ROAD LIGHTING AS AN ACCIDENT COUNTERMEASURE

Per Ole Wanvik

Norwegian Public Roads Administration, Arendal, Norway

This paper presents the results of a new PhD study on the relationship between road lighting and road accidents. The PhD thesis is based on four different studies conducted by the author. Conclusions are made about the safety effect of road lighting, and the future role of road lighting is discussed. 50 % of the work is published in road safety journals and 50 % is unpublished. The thesis will be defended in Trondheim 5th of Mai, but apart from this the work as a whole will be presented for the first time at the CIE conference.

Four studies and Methods used

The first study is a literature review. The study is the basis for the other studies and identifies gaps in knowledge.

The second study is a before-and-after study in Norway. The intention of this study was to test the validity of earlier study results on today's traffic and to consider more adequately potential confounding factors than most previous studies did. The study includes 1185 injury accidents on 125 main road sections were road lighting was installed in the 1990s. The safety effect of road lighting is estimated in terms of an odds ratio, where the odds of having an accident during darkness after the installation of road lighting is divided by the odds of having an accident during darkness before the installation of road lighting. The result is controlled for the effect of long-term trends in accidents and for the effect of "Regression to the mean".

The third study estimates the safety effect of road lighting on accidents in darkness on Dutch roads, using data from an interactive database containing 763,000 injury accidents in the period 1987 – 2006. Two estimators of effect are used, and the results are combined by applying techniques of meta-analysis. The first estimator is an odds ratio, where the odds of having an accident during darkness on a lit road is divided by the odds of having an accident during darkness on an unlit road. The second estimator is a ratio of odds ratios. This will be illustrated by an example. The method used in this study control for some of the confounding factors that are usually associated with darkness, such as fatigue, alcohol and speeding.

The fourth study is a detailed cross-section study of the effect of road lighting on motorway accidents mainly in the Netherlands. The main source is the same database as was used in the third study, containing 23,600 injury accidents and 153,100 property damage accidents on Dutch motorways in the period 1987 – 2006. Additional data from motorway accidents in Sweden and Great Britain are used for comparison.

Results

Earlier studies show that the mean effect of road lighting is 28 % reduction in injury accidents, 60 % reduction in fatal accidents, 45 % reduction in injury accidents involving pedestrians, 35 % reduction in injury accidents at rural junctions and 50 % reduction in injury accidents on motorways. However, most of the studies are more than 20 years old and insufficiently controlled for regression to the mean and other possibly confounding factors. Their validity is therefore questioned.

The before-and-after study in Norway shows that the number of injury accidents during darkness is reduced by 27 %. Road lighting is found to be more effective for older drivers than for younger drivers and more effective in fine weather than during precipitation. The

effect is larger for high speed roads than for low speed roads, while the effect is smaller on roads with high traffic volumes than on roads with low traffic volumes. However, the results in this study are statistically uncertain due to small accidents counts.

The study of Dutch accidents gives statistically valid results and efforts have been done to control for confounding factors. The results show that injury accidents during darkness are reduced by 50 % due to road lighting. The effect during twilight is 2/3 of the effect during darkness. The effect of road lighting is significantly smaller during adverse weather and road surface conditions than during fine conditions. The effects on pedestrian, bicycle and moped accidents are significantly smaller than the effects on automobile and motorcycle accidents. The risk of injury accidents is found to increase in darkness. The risk increase is 17 % in darkness on lit rural roads and 145 % in darkness on unlit rural roads. The risk increase due to darkness is higher during rainy conditions (50 % on lit roads and 190 % on unlit roads) and higher for pedestrian accidents (140 % on lit roads and 360 % on unlit roads).

The study of motorway accidents show that road lighting on Dutch motorways reduces the accident risk during darkness by 49 %. However, the effect of road lighting is found to be much smaller on Swedish and British motorways. The effect of road lighting on accidents in darkness is found to be smaller during precipitation and wet road surface than during fine weather, and no effect is found during fog. Collisions with light poles constitute 4 % of accidents on lit motorways in the Netherlands, and in Norway accident statistics show that "hit light pole" constitutes 10 % of motorway accidents. (All Norwegian motorways are lit).

Future road lighting

Road lighting is a most efficient road safety measure, especially on road sections with mixed traffic, but even on motorways. However, the need for energy savings demands more energy efficient solutions. Future road lighting must therefore be of the adaptive type, and two-way communication must be considered. More efficient light sources must be developed and adopted. The safety effect of alternative or supplementary measures like road markings, LED guide lights and light road surfaces must also be studied and safety or energy saving potentials must be utilized.

The effect of road lighting is smallest during adverse weather conditions when darkness accident risk is highest and visibility measures are most needed. It is therefore a challenge for researchers to improve the visual conditions during darkness in rain, snow and fog. The photometric property of wet road surfaces must be studied and proper combinations of road surfaces and road lighting design must found. Light from oncoming vehicles reflected from a wet road surfaces into the eye of the driver is a large problem that must be paid more attention. Scattered light through a wet windscreen is also a visibility problem during darkness, and it is a challenge to make the light conditions, as seen by the driver's eyes, optimal for carrying out critical driving tasks.

Today we do not know the relationship between lighting level and road safety. We do not know what lighting level that is needed for given situations, and we do not know the consequences on road safety of reducing or increasing the lighting level. It is essential that we find out more about this to be able to maximize the benefit/cost of road lighting (including environmental costs).

Future road lighting can be a very useful measure in the battle against road traffic injuries, the second-leading cause of death among young people worldwide. However, the potential must be utilized for making road lighting more energy efficient and cost efficient.