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REAL-WORLD USE OF HIGH-BEAM HEADLAMPS

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16. Abstract

Drivers in this study participated in a field operational test of two crash warning systems and were unaware that data about their high-beam use were being collected. Drivers were given instrumented vehicles to drive as their own car for periods ranging from 7 to 27 days. Most of the driving was in southeastern Michigan.

The results indicate that high-beam headlamp use is low, a finding consistent with previous studies that used different methods. Combined over all drivers and all road types, high beams were used for 3.1% of the distance driven at night. Drivers used high beams most frequently on local roads, but even that use was only 8.9%. Under the most favorable conditions for high-beam use (rural roads with, no opposing or preceding vehicles), drivers used their high beams 25.4% of the nighttime distance driven. Older drivers used high beams three times more frequently than did younger drivers, suggesting that older drivers, to at least some extent, understand their visual impairment at night, and therefore take some compensatory measures.

Because low beams do not provide sufficient illumination in many driving situations, the present findings imply that (1) increased high-beam use should be encouraged and (2) the use of automatic switching between high and low beams is likely to be beneficial.

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INTRODUCTION

The first extended study of naturalistic high-beam use in the United States was conducted in the late 1960s (Hare and Hemion, 1968). That study evaluated high-beam use at 17 locations in 15 states. A majority of the selected sites (14 of 17) were unlighted, rural, two-lane roads. For open-road scenarios, defined in that study as situations in which there was no opposing traffic and no leading vehicle within 183 m, high-beam use was greatest in the Southeast at 40% and lowest in the Northwest at 10%. While regional differences in high-beam use were observed, substantial underuse of high-beam headlamps was present in all areas of the country. Additionally, as might be expected, Hare and Hemion found an inverse relationship between traffic density and high-beam use. In car-meeting scenarios, on average, drivers dimmed their high beams at an intercar distance of 522 m. From an obstacle detection standpoint, Helmers and Rumar (1974) reported a distance of 250 m to 400 m as an optimal distance for switching from high to low beams. The dimming distances observed by Hare and Hemion were clearly substantially longer than is advisable for object detection and occurred at distances at which disability glare is not a factor.

Sullivan, Adachi, Mefford, and Flannagan (2003) investigated high-beam use at three rural locations in Ann Arbor, Michigan. Observations in that study involved analyzing the high-beam use in vehicles with no opposing or preceding traffic. Consistent with Hare and Hemion's observations from the 1960s, drivers in the Sullivan et al. study underused their high beams—using them in about 50% of the observations.

The present study investigated real-world use of high beams using a secondary analysis of data from a field operational test of two crash warning systems. Drivers were instructed to use instrumented experimental vehicles as their personal vehicles for extended time periods. The data collected during nighttime driving provided information about high-beam use on a wide variety of road types. Additionally, since the ages and gender of the drivers were known (unlike in the earlier observational studies), the effects of those variables on high-beam use could be investigated.

METHOD

Data analyzed in this study were originally collected in a field operational test (FOT) that evaluated crash-warning systems. This FOT featured 11 instrumented vehicles and 87 participants.

Participants

With the assistance of the Michigan Secretary of State office, 6,000 licensed drivers were selected at random for possible participation in the FOT. The random sample contained only drivers who belonged to one of the following age groups: 20-30, 40-50, or 60-70 years. From this random pool of 6,000 drivers, smaller random samples of names were selected to receive informational postcards. A toll-free number was provided for interested persons to learn more about the study and determine if they qualified. A minimum annual mileage threshold was required. This minimum value was determined using mean values from the 2001 National Personal Transportation Survey (NPTS). The NPTS reports average annual mileage by driver gender and age group. Additionally, drivers were excluded from participating in the study if they reported a significant violation (e.g., driving under the influence of alcohol, driving with a suspended license), or if they had had a crash that resulted in death or serious injury within the previous three years. The resulting sample of participants consisted of age groups of the following sizes: 20-30, $n = 32$; 40-50, $n = 28$, and 60-70, $n = 27$.

Instrumented Vehicles

Eleven identical 2003 Nissan Altimas with standard headlamps were used in this FOT. The high-beam headlamps were activated via a stalk-mounted control. Each instrumented vehicle was equipped with two crash warning systems (a lane departure warning system and a curve speed warning system), a face-camera video, a forward-looking video, and a data acquisition system that collected and stored over 500 data channels. Headlamp state (off, low, or high) was one of the collected channels.

Procedure

After a two-hour training session, participants were allowed to drive the research vehicle as their personal vehicle for 26 days. Of the 87 drivers who participated in the FOT, 74 drove the research vehicle for 26-day periods, while the remaining participants drove for periods ranging from 7 to 27 days. Because of the limits of the map database that was employed by the curve speed warning system, drivers were asked to restrict their travel to Michigan, northwestern

Ohio, northern Indiana, and parts of Illinois and Wisconsin. Participants were otherwise free to drive wherever and whenever they wanted. GPS data were collected during each trip.

Data Management

At the completion of each driver's participation, all of the data were downloaded from a hard drive on the research vehicle and transferred to servers. The curve speed warning system provided road type information for every high-beam event, and post-processing of the data provided additional information concerning rural versus urban location. Data from the Michigan Highway Performance Monitoring System (HPMS), which includes the rural/urban distinction, were joined with data from each high-beam event that occurred in Michigan. Because the available HPMS information was limited to Michigan, the analysis that focused on the use of high beams on rural roads with no other traffic present used the driving data from Michigan only.

RESULTS

For purposes of this study, night was defined by a solar zenith angle greater than or equal to 96° (6° below the horizon), which is the limit of civil twilight. A minimum speed of 16 km/hr was imposed to eliminate uninteresting events (e.g., while moving the car from a driveway to the street or driving in a parking garage). Approximately 21% of the miles accrued in this FOT were driven at night. Collapsed across all road types, drivers used high beams for 3.1% of the distance driven at night (see Figure 1). Figure 1 also shows the increased use of headlamps in general (low or high beams) with lower sun position.

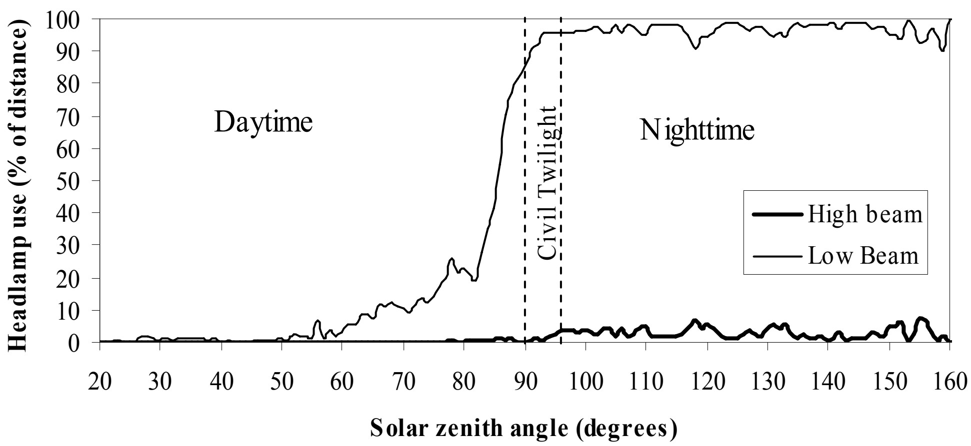

Figure 1. Headlamp use collapsed across all road types.

Drivers used high beams most frequently on local roads (8.9%), while rarely using them on limited access roads (0.2%). Figure 2 displays high-beam use by road type. Overall, high-beam use was less than 10% on any road type. High-beam use under the most favorable conditions identifiable in this study (rural roads, no opposing traffic, and no leading vehicle) was at 25.4%.

In order to investigate the effects of age (three levels: 20-30, 40-50, and 60-70 years) and gender on high-beam use, an analysis of variance (ANOVA) was run. Six of the drivers did not drive at night and were excluded from the analysis. (Half of these excluded drivers were in the oldest age group.) The results of the ANOVA showed a statistically significant effect of age, $F(2, 75) = 3.74$, $p = .028$. Post-hoc, pairwise comparisons among the age groups showed that the percentage of the distance driven at night using high beams by the oldest drivers differed from that of the youngest drivers. On average, the oldest group used their high beams more frequently than the youngest group by a factor of three. The results are presented in Figure 3. The effect of gender was not statistically significant, $F(1, 75) < 1$, $p = .651$.

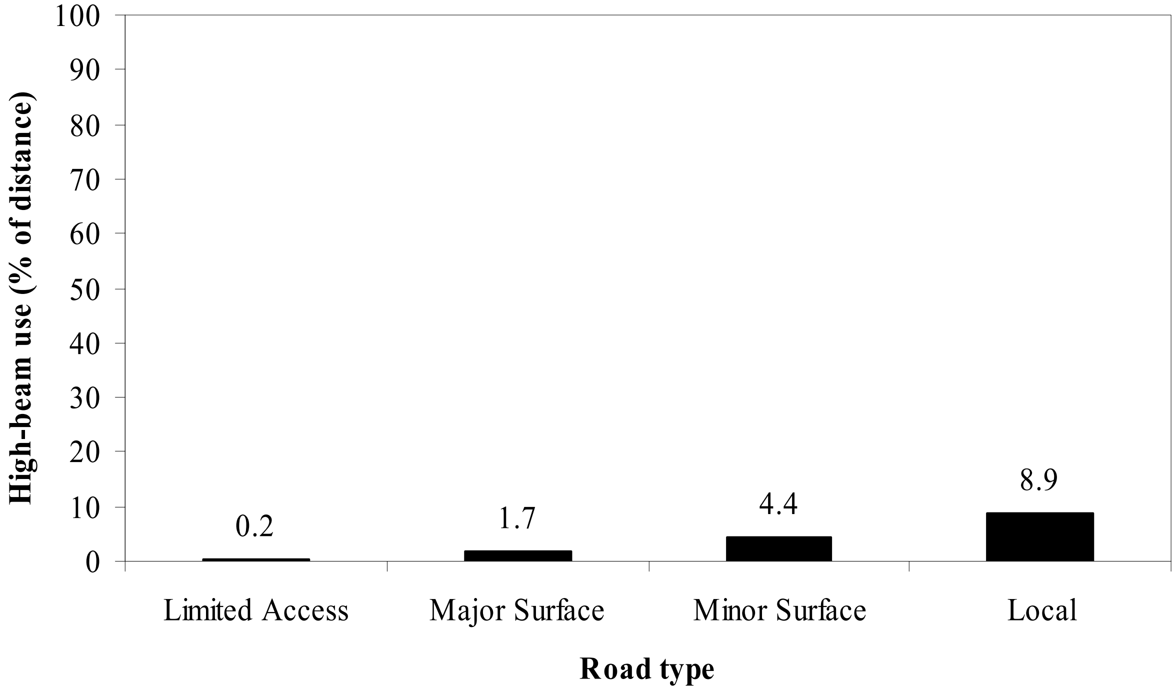

Figure 2. High-beam use by road type.

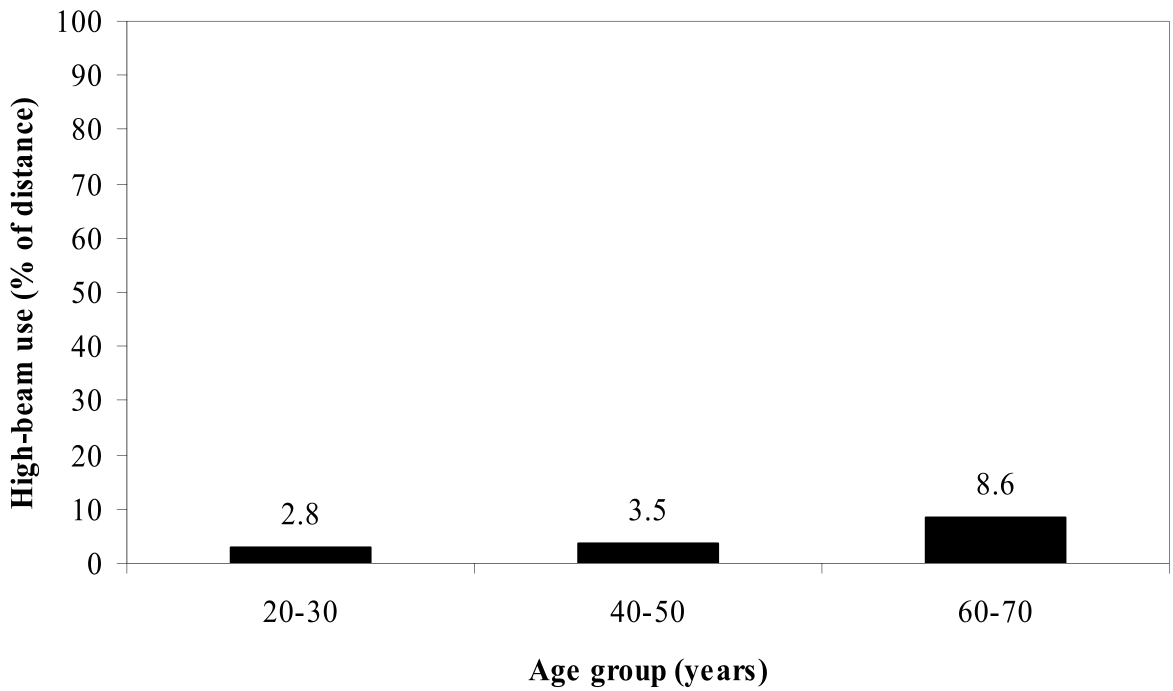

Figure 3. High-beam use by driver age group.

DISCUSSION

Drivers in this study participated in a field operational test of two crash warning systems and were unaware that data about their high-beam use were being collected. Drivers were given instrumented vehicles to drive as their own car for periods ranging from 7 to 27 days. Most of the driving was in southeastern Michigan.

The results indicate that high-beam headlamp use is low, a finding consistent with previous studies that used different methods. Combined over all drivers and all road types, drivers used high beams in 3.1% of the distance driven at night. Drivers used high beams most frequently on local roads, but even that use was only 8.9%. Under the most favorable conditions for high-beam use (rural roads with no opposing or preceding vehicles), drivers used their high beams 25.4% of the nighttime distance driven. This finding is consistent with the results reported by Hare and Hemion (1968) for the two Michigan sites they studied (27% and 24%). In comparison, Sullivan et al. (2003) found high-beam use under such conditions to be greater, although still low (at about 50%). However, the higher usage rate reported by Sullivan et al. could be a consequence of the specific three sites investigated or of the particular techniques used to determine the type of beams in use (photometric measurements supplemented with direct observations of oncoming vehicles).

Older drivers used high beams three times more frequently than did younger drivers. This finding suggests that older drivers, at least on some level, understand their visual impairment at night, and therefore take some compensatory measures.

It is generally recognized that low beams do not provide sufficient illumination in many driving situations. For example, Perel et al. (1983) estimated that low beams do not provide enough illumination at speeds exceeding about 70 km/hr. Consequently, the present findings imply that (1) increased high-beam use should be encouraged and (2) the use of automatic switching between high and low beams is likely to be beneficial.

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