The Prospects of Daytime Running Lights for Reducing Vehicle Crashes in the United States

ALLAN F. WILLIAMS, PhD
KIMBERLI A. LANCASTER

Both authors are with the Insurance Institute for Highway Safety, Arlington, VA. Dr. Williams is Senior Vice President, Research. Ms. Lancaster is a Writer in the Communications Department.

This work was supported by the Insurance Institute for Highway Safety. Charles M. Farmer of the Institute reviewed the statistical literature.

Tearsheet requests to Allan F. Williams, 1005 North Glebe Rd., Arlington, VA 22201; tel. 703-247-1500; FAX 703-247-1678.

Synopsis

Daytime running lights increase visual contrast between vehicles and their background, improving their noticeability and detectability. Seven countries require motor vehicles to have lights on during all daytime periods—Canada, Denmark, Finland, Hungary, Iceland, Norway, and Sweden. Studies from these and other countries have generally indicated that daytime running lights use is associated with small to moderate reductions in multiple-vehicle daytime crashes, especially those involving vehicles approaching from the front or side. There is evidence also that initial positive effects of daytime running lights do not dissipate over time, that is, there is little support for novelty or habituation effects. The bulk of the evidence suggests that running lights do not lead to increases in collisions involving pedestrians and pedalcyclists, allaying concerns that there would be negative consequences of making these road users relatively less conspicuous.

Most of the studies have been conducted in countries located at latitudes that are to the north of most of the continental United States and that have longer twilight periods and generally lower ambient illumination. The concern has been expressed that running lights may lose their effectiveness in countries located at lower latitudes, such as the United States, because the lights will provide less of a contrast. General Motors Corporation and some other manufacturers are now providing running lights on new models with higher intensities than are used in Scandinavian countries. Findings in running lights studies suggest that their effect in the United States will be positive, and their introduction provides an opportunity to determine the effect. The costs of running lights are low, so even modest crash reductions would be cost effective.

DAYTIME RUNNING LIGHTS (DRLs) are a low-cost measure intended to reduce multiple-vehicle crashes during daylight hours by increasing vehicle conspicuity and detectability. Various configurations of DRLs have been used. Typically, DRLs are high-beam headlights at reduced intensity, or low-beam headlights at full or reduced power. Tail lamps or turn signals also may be lit, and in some vehicles, turn signals alone function as DRLs, especially when the headlamps are retractable. Only front turn signals can function as DRLs, and they must burn steadily until signaling a turn. When front turn signals are used in combination with DRLs, they may be optically combined with the DRLs and used at the same operational intensity.

DRLs, at sufficient levels of intensity, increase visual contrast between vehicles and their background. Various studies have shown that DRLs can improve the noticeability and detectability of vehicles in the central and peripheral fields of view (*1–7*). They increase the distance at which vehicles are detected, and drivers allow greater margins of safety in overtaking and turning interactions with DRL-equipped vehicles. Driver inattention, misdirected attention, or perceptual or judgment errors are common factors in multiple-vehicle collisions. The crash reduction potential of DRLs is a function of their ability to attract attention, especially in the peripheral visual field, and to enhance detectability.

Experience in Other Countries

Several countries require that vehicles have lights on during daytime periods of rain or low visibility, and some countries require that motorcycles have lights on during all daytime periods. Only seven countries, however, require passenger vehicles to have lights on during all daytime periods. In 1972, Finland mandated daytime lights in winter on rural roads and, a decade later, made them mandatory year-round. Laws requiring daytime light use at all locations at all times of the day went into effect in Sweden in 1977 and in Denmark in 1990. Vehicles do not have to be equipped with DRLs that operate automatically (activated by the ignition) in any of these countries, but motorists are required to turn on their headlights if they are not automatic. Norway instituted a law in 1985 that required new cars to have automatic running lights, although older cars did not have to have lights on in the daytime until 1988, when use of daytime lights was required for all vehicles. Iceland has required drivers of all motor vehicles to use DRLs since 1988. In Canada, vehicles manufactured after December 1, 1989, are required to have automatic DRLs. DRLs use has been required on rural roads in Hungary since March 1993.

Do DRLs Reduce Crashes?

Nearly all published reports indicate that DRLs reduce the types of crashes they would be expected to affect, that is, daytime multiple-vehicle crashes. DRLs would not be expected to have any effect on nighttime crashes or single-vehicle daytime crashes, allowing these crash types to be used as controls in attempts to isolate the effects of DRLs. However, nearly all the studies also have design or analysis weaknesses, or small sample sizes, so that the magnitude of the effect is difficult to estimate. In addition, most of the studies have been conducted in northern countries, and the applicability of the results to lower latitudes with higher daytime brightness levels, such as in the United States, is uncertain.

Evidence concerning DRL effects on crashes comes from two sets of studies—earlier studies (through 1986) in Scandinavia, where DRL use was increasing because of recommendations and laws, plus fleet studies in the United States, and later studies (1991–94) primarily from Scandinavia and Canada. These studies will be reviewed and summarized, and the past, present, and future of the United States experience with DRLs will be discussed and assessed.

Early Studies

A study in Finland conducted between 1968 and 1974 found that DRLs, when required on rural roads in the winter, were associated with a 21-percent reduction in daytime multiparty crash events (involving more than one motor vehicle or motor vehicles colliding with pedestrians or pedalcyclists) (*8*). In Sweden, a study based on 2 years of pre-law and 2 years of post-law data reported an 11-percent reduction in multiparty daytime crashes subsequent to the DRL law (*9*). A study in Norway [published in Norwegian and reviewed by Koornstra (*10*)] found a 14-percent drop in multiparty crashes prior to the law, during the 1980-85 period when voluntary DRL use was climbing (*11*). These reported reductions occurred as the number of DRLs on vehicles increased from about 50 percent to about 97 percent in Finland, 55 percent to 98 percent in Sweden, and 35 percent to 65 percent in Norway. Since DRLs were present in many cases in the "before" periods, the percentage reductions in crashes would be expected to be substantially greater if the proportion of vehicles equipped with DRLs went from 0 to 100 percent.

In the United States, a small-scale fleet study conducted in the 1960s found an 18-percent lower daytime, multiple-vehicle crash rate for DRL-equipped vehicles (*12*). In a much larger fleet study conducted in the 1980s, more than 2,000 passenger vehicles in three fleets were equipped with DRLs (*13*). One fleet operated in Connecticut, another in several States in the Southwest, and the third operated throughout the United States. A 7-percent reduction was found in daytime multiple-vehicle crashes in the DRL-equipped vehicles compared with control vehicles.

The early Scandinavian and United States studies have been subjected to considerable criticism with regard to their evidence of DRL effectiveness. For example, the 11-percent effect in the Swedish study (*9*) and the 7-percent effect in the Stein study (*13*) were not statistically significant. In addition, in the study by Stein, it was not always possible to ensure that the exposure of DRL-equipped and comparison vehicles was similar. Theeuwes and Reimersma (*14*) have criticized the analysis methods used in the Swedish study. Despite problems with these early studies, however, when they are taken together, they support a conclusion that DRLs can reduce crashes.

Later Studies

The later studies add important knowledge about the effects of DRLs on crashes. A study in Norway, covering the period 1980 to 1990, examined the effect of the country's DRL law, which applied to new cars in 1985 and to all cars beginning in 1988 (*15*). DRL use was estimated to be about 30–35 percent in 1980–81, 60–65 percent in 1984–85, and 90–95 percent in 1989–90, so, as in the earlier Scandinavian studies, only partial implementation of DRLs was assessed. There was a statistically significant 10-percent decline in daytime multiple-vehicle crashes associated with DRLs in this study, excluding rear-end collisions, which increased by 20 percent. For all daytime crashes involving multiple parties, there was a statistically significant 15-percent reduction associated with DRLs in the summer but not in the winter. No significant effects of DRLs were found for collisions involving pedestrians or motorcyclists.

Two studies evaluating Denmark's 1990 DRL law have been completed, one that assessed short-term effects, the other looking at longer term effects (*16,17*). Results of these two studies were quite consistent. There was a small reduction in daytime multiple-vehicle crashes (7 percent) in the first year and 3 months the law was in effect, with one type of DRL-relevant crash (left turn in front of oncoming vehicle) reduced by 37 percent. In the second study, which covered 2 years and 9 months of the law, there was a 6-percent reduction in daytime multiple-vehicle crashes, and a 34-percent reduction in left-turn crashes. There was a small reduction in motor vehicle-pedalcyclist collisions (4 percent) but a statistically significant increase (16 percent) in motor vehicle-pedestrian collisions.

In a study in Canada comparing 1990 model year vehicles (required to have DRLs) with 1989 vehicles, a statistically significant 11-percent reduction in daytime multiple-vehicle crashes other than rear-end impacts was estimated (*18*). This estimate was adjusted to take into account the fact that about 29 percent of 1989 vehicles were fitted with DRLs. Collisions involving pedestrians, pedalcyclists, motorcyclists, and heavy trucks and buses were not included in this study.

In another Canadian study, crashes of vehicles with and without DRLs in a government fleet in Saskatchewan were compared with a random sample of crashes involving vehicles without DRLs (*19*). The estimated reduction in daytime two-vehicle crashes was 15 percent. When the analysis was limited to two-vehicle collisions most likely to be affected by DRLs—involving vehicles approaching from the front or side—the estimated reduction was 28 percent.

The only study to report negative effects of DRLs was conducted in Israel, where a 3-month campaign was undertaken to encourage use of DRLs in conditions of reduced visibility (*20*). Sizeable increases were observed in all daytime crash categories (all crashes, rainy weather crashes, head-on and right-angle crashes, and collisions with pedestrians). These results were based on night-day crash ratios and are thus sensitive to any shifts in travel from nighttime to daytime that may have occurred in the 3-month study period compared with previous periods. The negative results are inexplicable, particularly the 19-percent increase in all daytime crashes and the 23-percent increase in head-on and right-angle crashes. These large increases were noted despite the fact that during the campaign very few motorists used DRLs in clear and cloudy periods, when most of the crashes (about 85 percent) occurred. For example, the estimated before and after increase in DRL use was from about 1 percent to 5 percent in clear weather, and from about 4 percent to about 8 percent in cloudy weather.

'The crash reduction potential of DRLs is a function of their ability to attract attention, especially in the peripheral visual field, and to enhance detectability.'

In summary, although the studies of DRLs have differed in design, analysis techniques, and outcome measures, the later studies are largely in accordance with the earlier ones, indicating that the overall effect of DRLs on motor vehicle crashes is positive. This has been the conclusion reached by every reviewer of the literature (*10,21,23*), including the International Steering Committee on Daytime Running Lights (*24*), with the exception of Theeuwes and Riemersma (*14*), who concluded, " . . . the available evidence in terms of accident rates seems equivocal . . . " It should be noted that in several of the later studies the effects have been less than expected (*15,17,18*). For example, Hansen (*17*) reported that the net crash reduction effect of DRLs amounted to only about half of what was anticipated in the Danish Road Safety Action Plan. In the Canadian study comparing 1989 and 1990 vehicles, the estimated effect (11 percent) was close to the bottom of the range of anticipated effects (10–20 percent) (*25*).

Duration of DRL Effects

The early and later DRL studies have shed light on concerns about the duration of DRL effects and the possibility of negative effects of DRLs on some road users. It has been suggested that when DRLs are first introduced into some part of the vehicle population, positive crash reduction effects will be found only because DRLs are new and unique and the vehicles that have them stand out from those that do not. Once people get used to seeing vehicles with DRLs, it is conjectured, their effects will diminish, and, if all vehicles have them, their noticeability will be reduced or drivers will come to ignore the extra information.

All three of the early Scandinavian studies examined the effects of DRLs over a period of several years when DRL use was increasing, and DRL effects were estimated in Sweden and Finland when DRL use was nearly 100 percent. Thus to the extent that novelty or habitation effects occur, the effects of DRLs in the early Scandinavian studies were still positive over time and with close to 100 percent use. In the study in Sweden (*9*), the reduction in crashes was somewhat lower in the second year of the law, but this is more likely due to variation in the effect measure (which also existed prior to the law) than to a novelty effect.

The later studies also suggest that the initial positive effects of DRLs do not dissipate over time. The reductions in multiple-vehicle crashes found in the Denmark studies, based on experience during the first 15 months of the law (*16*) and then extended to include the first 33 months (*17*), were very similar. This similarity led the author to conclude that the effect was a permanent one and not due to the novelty of DRLs. In the study in Norway (*15*), the reduction in daytime multiple-vehicle crashes was maintained during the 3 years in which DRLs were required for all vehicles and use was close to 100 percent. The reduction was greater in the second year of the law covering all vehicles than it was during the first year. In the fleet study in Canada (*19*), the initial positive effect disappeared about 18 months after the installation of DRLs, but it reappeared the following year. As was the case in the Swedish study, the odds of a DRL-relevant crash for the DRL and non-DRL groups in the Canadian study showed considerable year-to-year fluctuation in the years prior to installation of DRLs, so the interpretation of yearly fluctuations post-DRLs is not straightforward.

Possible Negative Effects of DRLs

Concern has been expressed that the relative conspicuity of pedalcyclists and pedestrians could decrease with DRL use and have potential negative effects. However, all three of the early Scandinavian studies found substantial decreases in motor vehicle collisions with pedalcyclists and pedestrians that were greater than the decreases in multiple-vehicle collisions. This led the International Commission on Illumination to conclude, "Those road users that probably benefit most from DRL are pedestrians and cyclists" (*26*).

The later studies provide limited and mixed evidence in regard to DRL effects on pedestrians and pedalcyclists. Neither Canadian study included analyses of these road users. In the Norway study, a small, not statistically significant increase in daytime pedestrian collisions was found; pedalcyclists were not studied. In the initial Denmark study, no effects were found for pedestrians or pedalcycles. In the longer term study, daytime pedestrian collisions increased, whereas there was a "moderate positive impact" on crashes involving pedalcyclists, which the author finds inexplicable on the assumption that the effect should be similar for these two groups.

Based on all the evidence from the early and later studies, the concern that DRLs would make unprotected road users less conspicuous does not appear to translate to a crash problem. More evidence is needed, however, to clarify the effects of DRLs on pedestrians and pedalcyclists. It has been argued that DRLs should lead to reductions in collisions involving these road users, because it is especially important for pedestrians and pedalcyclists to be able to detect vehicles in their peripheral visual field, and DRLs make it easier for them to do so. On the other hand, concern about the conspicuity of pedestrians and pedalcyclists to motorists was a main reason that The Netherlands has dropped any plans to enact a DRL law or to study the effects of DRL in advance of considering legislation.

It is also possible that in countries where DRLs for motorcycles were required prior to mandating DRLs in passenger vehicles, motorcyclists might lose their conspicuity advantage, with detrimental results. It has also been argued, however, that the conspicuity of motorcycles will not be reduced if all vehicles have DRLs and that the risk of motorcycle collisions may be reduced by making it easier for motorcyclists to see other vehicles (*23*). The effect of DRLs on motorcycle crashes has been studied in Denmark and Norway, where daytime lights were required for motorcyclists prior to the DRL law for passenger vehicles. In the study in Norway, a 4-percent increase, not statistically significant, was found for motorcyclist crashes (*15*). In Hansen's evaluation of Denmark's law, daytime multiple-vehicle crashes involving motorcycles were unchanged, but nighttime and single-vehicle daytime motorcycle crashes decreased over this period, leading Hansen to conclude that there might be a "minor negative impact" of DRLs on motorcycle crashes (*17*).

The possibility has also been raised that rear-end crashes could increase in cases where rear-position DRLs are used, in that brake lights would be masked. This has been judged in laboratory studies not to be an issue (*27,28*), and stop lamps, mounted in the high center of the rear of the car which all 1986 and later model year vehicles in the United States have, should eliminate any masking problem. However, an increase in rear-end crashes was reported by Elvik (*15*) and has been found in some studies (*8*) but not in others (*17*). This is an issue that can be addressed in future studies of DRLs involving rear lights. Certainly, the literature is clear that the major effect of DRLs is likely to be found in two-vehicle collisions involving vehicles approaching from the front, or, especially from the side, which are the types of crashes in which the increased conspicuity and detectability provided by DRLs is most relevant.

Masking of vehicles without DRLs has also been voiced as a concern. This may occur, particularly at twilight periods. The effect on crashes involving unlit vehicles is unknown, but the various Scandinavian studies that investigated DRL effects as DRL use increased from low to very high levels have indicated that the overall effect as measured in the entire vehicle population is a reduction in crashes.

It has also been suggested that drivers may increase their risk-taking, driving at higher speeds, for example, in response to perceived safety benefits of their car and other cars having DRLs (*15,29*). Behavioral adaptation of this sort has been noted in vehicles with performance-changing features such as improved brakes that drivers can feel the benefits of (*30,31*). There is no such direct feedback with DRLs, although drivers know that they have DRLs and that other vehicles have them. The perceptual effect of DRLs is that oncoming cars with DRLs appear to be closer than cars without them (*2*). No empirical evidence exists concerning effects of DRLs on driver behavior, and if such occurs, the safety benefits of DRLs remain.

DRLs in the United States

Although DRL studies indicate crash reduction effects in northern countries, the question concerning their effects in lower latitudes is not yet answered. The positive effects found in the Canadian evaluation of DRLs are important, because most of Canada's population is at a lower latitude than Scandinavia. Closer to the poles, twilight lasts longer, as do periods with low sun and generally low ambient illumination. The concern has been expressed that DRLs may lose their effectiveness at lower latitudes like those in the United States, because in brighter conditions DRLs will provide less of a contrast between vehicles and their background.

'Multiparty crashes occurring in daylight periods account for about half of all police-reported crashes in the United States. If DRLs are 5–10 percent effective in reducing crashes, that would have translated to a reduction of 157,725 to 315,445 crashes in 1993.'

The idea of driving with headlights on during the day apparently originated in the United States in the late 1950s or early 1960s (*32*), but no State currently requires DRLs on all motor vehicles during all daytime hours. There are times and places, however, where DRL use is required or requested for some or all motor vehicles. There are a few States that require motorists to turn on their headlamps when it is raining or when there is poor visibility during the day, and many States require lights one half-hour after sunset. Twenty-two States require motorcyclists to ride with their headlights on during all hours, and all manufacturers equip their cycles with DRLs activated by the ignition switch, although they are not required by Federal law to do so. There have been scattered campaigns to get drivers to turn on lights during such times as holiday weekends. Headlight use during the day is requested on some roads, such as sections of the Mid-Cape Highway in Massachusetts and certain stretches of road in California and Washington.

One impediment to DRLs in the United States has been some State lighting laws that inadvertently prohibited DRLs until the National Highway Traffic Safety Administration (NHTSA) agreed in 1993 to permit automakers to offer them on vehicles sold in all 50 States. This action, which preempted State laws, followed a petition by General Motors Corporation. The Insurance Institute for Highway Safety had filed a similar petition in 1985.

After initially granting this petition and contemplating a major fleet study to decide the issue of DRL effectiveness in the United States, NHTSA terminated rulemaking in 1988, saying that auto manufacturers "tended to oppose, rather than support, the proposal," and that it had not been demonstrated sufficiently that DRLs would be a cost-effective crash reduction measure in the United States. The basis for this argument was that the Scandinavian experience with DRLs was not necessarily applicable to the United States. The petition denial also stated that NHTSA would carefully monitor the Canadian experience with DRLs.

General Motors is equipping approximately half a million 1995 models and all 1997 models with standard DRLs. These DRLs are primarily high-beam headlights with reduced power. Some use reduced power low-beams or marker lamps for vehicles with hidden headlights. Volvo and Saab are making the lights standard beginning with 1995 models. Volvo DRLs are full-power low beams, taillights, and turn signal lights. The front turn signal lights (which also function as parking lights on Volvo cars) burn steadily when the DRLs are on, but when the driver signals a turn, the lights flash. Saab will use low beam headlights and taillights. Volkswagen is equipping its 1995 Golf III, Jetta III, and GTI cars with DRL systems using reduced-intensity low beams and taillights.

The introduction of DRLs on vehicles in the United States will provide an opportunity to evaluate their effect on all types of daytime crashes—those involving multiple vehicles, pedestrians, pedalcyclists, and motorcycles. There also will be an opportunity to see if the effect is different in northern and southern regions of the United States.

Although the extent to which DRLs will affect crashes in the United States is an open question, there are reasons to think—both on empirical and theoretical grounds—that the effect will be positive. The Canadian studies are encouraging in this regard, as are the early U.S. fleet studies, which though limited, are suggestive of positive effects of DRLs in this country. In addition, State laws requiring the use of motorcycle headlights in the United States have been found to reduce fatal motorcycle crashes by about 13 percent (*33*).

Although results of DRL studies conducted in oher northern locations cannot be directly generalized to the United States, findings from these studies suggest there will be positive effects on crashes in countries with brighter skies. A study by Environment Canada indicated that although Sweden has less daytime brightness than Canada, 40 percent of total daylight hours in Sweden were considered bright or very bright versus 54 percent in Canada (*34*), and in the Andersson and Nilsson study (*9*), the crash reduction effect in Sweden was about the same in high- and low-ambient conditions. In the Saskatchewan study, DRLs were estimated to reduce crashes more during twilight than during daylight periods, but the reductions during full daylight were also substantial, leading the authors to conclude that vehicles equipped with DRLs in the United States would be expected to reduce multiple-vehicle crashes by only marginally less than 15 percent (*19*).

Finally, it has been demonstrated in a test track study that although low intensity DRLs do not improve vehicle detection in high ambient conditions, DRL intensities of 1,600 candela do improve detection over a range of ambient light levels characteristic of the United States (in California sunshine, for example) (*6,7*). NHTSA allows light intensities of up to 3,000 candela. The candela of General Motors DRLs varies by model, but all operate at 2,250–2,760 candela. These light intensities are considerably higher than those used in Scandinavian countries (generally 300–1,200 candela) but are not expected to cause glare problems (*35*). Thus, although daytime light is brighter in the United States, the higher candela will aid in producing visual contrast between vehicles and their backgrounds, which is the basis for the DRL effect.

DRL costs are low, so even very modest crash reduction capabilities would be cost effective. For example, according to General Motors, there is a minimal wiring cost in converting to DRLs, and a fraction of a mile fuel penalty (about $3 per year for the average driver). DRLs as currently provided in the United States work automatically, not relying on motorists to turn their lights on during the daytime, so if required, the measure is guaranteed to be applied.

Multiparty crashes occurring in daylight periods account for about half of all police-reported crashes in the United States. If DRLs are 5–10 percent effective in reducing crashes, that would have translated to a reduction of 157,725 to 315,445 crashes in 1993 (*36*). If DRLs are found to be effective in the United States, there will be renewed efforts to have them required, although—as in the case of air bags—many automakers would likely offer them for competitive reasons in an era of consumer concern for safety features, in advance of any requirement to do so.

References

1. Allen, J. M., Strickland, J., Ward, B., and Siegel, A.: Daytime headlights and position on the highway. Am J Optometry 46: 33–36 (1969).

2. Attwood, D. A.: Daytime running lights project, IV: Two-lane passing performance as a function of headlight intensity and ambient illumination. Technical Report RSU 76/1. Defense and Civil Institute of Environmental Medicine, Downsview, Ontario, Canada, 1976.

3. Attwood, D. A.: Daytime running lights project, II: Vehicle detection as a function of headlight use and ambient illumination. Technical Report RSU 75/2. Defense and Civil

Institute of Environmental Medicine, Downsview, Ontario, Canada, 1975.
4. Horberg, U.: Running light—twilight conspicuity and distance judgement. Report 215. Department of Psychology, University of Uppsala, Sweden, 1977.
5. Horberg, U., and Rumar, K.: Running lights—conspicuity and glare. Report 178. Department of Psychology, University of Uppsala, Sweden, 1975.
6. Kirkpatrick, M., Baker, C. C., and Heasly, C. C.: A study of daytime running lights design factors. (DOT HS 807 193). National Highway Traffic Safety Administration, Washington, DC, 1987.
7. Ziedman, K., Burger, W., and Smith R.: Evaluation of the conspicuity of daytime running lights. (DOT HS 807 609). National Highway Traffic Safety Administration, Washington, DC, 1990.
8. Andersson, K., Nilsson, G., and Salusjarvi, M.: The effect of recommended and compulsory use of vehicle lights on road accidents in Finland. Report 102A. National Road and Traffic Research Institute, Linkoping, Sweden, 1976.
9. Andersson, K., and Nilsson, G.: The effects on accidents of compulsory use of running lights during daylight hours in Sweden. Report 208A. National Road and Traffic Research Institute, Linkoping, Sweden, 1981.
10. Koornstra, M. J.: Road safety and daytime running lights: a concise overview of the evidence. Presented at Joint Meeting of the ECMT's Road Safety Committee and Committee for Road Traffic, Signs, and Signals. The Hague, The Netherlands, 1989.
11. Vaaje, T.: Kjorelys om dagen reducerer ulykkestallene. Arbetsdokument 15.8.1986. Transportokonomisk institutt, Postboks 6110 Etterstad, N-0602 Oslo 6, Norway, 1986.
12. Cantilli, E. J.: Accident experience with parking lights as running lights. Highway Research Record Report No. 32. National Research Council, Transportation Research Board, Washington, DC, 1970.
13. Stein, H. S.: Fleet experience with daytime running lights in the United States. Technical Paper 851239. Society of Automotive Engineers, Warrendale, PA, 1985.
14. Theeuwes, J., and Riemersma, J. B. J.: Daytime running lights: a review of theoretical issues and evaluation studies. TNO Institute for Perception, Soesterberg, The Netherlands, 1990.
15. Elvik, R.: The effects on accidents of compulsory use of daytime running lights for cars in Norway. Accid Anal Prev 25: 383-398 (1993).
16. Hansen, L. K.: Daytime running lights in Denmark—Evaluation of the safety effect. Danish Council of Road Safety Research, Copenhagen, 1993.
17. Hansen, L. K.: Daytime running lights: Experience with compulsory use in Denmark. Fersi Conference, Lille, 1994.
18. Aurora, H., et al.: Effectiveness of daytime running lights in Canada. TP 12298 (E). Transport Canada, Ottawa, 1994.
19. Sparks, G. A., et al.: The effects of daytime running lights on crashes between two vehicles in Saskatchewan: a study of a government fleet. Accid Anal Prev 25: 619–625 (1991).
20. Hocherman, I., and Hakkert, A. S.: The use of daytime running lights during the winter months in Israel—Evaluation of a campaign. Transportation Research Institute, Technion-Israel Institute of Technology, Technion City, Haifa, Israel, 1991.
21. Helmers, G.: Daytime running lights—a potent traffic safety measure? VTI rapport, Vag-och Trafik Institutet, Swedish Road and Traffic Research Institute, Linkoping, Sweden, 1988.
22. Streff, F. M.: The effectiveness of daytime running lights to reduce crashes and crash injuries. University of Michigan Transportation Research Institute, Ann Arbor, 1991.
23. Transport Canada: Information on daytime running lights. Road Safety and Motor Vehicle Regulation Directorate, Ottawa, Canada, 1994.
24. SWOV Institute for Road Safety Research: Motor-vehicle lighting during daytime; a report of the international steering committee on the justification of new experiments in European countries. Review and evaluation of existing evidence on the effectiveness of motor-vehicle lighting during daytime. Leidschendam, The Netherlands, 1991.
25. Lawson, J.: Analysis of a proposed regulation requiring daytime running lights for motor vehicles. TP 7873. Transport Canada, Ottawa, 1986.
26. Automobile Daytime Running Lights (DRL). (CIE-104). International Commission on Illumination, Vienna, Austria, 1993.
27. Farber, B., et al.: Brake lights-daylight detectability with and without lighted tail-lights. Department of Psychology, University of Uppsala, Sweden, 1976.
28. Attwood, D. A.: The potential of daytime running lights as a vehicle collision countermeasure. Technical Paper Series 810190. Society of Automotive Engineers , Warrendale, PA, 1981.
29. Perel, M.: Evaluation of the conspicuity of daytime running lights. National Highway Traffic Safety Administration, Washington, DC, 1991.
30. Lund, A. K., and O'Neill, B.: Perceived risks and driving behavior. Accid Anal Prev 18: 367–370 (1986).
31. Williams, A. F., and Wells, J. K.: The experience of drivers with antilock brake systems. Accid Anal Prev 26: 807–811 (1994).
32. Allen, A. M., and Clark, J. R.: Automobile running lights—a research report. Am J Optometry and Arch Am Acad Optometry 41: 293–315 (1964).
33. Zador, P. L.: Motorcycle headlight-use laws and fatal motorcycle crashes in the U.S., 1975-83. Am J Public Health 75: 43–46 (1985).
34. Environment Canada, Canadian Climate Centre: Daylight intensity for representative Canadian and Swedish locations. Contract report for Road Safety Directorate, Transport Canada, Ottawa, 1986.
35. Federal motor vehicle safety standards: lamps, reflective devices, and associated equipment. Final Rule. Federal Register 58: 3500–3507, Jan. 11, 1993.
36. Traffic safety facts: a compilation of motor vehicle crash data from the Fatal Accident Reporting System and the General Estimates System. National Highway Traffic Safety Administration, Washington, DC, 1994.