compiled indicated their crash data showed vehicles without daytime running lights had 1.73 higher odds of involvement in crashes than those vehicles with DRLs (MnDOT, 2011).

Krajicek and Schears, who are both trauma physicians, found that of crashes during daylight hours in Minnesota between 1995 and 2002, those with daytime running lights had a significantly reduced rate of involvement in crashes. Because daytime running lights are not required on vehicles sold in the United States, these researchers had to seek out the Vehicle Identification Number (VIN) of the vehicle involved in the crash and then cross reference it with a list of vehicles sold with daytime running lights in the United States to perform their analysis (Krajicek & Schears, 2009).

The National Highway Traffic Safety Administration (NHTSA) conducted research on the use of daytime running lights in 2000 and they found no significant effect. However, the work published by NHTSA used fatal crashes as the numerator and overall crashes as the denominator. But fatal crashes are a very small subgroup of crashes overall and there may be more significant factors affecting fatal crashes and the events immediately beforehand than just daytime running lights (Krajicek & Schears, 2009). But utilizing a different methodology, more oriented toward crashes as a whole, in 2004, NHTSA found crash reductions of five-percent for head-on crashes, twelve-percent reduction in vehicle crashes with pedestrian and bicyclist, and a 23-percent reduction in head-on crashes involving motorcycles (NHTSA, 2004).

In 2008 NHTSA revisited the subject of daytime running lights. This study reviewed FARS data from 2000 to 2005 in nine states, including Pennsylvania, and for general passenger cars found no statistically significant effect on two-vehicle crashes (excluding rear-end crashes), single-vehicle crashes with pedestrians or cyclists, or single-vehicle crashes with motorcycles. (NHTSA, 2008). But this study did find a statistically significant, 5.7-percent reduction in light truck and van involvement in two-vehicle crashes. This result was found by excluding crashes not involving light trucks and vans (NHTSA, 2008). Based on the three NHTSA studies, it seems clear that the effects of daytime running lights are far more conspicuous when evaluating crashes as a whole rather than specifically fatal crashes. But this effectively illustrates some of the ambivalence toward daytime running lights caused by methodologies and approaches with varying outcomes.

Sparks and his colleagues (1993) investigated the potential benefits of daytime running lights on government fleet vehicles in the Canadian province of Saskatchewan. Data from their study came from the Traffic Accident Information System (TAIS) and they performed a with-and-without analysis of crashes. The analysis was limited to two-vehicle crashes occurring during daylight or twilight hours, where both vehicles were fully part of the traffic stream, and where damages exceeded $500. Then crashes were divided between those that were relevant to investigating daytime running lights and those not, judgment was used with the TAIS data to determine if the lights would have been visible immediately prior to the crash. Additional variables were selected to establish more precise conclusions if the general results proved significant.

Analysis was performed using a series of proportions and odds equations followed by a loglinear model fitted to the odds of daytime running light relevance for a number of factors. Ultimately they estimated that installation of daytime running lights on this fleet of vehicles reduced daytime running light-relevant, two-vehicle crashes by 28-percent, and this was found significant at the 0.05 level. The authors felt the results of this study were conservative and also recommended taillight daytime running lights should also be required as they may reduce rear-end crashes (Sparks, et al, 1993). While their methodology found results desirable to the case of daytime running lights, the methodology is vulnerable to experimenter bias due to the necessity of judgment in determining the initial equations generating the data for use in the model.

Aside from the concerns over their effect in preventing crashes, the benefits of daytime running lights have been questioned in the context of additional cost to drivers and additional emissions. One paper estimated a cost-benefit ratio of 1.96, so for every $1.00 spent, the benefit is valued at $1.96 (Elvik, et al, 2003). Another report indicated that the fuel consumption caused by the use of daytime running lights did not exceed one-percent (CEC, 2008).

Williams and Lancaster (1995) pointed out that countries with required daytime running lights legislation are at typically higher latitude than the United States. Although they were optimistic that the results from Canada may help push the technology in the United States because most of the Canadian population lives at lower latitudes than the Scandinavian countries and within 100 miles of the United States border. This is significant because areas closer to the poles have longer twilight periods as well as longer periods with low sun (Williams & Lancaster, 1995).

By far the most expansive meta-analysis on the subject of daytime running lights was conducted by Rune, Christensen, and Olsen. Their analysis focused both on the intrinsic effect on safety for individual vehicles with daytime running lights as well as the aggregate effect of laws and public campaigns leading to increased overall use of daytime running lights on the total number of crashes. Consistent with NHTSA's findings, results on the effect of daytime running lights with fatal crashes was inconsistent and not significant overall, but they found daytime running lights had their greatest effect on the most severe crashes (Rune et al, 2003). Though in general terms, it is still not well understood what differentiates severe crashes from fatal crashes in many cases.

Other critical findings from the Rune, Christensen, and Olsen analysis included a weak relationship between geographical latitude and the effects of daytime running lights. The further from the equator, the more benefit was found from daytime running lights. The effects of daytime running lights do not have a significant variation during different times of year (Rune et al, 2003). They also considered effects on bicyclists and pedestrians in their analysis and found that it was unlikely to impact these groups when examined as a whole, noting that smaller, localized studies did find some negative effects (Rune et al, 2003).

Overall, the literature strongly supports implementation of daytime running lights, despite a few clear arguments. With improved computing power and more developed statistical techniques research less prone to methodological complaints can be performed, one such method will be described in more detail later in this paper. Additionally, cost to benefit ratio is almost two-to-one. Although that benefit is not evenly distributed throughout the driving public because not every driver will avoid a crash because of the presence of daytime running lights. It is also evident daytime running lights do not have the same effect on fatal crashes as they do on crashes as a whole.

Acceptability of Daytime Running Lights

Several auto manufacturers voluntarily sell vehicles in the United States with automatic daytime running lights, including Audi, General Motors, Suzuki, Volkswagen, and Volvo (Krajicek & Schears, 2009). As a result, it is not uncommon to see vehicles sold in the United States with daytime running lights. Additionally, some drivers voluntarily turn on their headlights regardless of the lighting conditions because they believe it is an easy means to improve safety.

Methodology

To evaluate the penetration of daytime running lights onto American roads, data was collected observationally. Between the hours of 11:00am and 3:00pm on ten separate days in ten separate locations 100 cars were observed, ones with daytime running lights of any kind or headlights on were counted. All observations were taken during dry conditions, although lighting conditions varied based on the time of day and the presence and quantity of clouds. There was no effective way to control for these factors in the given period of study. Table 1 lists the time, date, and location of the observations. Table 2 lists the counts of the presence of daytime running lights, either automatic or behavioral, at each of those locations.

Table 1: Observation Locations

Site	Date/Time	Location
1	11/14/2011 2:00pm	Waupelani Dr at Southgate Dr, State College, PA
2	11/15/2011 2:00pm	Blue Course Dr at Bayberry Ct, State College, PA
3	11/16/2011 12:00pm	Whitehall Rd at W College Ave, State College, PA
4	11/17/2011 11:00am	University Dr at Hastings Rd, University Park, PA
5	11/18/2011 2:00pm	Bigler Rd at Eisenhower Rd, University Park, PA
6	11/21/2011 11:00am	Collins Ferry Rd at Burroughs St, Morgantown, WV
7	11/22/2011 1:00pm	High St at Pleasant St, Morgantown, WV
8	11/23/2011 12:00pm	8th St at 13th Ave, Huntington, WV
9	11/24/2011 1:00pm	4th Ave at 10th St, Huntington, WV
10	11/25/2011 11:00am	Washington Blvd at 6th St, Huntington, WV

Table 2: Observations at Each Site

Site Number	1	2	3	4	5	6	7	8	9	10	Average
With DRLs	22	26	19	21	25	17	22	15	16	19	20.2%
Without DRLs	78	74	81	79	75	83	78	85	86	81	80%
Total	100	100	100	100	100	100	100	100	100	100	

Results

With such a small sample, performance of statistical analysis on the observed data would likely not yield meaningful results. This was simply an exercise to see what exists. Overall, it found that an average of 20-percent of vehicles on the road at these sites were either utilizing daytime running lights or the drivers were engaged in the habit of turning their lights on to drive. Considering this was an observational analysis without any control over the vehicles selected, it seems that DRLs, either as standard equipment or behavior, do have a reasonable level of acceptance in the areas observed.

The findings of the observational analysis indicate that further analysis of daytime running lights in the United States would be helpful. If approximately 20-percent of drivers are doing this, automakers and/or drivers think this is important.

Framework of Analysis

Empirical Bayes (EB) analysis is the state of practice and used in the Interactive Highway Safety Design Manual for analyzing issues when the expectation of safety (e.g. number, type, and severity of crashes) is unknown. Because expectation is unknown, EB is used to estimate. EB excels in yielding precise results where there may be limited year data and where there is concern for regression-to-the-mean bias (Hauer et al, 2002).

Essentially, EB is the uses two indicators to understand the safety of two like entities, the crash record of the entity in question and the expected frequency at a similar site, with a weighted average. (Hauer et al, 2002). The main indicator for determining the weighted average is the safety performance function (SPF). The SPF is typically calibrated through the use of a negative binomial model to analyze crashes and characteristics of the site (Hauer, 2003). As more work has been done in this field, it is possible to look up expected SPFs for certain sites rather than generate them independently. An excellent source of information on SPFs is the Highway Safety Manual. Though some feel the weight generated from the SPF is a methodological weakness, it is still the most reliable methodology for examining these types of problems. Calculation of the weight is done by (Hauer et al, 2002):

$$Weight = \frac{1}{1 + \frac{\mu \times Y}{\varphi}}$$

Where:

μ = crashes/km-year, on average, from the SPF

Y = number of years from which the crash count materialized

φ = the overdisperson parameter, from the SPF

To perform an EB analysis regarding daytime running lights it would be ideal to compare similar sites in Canada and the United States during the same time periods. Using data from the same time periods rather than differing time periods addresses the issue of regression to the mean, which describes the year-to-year random variation of crashes at a given site (Hauer, 2003). In simple terms, the EB equation looks like this:

$$Estimate\ of\ Effect\ of\ DRLs = SPF \times Crashes\ without\ DRLs + (1 - SPF) \times Crashes\ with\ DRLs\ where\ \leq SPF \leq 1$$

The full-Bayes procedure can analyze paired data dating back several years, but data more than a few years old may not reflect current driving conditions. The inclusion of extended years of data could significantly alter the outcome of the model and risk the generation of results relevant to present conditions. It is fundamental to remember that the goal is to establish whether or not daytime running lights would create a significant improvement looking forward, not to prove that daytime running lights are a significant improvement.

Though with this particular subject matter, analysis may show less and less of an effect as automakers and even individuals are opting in to using some form of daytime running lights. There is no clear way to adjust for the increase in use of daytime running lights when comparing with an area with required daytime running lights.

Discussion

Overall, daytime running lights are positively accepted in the literature and, whether they realize it or not, about 20-percent of drivers in the areas sampled are using some form of daytime running lights. There is also sound methodology available and accepted in the field to analyze the effect of the presence of daytime running lights. The evidence and the tools are all available to prove the value of daytime running lights in the United States.

Daytime running lights do not seem to have a significant effect on fatal crashes (NHTSA, 2008; Krajicek & Schears, 2010). It is worth noting that fatal crashes are the rarity. Other factors may be more significant in fatal crashes, thus hiding any role, if there is one, that daytime running lights may have. This could be considered with the z-score in a Poisson or negative-binomial regression. But non-fatal crashes incur great costs, including medical expenses, property damage, and the time of those delayed by the traffic disruption (Wang et al, 1999). Not finding a correlation with fatal crashes does not dismiss the validity of daytime running lights.

Unfortunately, it seems unrealistic for any groups to lead the charge in favor of daytime running lights other than governmental organizations or auto insurance companies. Insurance companies may wish to specifically consider daytime running lights when quoting car insurance rates. The insurance companies stand to be the greatest winners financially with any daytime running light-related legislation. Recall the estimated a cost-benefit ratio of 1.96 for daytime running lights (Elvik, et al, 2003). Crashes cost them more money than they do any other entity. It seems likely that daytime running lights enter the equation for insurance quotes on vehicles that come standard with them, but an added benefit for those who elect to install daytime running light systems on their car would likely offer a great incentive. Only a handful of crashes would have to be avoided for daytime running lights to be a huge payoff for an insurer.

It may be worth investigating the effect daytime running lights may or may not have had in terms of insurance payouts. If the number of crashes is reduced and insurance companies are saving money on payouts, it is very likely they have data to illustrate this. If this data can be located, it would be ideal in calculating the most accurate weight in the empirical Bayes model.

It is also worth noting that daytime running lights are a very inexpensive safety measure (Williams & Lancaster, 1995). The cost to outfit a 2004 Ford Focus sold in the United States to have it conform with Canadian standards cost about $15, using original equipment manufacturers parts at retail price. Cost to the manufacturer to include them as standard equipment would likely be substantially less. Indeed, manufacturers’ voluntarily equipping their vehicles with this safety device is an indicator that it is a reasonable measure to take.

A final note of discussion, driving without headlights on is also a component of American automotive folklore. Stories abound including a hypothetical drunk driver who forgets to turn their headlights on and then a car load of innocent people do not see the car and everyone dies in a fiery wreck. Out in the southwest United States, another folk story exists where the "coyotes" (human traffickers) drive through the desert with vehicle-loads of undocumented immigrants from Mexico without their lights on to avoid detection by the Border Patrol. Without their lights on they may run off the road or crash into another vehicle that could not see them.

No measurement has been to look into the frequency of these hypothetical cases, but they are legends that could largely be put to rest with daytime running lights. They could join the ranks of the young man just getting his driver's license in the 1950s, hitting a telephone pole at a high rate of speed, and being impaled on the steering column.

Conclusions and Future Work

The literature supports the implementation of legislation of requiring daytime running lights without exemption in the United States. Indeed, the literature indicates countries of higher latitude can find greater benefits from daytime running lights. Thus, states including Alaska, Maine, Michigan, and Minnesota may see greater effects than Arizona, Florida, and Hawaii. Furthermore, the observational analysis found that about 20-percent of drivers are using some form of daytime running lights in the areas where data was collected.

The next steps to research this issue is to gather geographic and time appropriate data and plug it into the empirical Bayes model described. While the literature largely supports daytime running lights and so does the observational data, the most effective way to understand how daytime running lights will benefit safety in a given area is to test it with the model. Use of the model over simple observational data will generate more robust results, protected from the natural, random changes in crashes from year to year, which is regression to the mean bias (Hauer, 2003).

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