Summary Report

HSIS

Highway Safety Information System

The Highway Safety Information System (HSIS) is a multi-State safety data base that contains crash, roadway inventory, and traffic volume data for a select group of States. The participating States—Illinois, Maine, Michigan, Minnesota, and Utah—were selected based on the quality of their data, the range of data available, and their ability to merge data from the various files. The HSIS is used by FHWA staff, contractors, university researchers ,and others to study current highway safety issues, direct research efforts, and evaluate the effectiveness of crash countermeasures.

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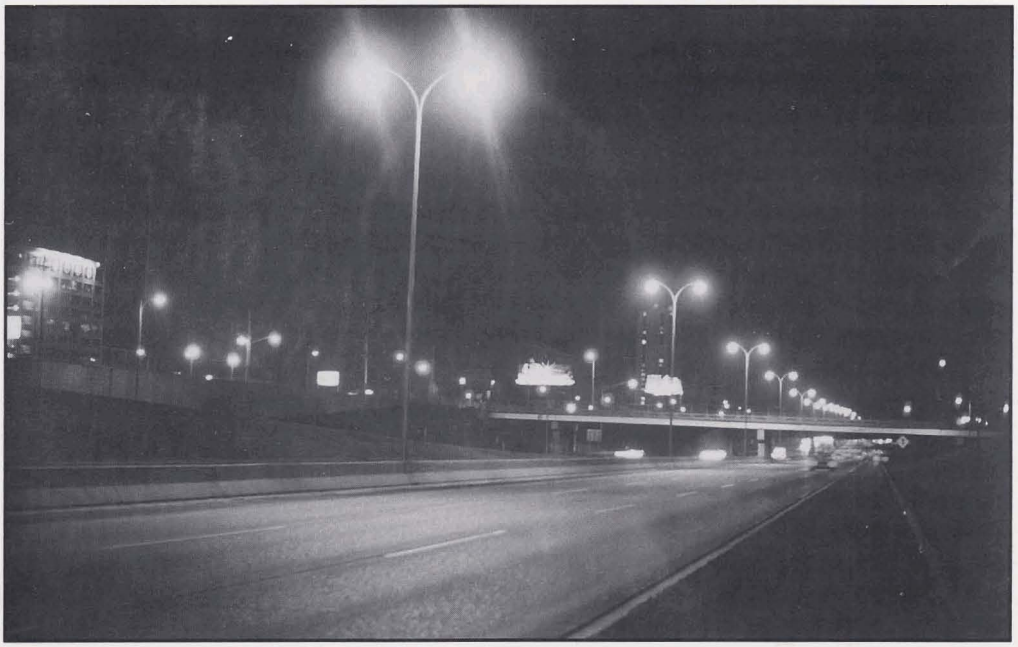
Comparison of the Safety of Lighting Options on Urban Freeways



Nationwide accident statistics show that more than 50 percent of fatal accidents occur during the hours of darkness. Because only 25 percent of travel occurs during the same period, the fatality rate is about three times higher at night than during the day. The installation of overhead lighting is a potential countermeasure to this nighttime accident problem. However, this is expensive, and much of the research to date offers inconclusive results about its effect on highway safety.

Many previous studies have evaluated the relationship of urban freeway lighting and highway safety. However, the majority of these studies were conducted in the 1960's and early 1970's, and the results from these studies may be outdated. On our Nation's highways, there have been many changes in traffic flow, vehicle fleet, and road-user demography in the past 20 to 30 years. Clearly, the volume of traffic on urban freeways is significantly higher today, and congestion is a greater problem.

This study compared the safety of continuously lighted urban freeways and urban freeways with interchange lighting only. A freeway section with continuous lighting has overhead lighting at the interchanges and between the interchanges, as opposed to overhead lighting at the interchanges only.

State Data Bases Used

Minnesota was the only HSIS State with a sufficient number of urban freeway sections with roadway lighting that had complete accident, roadway, and lighting information to permit a safety analysis of roadway lighting on urban freeways. In addition, at the time of the study, Minnesota was the only HSIS State with a videodisc photolog system. The Minnesota videodisc photolog system is a key tool in the HSIS laboratory, which allows users to have automatic computer access to all video images of the State-maintained roadway network. This system is used to collect supplementary data for studies and to verify existing data.

Currently, the HSIS laboratory has videodisc photolog systems for Minnesota and Michigan.

Analysis Methods

A cross-section approach was used in this research study to assess the safety effects of urban freeway lighting. The cross-section approach compares the safety of sites that are different. Two groups of sites were compared in this study: urban freeway sections with continuous lighting and urban freeway sections with interchange lighting only. The urban freeways evaluated in this study are located in the Minneapolis-St. Paul metropolitan area.

A review of the Minnesota HSIS data files revealed that most of the desired accident and roadway variables needed to conduct this study were present. However, the files did not have the lighting information or 24-h traffic distributions needed to develop day versus night accident rates. The Minnesota Department of Transportation (MnDOT) was able to provide needed supplementary information to support HSIS data. MnDOT provided lighting information (identification of urban freeway sections with roadway lighting, type of lighting, etc.) and automatic traffic recorder reports that provided summaries of 24-h traffic distributions. Sunrise and sunset information was acquired from the United States Naval Observatory to classify accident and traffic volume data by day and night.

A total of 87.9 km of urban freeway segments with continuous lighting and 57.1 km of urban freeway segments with interchange lighting only was used in the study. There is one major roadway difference between the urban freeway sections with continuous lighting and those with interchange lighting only. This difference pertains to the number of inter-changes per mile. The average spacing between interchanges is 1.3 km on the continuously lighted sections and 1.9 km on the sections with interchange lighting only. All of the interchanges are of the diamond type, except three that are cloverleafs.

Results

Day and night accident rates were calculated for the study sections. Accident data from 1985 through 1990 were used. Table 1 shows the total day accident rates, total night accident rates, and the total night/day accident-rate ratios. The total day accident rate is 3 times higher for the continuously lighted sections than the total day accident rate for the interchange lighting only sections. This contrast in the total day accident rate signifies differences exist between the subject sections. Comparisons between the subject sections can not be made without accounting for these differences. Night/day accident-rate ratios were calculated to adjust for roadway, traffic, driver, and/or other differences between the freeway sections with continuous lighting and those with interchange lighting only. The night/day accident rate ratio is computed by dividing the night accident rate by the day accident rate. This ratio gives an indication of the relative magnitude of the night accident problem to the day accident problem.

Table 1. Accident rates.

	Continuous Lighting	Interchange Lighting	Difference
Total Day Accident Rate	1.50	0.48	
Total Night Accident Rate	1.95	0.70	
Total Night/Day Accident-Rate Ratio	1.30	1.46	+12%*

* Indicates that the **ratios** are statistically different.

Accident rate is per 1 million vehicle-miles traveled.

The total night/day accident-rate ratio for the sections with interchange lighting only is 12 percent higher than the total night/day accident-rate ratio for sections with continuous lighting (a larger night/day accident-rate ratio indicates a relatively more hazardous night condition).

Figure 1 shows serious injury, injury, and property damage only (PDO) night/day accident-rate ratios. The only meaningful difference between the ratios is that the PDO night/day accident-rate ratio is 19 percent higher for the freeway sections with interchange lighting only than the PDO night/day accident-rate ratio for the continuously lighted sections.

Figure 2 shows the accident-rate ratios for interchange and non-interchange areas. For interchange areas, the night/day accident-rate ratios are statistically equal for continuously lighted sections and sections with interchange lighting only. One would expect these ratios to be similar since overhead lighting exists at the interchanges located on the sections with continuous lighting and the sections with interchange lighting only.

The night/day accident-rate ratio for non-interchange areas is 18 percent higher for sections with interchange lighting only than it is for continuously lighted sections. Statistically, the night/day accident-rate ratios for non-interchange areas are different. The primary focus of the study was to compare the non-interchange areas of the continuously lighted sections and interchange lighting only sections. The non-interchange areas of the continuously lighted sections are **lighted** and the non-interchange areas of the interchange lighting only sections are **unlighted**. A detailed analysis of the non-interchange areas was conducted.

Crash costs for lighted and unlighted sections for non-interchange areas were calculated. The costs were calculated for each accident severity by multiplying the accident frequency by the corresponding

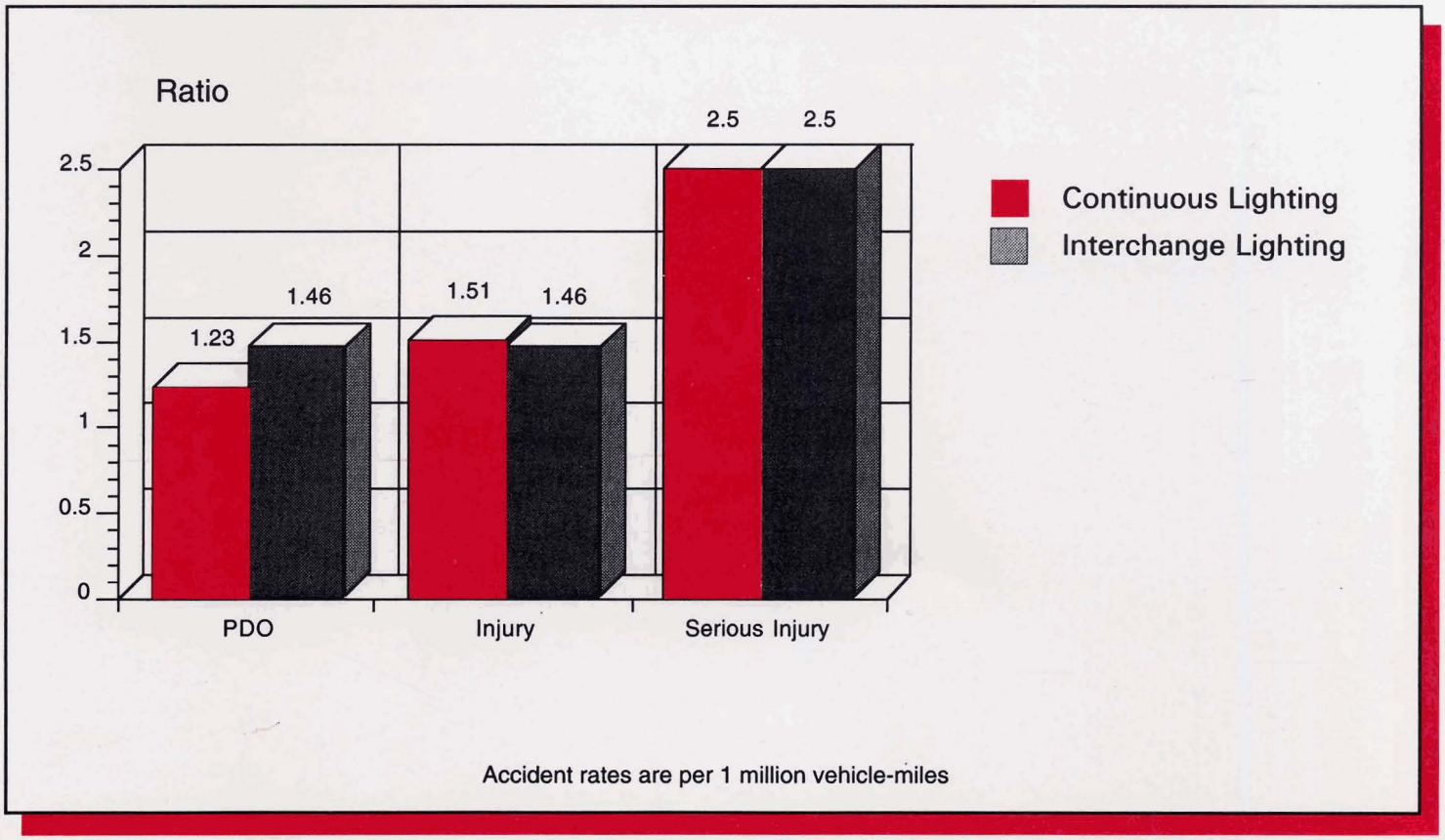


Figure 1. Night/day rate ratios

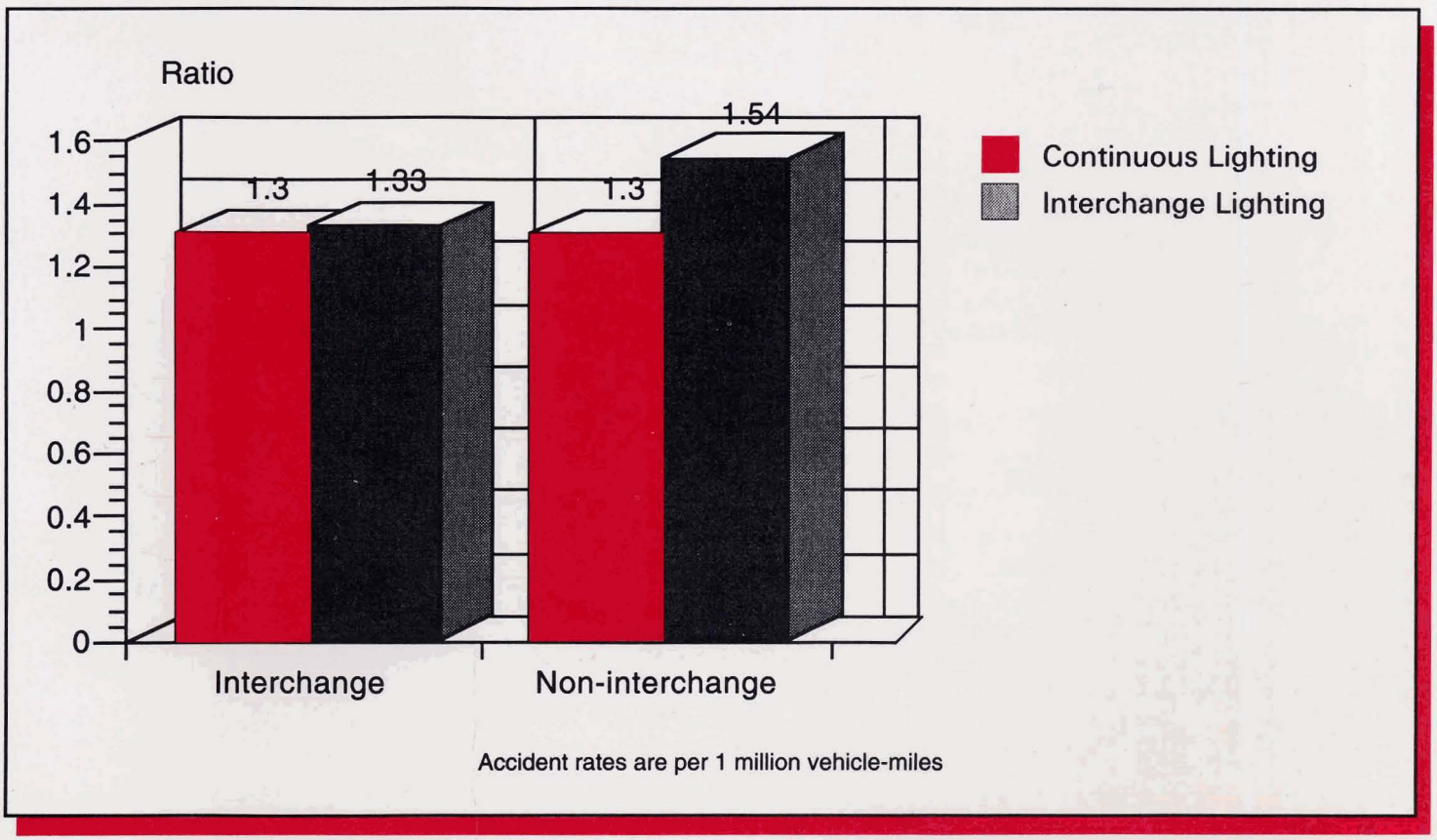


Figure 2. Total night/day rate ratios

cost per crash. The costs per crash used in 1988 dollars were: $2,722,548 (K-fatal), $228,568 (A-incapacitating), $48,333 (B-evident), $25,228 (C-possible), and $4,489 (O-property damage).[1] For the lighted sections between interchange areas, the total crash costs for night and day were $37,617,605 and $46,270,320, respectively. For the unlighted sections between interchange areas, the total crash costs for night and day were $17,727,099 and $17,228,489, respectively.

Night/day crash-cost ratios were computed using the crash costs. The night/day crash-cost ratios for freeway sections between interchange areas with lighting and without lighting were $37,617,605/$46,270,320 = 0.81 and $17,727,099/$17,228,489 = 1.03, respectively. The night/day crash-cost ratio for freeway sections between interchange areas without overhead lighting is 27 percent higher than the night/day crash-cost ratio for freeway sections between interchange areas with overhead lighting.

A benefit/cost analysis was conducted for the freeway sections between the interchange areas with lighting. The hardware, installation, and electric power costs for an urban freeway lighting system were obtained from a New York Department of Transportation (NYDOT) official. The use of lighting system costs from New York was not deemed to be ideal. However, these costs could not be obtained from Minnesota DOT. The costs of overhead lighting systems can vary across different regions of the country and, therefore, the benefit/cost results should not be considered definitive.

Based on the NYDOT cost information, it's estimated that the total costs (hardware, installation, and power) from 1985 through 1990 for the 35 km of continuously lighted freeways between the interchange areas were $2.7 million. The hardware and installation costs were established on a 20-year amortization period. These calculations are based on the assumption that the entire roadway lighting system was installed in 1984. The overhead lighting system was actually installed between 1960 and 1984 at the study locations.

For the benefit/cost analysis, the expected night crash costs (if roadway lighting did not exist at these locations) had to be calculated for the 35 km of continuously lighted freeways between the interchange areas. This was found by using the night/day crash-cost ratio for the unlighted sections between the interchange areas. One would expect that if roadway lighting was not installed on the 35 km of continuously lighted freeways between interchange areas that the night/day crash-cost ratio would equal 1.03 (night/day crash-cost ratio for the unlighted sections) and not 0.81. The expected night crash costs were equal to $47,658,429 ($46,270,320 x 1.03).

The actual night crash costs were $37,617,605; this was $10,040,824 less than the expected night costs. Therefore, the estimated economic benefit of roadway lighting is $7,340,824 ($10,040,824 - $2,700,000 [estimated hardware, installation, and power costs]) for the years 1985 through 1990. The benefit/cost ratio equals 3.7 ($10,040,824/$2,700,000).

Study Implications

Accurate estimates of the safety benefits of roadway lighting for urban freeways are needed. These estimates are required to better understand the potential impact roadway lighting can have on the nighttime accident problem for urban freeways. The majority of the previous research is 20 to 30 years old and it's inconclusive. This study provided new accurate information and found a positive relationship between roadway lighting and urban freeway safety.

Jurisdictions considering the installation of a roadway lighting system for an urban freeway facility need to assess its potential economic impact. Benefit/cost analyses should be conducted for the different types of freeway lighting systems that are being considered. The benefit/cost ratio of overhead lighting for the study's 35 km of urban freeway sections between interchange areas is 3.7. This ratio is primarily a function of the reduction of property damage only (PDO) accidents.

Additional research is needed to develop an even stronger knowledge base on the safety effects of roadway lighting for urban freeways. A before-and-after study would be desirable with data from several States that have urban freeway lighting systems in service with a wide range of maintained illumination levels.

The warranting conditions for continuous freeway lighting, complete interchange lighting, and partial interchange lighting can be found in publication The American Association of State Highway and Transportation Officials (AASHTO's) Informational Guide for Roadway Lighting.

For More Information

This research was conducted by Michael S. Griffith, a mathematical statistician with FHWA in the Office of Safety and Traffic Operations R&D. The final report was published in the Autumn 1994 issue of FHWA's *Public Roads*. To obtain more information about the study or HSIS, contact Jeffrey F. Paniati, HSIS Program Manager, at (703) 285-2568.

Reference

1. *The Costs of Highway Crashes*, Federal Highway Administration, October 1991, FHWA-RD-91-055.

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