AN EVALUATION OF THE TRAFFIC SAFETY RISK OF BIOPTIC TELESCOPIC LENS DRIVERS

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13. ABSTRACT *(Maximum 200 words)*

This report compares the 2-year accident and citation rates for 609 drivers who must wear a bioptic telescopic lens (BTL) device when driving with those for a randomly selected comparison group of 28,109 drivers. The criterion measures were statistically adjusted using age and gender as covariates. The results indicate that the adjusted total and fatal/injury accident rates for the BTL group were 1.9 and 1.7 times higher, respectively, than those for the comparison group. However, an opposite result was found for total citations; the adjusted rate for the BTL group was 0.7 of the adjusted rate for the comparison group on this measure. All of the differences were statistically significant. The differences in the adjusted means were even greater when only drivers with valid licenses were considered. These findings suggest that BTL drivers do not sufficiently compensate for their higher-risk status. The study also found that the department's policy of restricting BTL drivers from driving at night was followed for only 35% of the BTL subjects. The department is in the process of correcting this operational deficiency.

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PREFACE

This report is being issued as an internal monograph of the Department of Motor Vehicles' Research and Development Branch rather than as an official report of the State of California. The findings and opinions, therefore, may not represent the views and policies of the State of California.

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The author wishes to acknowledge the individuals who have contributed to this project. The study was conducted under the general direction of Raymond C. Peck, Research Chief. Robert Hagge, Research Manager I, supervised the project and assisted in the writing and editing of the report. The final draft of the report was also edited by Mary Janke, Research Scientist III, and David Hennessy, Research Program Specialist I. Eric Berube, Research Scientist I, provided consultation on statistical analyses and programming. Michael Gebers, Research Analyst II, performed the file extraction of subjects' driving records. Patricia Romanowicz, Research Analyst II, analyzed these electronic records to determine the percentage of subjects restricted from driving at night. Douglas Luong, Office Technician, assisted in typing the report. Debbie McKenzie, Associate Governmental Program Analyst, prepared the graphs and proofread the final report.

EXECUTIVE SUMMARY

Because of low vision, bioptic telescopic lens (BTL) drivers wear eye glasses with a miniature telescope attached to the upper part of the standard carrier lenses (generally only the lens for the driver's better eye). The telescope enhances distance visual acuity, and is used for quick scanning of traffic signs and signals.

In the present study, the 2-year (1993-94) total accident, fatal/injury accident, and total citation rates for BTL drivers were compared to those for a comparison group. The BTL group consisted of 609 drivers with a BTL restriction code ("44") recorded in the department's automated driver license (DL) masterfile. The comparison group was made up of 28,109 non-BTL drivers who had a DL number with terminal digits of "101." Deceased drivers, X-numbers (masterfile entries for which the DL number of the driver could not be identified), and non-licensed holders of an identification (ID) card were excluded from both groups. The two groups were compared both before and after removing drivers with invalid (expired, suspended, or revoked) licenses.

The purpose of the study was to determine whether BTL drivers pose an increased risk to traffic safety compared to non-BTL drivers of similar age and sex. Significance tests were performed to determine the differences between the BTL group and the comparison group on 2-year total accident, fatal/injury accident, and total citation rates. The results indicate that the two groups differed significantly on these criterion measures ($p < .01$). Using analysis of covariance, the two groups were also compared on these criterion measures after statistically adjusting for differences in age and gender. The adjusted total and fatal/injury accident rates for the BTL

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group were 1.9 and 1.7 times higher than those for the comparison group, respectively. However, an opposite result was found for total citations; the adjusted rate for the BTL group was 0.7 of the adjusted rate for the comparison group on this measure. All of the differences were statistically significant ($p < .02$).

The differences between the BTL and comparison groups on the three raw criterion measures were even greater after drivers with invalid licenses were removed, and their statistical significance was enhanced ($p < .006$). After adjusting the validly-licensed driver group means for differences in age and gender, the BTL group's total accident and fatal/injury accident rates were 2.2 and 2.3 times higher, respectively, than the comparison group's rates. The BTL drivers' adjusted total citation rate, on the other hand, was again 0.7 of the comparison group's rate. These adjusted-mean differences were more extreme than those for the total sample and were of enhanced significance ($p < .004$).

The current study findings are consistent with those of an earlier departmental study (reported by Janke and Kazarian, 1983 and Janke, 1983), in which the standardized total and fatal/injury accident rates for the total BTL group were roughly 1.5 and 2.2 times higher than those for the comparison group, respectively. Given that the BTL drivers in the present study had consistently lower adjusted total citation rates than did drivers in the comparison group, it would appear that BTL drivers are self-restricting their driving exposure and/or driving more lawfully than non-BTL drivers.

Janke (1983) found a high incidence of cases in which BTL drivers were not appropriately restricted, and recommended that license restriction rather than revocation be considered for these vision-deficient drivers. Following this recommendation, it became formal departmental policy that BTL drivers be restricted from driving at night. In order to determine the extent to which this policy was being followed, the driving records of BTL subjects in the current study were examined to verify whether a sunrise-to-sunset license restriction code was recorded. Only 35% of subjects in the sample had such a restriction code on their records, indicating a very substantial deviation from the restriction policy.

The findings of the present study indicate that attempts to reduce the accident rate of bioptic drivers have not been successful. The accident risk posed by BTL drivers remains substantially higher than that posed by non-BTL drivers of the same age and gender. This risk differential exists in spite of the presumptive attempt by BTL drivers to compensate for their increased risk by driving less and more lawfully, as suggested by their lower rate of traffic citations compared to the rate for non-BTL drivers. Of even greater concern is the fact that Janke's recommendation (and departmental policy guidelines) consistent with greater use of restrictions appear to have gone unheeded. It may, therefore, be appropriate for the department to reexamine its policy of allowing drivers with substandard vision that is not correctable to be licensed under a bioptic lens condition. It is also recommended that an operations audit be conducted to determine the mechanisms by which the vast majority of BTL drivers have managed to avoid a sunrise-to-sunset license restriction. The latter effort has already been initiated and a task force will be convened to devise corrective measures.

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INTRODUCTION

Background and Study Objective
The California Department of Motor Vehicles (DMV) allows the use of bioptic telescopic (BTL) lenses by low-vision applicants taking vision and driving tests. BTL drivers use the telescope, mounted on a carrier lens, to identify/read traffic signs and signals and in some situations to see a potential hazard more clearly. Among the vision conditions for which these lenses may partially compensate are macular degeneration and severe myopia.

The BTL telescope is usually though not always attached in front of one of the eye-glass carrier lenses. Three commonly used variants are: the Galilean telescope, which is attached on one side of the carrier lens; the Keplerian telescope, which is mounted on the inside of the carrier lens; and the Periscope and Keplerian telescope combination, which is mounted on the top of the carrier-lens frame (CA DMV, 1995). The telescopes also vary in size and magnification power. With one system, the telescope, suspended behind a tinted carrier lens, has slide-control focus (Pasfield, 1989). Another system uses micro-miniature telescopes, which the manufacturer claims eliminate head dipping, depth-perception distortion, and scotoma (Edwards Optical Corporation, 1980).

California first started licensing BTL drivers in 1971 (Levin & Kelleher, 1975). There are 21 other states that license BTL drivers. Yet, their licensure remains a controversial issue. Bailey (1985), a proponent of licensure, stated that if the telescope is mounted before one eye and the driver keeps both eyes open, there is no scotoma (blind area) present. Fonda (1985) argued against licensing BTL applicants, because he contended that using a telescope that is mounted before only one eye causes diplopia (double vision), while placing telescopes on both carrier lenses creates a serious scotoma or blind area.

The current study was done to expand and update earlier CA DMV research on BTL drivers by Janke (1983). The author compared the 2-year total and fatal/injury accident rates for 229 BTL drivers with those for a group of 21,064 non-BTL drivers randomly selected from the department's automated driver license (DL) masterfile. The BTL group's rates were standardized on age and gender to make the two groups statistically equivalent on these two variables. The standardized total accident and fatal/injury accident rates for the BTL group were 1.5 and 2.2 times those for the non-BTL group, respectively. The differences between the groups were significant for both criterion measures.

The two groups were also compared using only subjects with valid licenses. Although the differences between the gender- and age-adjusted accident rates for the two groups were not significant, the results were consistent with those found for the total sample.

The present analysis was undertaken to replicate and extend the earlier study. In addition to supplying current information on a larger sample of BTL drivers than was used by Janke, the present study also assessed whether the risk of BTL drivers

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declined following changes in departmental driver licensing procedures that occurred since the earlier study was conducted.

DMV's current official policy is to restrict all BTL drivers to driving only between sunrise and sunset. To have this daytime-only restriction lifted requires all of the following: a vision care specialist must determine that the driver has adequate nighttime vision; the BTL driver must request the lifting of the daytime restriction; and the BTL driver must pass a nighttime drive test. DMV management requested the current study of BTL drivers to provide information for making decisions on possible modifications in departmental policy related to these drivers.

Review of Policy Issues and Practices
Vision standards. Testing of static visual acuity is performed in all 50 states, and 22 states allow BTL users to drive (Bailey & Sheedy, 1988). Bailey and Sheedy suggested the following vision standards for BTL drivers: telescopic visual acuity of 20/40 or better; corrected binocular acuity through the carrier lenses between 20/100 and 20/200; and visual field in both eyes meeting a state's standards. They have found that most BTL drivers have a visual acuity between 20/80 and 20/125 and use telescopes with a magnification between 2.5X and 5X. Bailey (1990) proposed the following visual acuity levels and the likelihood of benefiting from bioptic lens correction: at 20/80, drivers probably need a BTL device; at 20/125, driving may be permissible with 3X-4X magnification; at 20/200 acuity, driving should not be allowed. Other recommendations are that the driver have two useful eyes and the telescope (monocular only) should go before the better eye.

West Virginia Rehabilitation Center (WVRC) conducted a 3-year study on 50 BTL drivers. There were 14 people who finished driver training for low-vision applicants and were granted driver licenses in the first 2 years of the study. To participate in the study, subjects had to meet the following vision standards: visual acuity between 20/200 and 20/50 for corrected vision in the better eye; visual acuity correctable to at least 20/40 with a BTL system of 1X-4X magnification; and visual field in the better eye of 120 degrees horizontally and 80 degrees vertically (Huss, 1988).

The Ohio Bureau of Motor Vehicles (OBMV) requires that corrected binocular visual acuity be at least 20/60, and that field of vision "without the use of field expanders show a horizontal limit of no less than 70 degrees temporally in each eye" (OBMV, 1990). The Indiana Bureau of Motor Vehicles (IBMV) requires these vision standards for BTL drivers: visual acuity using a BTL device of at least 20/40; field of view of 130 degrees horizontally; and no pronounced blind spots (IBMV, 1992).

The Texan Department of Public Safety requires BTL drivers to have visual acuity of at least 20/120 in the better eye and a field of view of at least 140 degrees (Spitzberg, 1991).

Training in BTL use. Generally, a bioptic telescope is mounted high on the carrier lens in order to allow an unobstructed view through the lower portion of the lens. Users tilt their heads forward to view through the BTL device and backward to view through the carrier lens. "With both eyes open, a monocular spectacle-mounted

telescope does not cause any loss of binocular visual field" when the BTL is not being used (Bailey, 1990). Bailey disputes the claim made by some vision experts that a telescope mounted on a carrier lens creates a ring scotoma and diplopia. He believes that the problem can be avoided by training users when to tilt their heads and to make an effort to keep both eyes open at all times (Bailey, 1985).

Bailey believes that patients should demonstrate their proficiency with a hand-held telescope before being prescribed a BTL device. He recommended, among other things, that a BTL user perform the following exercises as a passenger: finding and reading traffic signs while the car is moving and also when it's stopped; and interchanging from the telescope to the carrier lens (Bailey, 1990).

Training standards for low-vision drivers. As part of the WVRC study mentioned above, low-vision drivers received twice the normal amount of behind-the-wheel training and classroom instruction, which is usually 6 and 30 hours respectively (Huss, 1988).

In Ohio, state-certified driver training and evaluation programs must take the following steps for low-vision drivers:

• examine the person to determine whether a BTL device will improve vision to required state vision standards;
• require a knowledge test of motoring laws and traffic signs and signals;
• if the person passes the knowledge test, permit the student to drive only with an instructor;
• issue a certificate of successful completion to those who pass driver training;
• decide whether to recommend that the student attempt a drive test once he/she has completed the training program; and
• if a person fails the drive test three times, he/she must be evaluated again, receive more training, earn a new training certificate, and be recommended to take another drive test (OBMV, 1990).

Spitzberg (1991) identified some of the ways in which low-vision people can compensate while driving: "1) slowing down sooner than the average person at a light or stop sign, 2) driving below the speed limit, 3) driving at a lower rate of speed when encountering heavy traffic, and 4) longer observation times at intersections and medians to make sure there is sufficient clearance to proceed."

BTL driver license restrictions and graduated licensing. Successful BTL applicants in Ohio have their licenses restricted to daylight hours for the first year. In order to get the daytime-only restriction lifted, BTL drivers must do the following:

• have no traffic convictions or at-fault accidents on their records;
• pass a state vision test while using a BTL device;
• be evaluated and trained in night driving; and
• pass a nighttime drive test given by at least two highway patrol examiners (OBMV, 1990).

Bailey (1984) suggested restrictions similar to Ohio's for BTL drivers, including an initial 1-year license for novice drivers. He also recommended more in-depth testing, a closer monitoring of BTL driving records, and possible renewal drive testing every 4 years.

Although authorities such as Bailey have argued that BTL drivers do not present undue safety risks, the findings of Janke (1983) do substantiate that such drivers represent increased accident risk. If one assumes that BTL drivers drive less than "normal-vision" drivers, the risk differential between these two groups is even greater in terms of accidents per unit of exposure.

It is instructive to consider how the visual defects of BTL drivers, and the dynamics of using the telescopic lenses, articulate with the task of driving. The following passage from Hennessy (1991) rather nicely portrays what one is faced with in safely driving a vehicle through traffic:

> Safe driving requires the driver to continually search for information relevant to driving. This kind of information includes road signs, appearance of hazards, and changes in the flow of traffic. Continual searching in driving is mostly done with our eyes (and brain) and is in large part carried out automatically and without conscious awareness. Periodically, during this continual searching, the driver's attention will be directed to locations in space where there is driving-relevant information. Once the driver is alerted and consciously notices, this driving-relevant information is processed so as to discern detail, identify, and/or recognize what the driver is looking at.
>
> Detecting relevant information depends on the size of the driver's 'window of attention'–the size of the visual field in which useful information can be acquired in a single glance. Imagine looking over your steering wheel at a busy intersection. While looking straight ahead, your window of attention will be outlined by the circle encompassing the area in which you will notice important events. The size of this circle depends on the driving situation and you, the driver. For example, the more a driver has to focus on dealing with some aspect of the driving task, such as avoiding rear-ending a suddenly braking car, the smaller the circle (that is, the smaller the driver's window of attention is). The smaller the size of the window of attention, the less likely a driver is to notice other relevant information, such as the car in the next lane drifting into the driver's lane. The size of a driver's window of attention may also be diminished if the driver has suffered a sensory loss and perhaps cannot detect objects in one or more portions of the field of view. Such losses may occur with glaucoma, retinal disorders, cataracts and normal aging.

There are many ways in which BTL drivers are at a disadvantage in coping with the above task demands. The key issue, then, is to what extent BTL drivers can acquire compensatory skills for recognizing and responding to critical hazard cues and thereby keep their accident risk at a tolerable level. The driving records for BTL and non-BTL drivers were analyzed in order to answer this question.

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METHODS

Subjects

For the present study, the treatment group consisted of 609 drivers who had a BTL restriction code ("44") recorded on their driving record in the DL masterfile. The comparison group consisted of 28,109 non-BTL drivers with a DL number ending in "101" (or 1 out of every 1,000 drivers). California DL numbers are assigned by an automated system that selects the next available number from random blocks of numbers distributed to field offices. Because employees do not assign the numbers, there is no opportunity for human error or bias. Therefore, extracting driver records using terminal digits of the DL number would be expected to produce a simple random sample. This sampling procedure is the same as that used in the earlier BTL study by Janke (1983). Deceased drivers, unlicensed ID card holders, and X-numbers were excluded from both groups.

Data Analysis

The BTL and comparison groups were compared on their 2-year rates of total accidents, fatal/injury accidents, and total citations. The latter measure included citations for which the driver failed to appear in court or pay a fine, or which were dismissed following the driver's completion of a class at an approved traffic violator school or of a court-approved diversion program. Analysis of covariance (ANCOVA) was used to determine the significance of differences between group criterion means after statistically adjusting the measures for group differences on age and gender. The adjusted means represented the predicted values of the dependent variables for each group at the average value of the covariates, gender and age.

All analyses were performed using SAS Software Version 6.08. The raw-score covariate and criterion (dependent variable) means were obtained for each group, and t-tests were performed to determine whether group differences on these measures were statistically significant. Prior to computing the adjusted criterion means, regression homogeneity tests were performed to determine whether the relationship (represented by the within-group regression coefficient or "slope") between each covariate separately and the criterion was the same for both groups. If the group slopes were not significantly different, a common-slopes model was used to compute the adjusted criterion means. However, if the slopes were found to be heterogenous for a particular criterion/covariate combination, a within-group slopes model (incorporating both of the within-group regression coefficients) was used to make the statistical adjustments. The SAS GLM routine was used to compute the adjusted criterion means and perform significance tests.

In addition to the above analyses, the driver records of all BTL subjects in the total sample were checked to see whether a daytime-only (sunrise-to-sunset) driving restriction code ("07") was recorded. This was done to determine the extent to which the department's official policy of restricting BTL drivers from driving at night was being followed.

RESULTS

All Subjects
Age and gender. Table 1 presents the number of subjects, mean age, and percentage of men in the BTL and comparison groups. The mean age of BTL drivers (46.7 years) was higher than that for drivers in the comparison group (41.2 years). The BTL group also had a higher percentage of men (71.3%) than did the comparison group (55.1%). All of the group differences were significant ($p < .0001$).

Table 1

Number of Subjects (*n*), Mean Age, and Percentage
Male by Group for the Total Sample

Group	*n*	Mean age	% men
BTL	609	46.7	71.3
Non-BTL	28,109	41.2	55.1

Unadjusted accident and citation rates. Table 2 presents the unadjusted 2-year rates of total accidents, fatal/injury accidents, and total citations for the two groups. The total accident and fatal/injury accident rates for the BTL group were 1.9 and 2.0 times higher, respectively, than the rates for the comparison group. Both of these differences were significant ($p < .01$). In contrast, the BTL group's citation rate was 0.7 of that for the comparison group, and the difference was highly significant ($p < .0002$).

Table 2

Unadjusted 2-Year Total Accident, Fatal/Injury Accident, and Total
Citation Rates Per 100 Drivers by Group for the Total Sample

Group	Total accidents	Fatal/injury accidents	Total citations
BTL	15.44	4.60	20.69
Non-BTL	7.97	2.35	30.04

Adjusted accident and citation rates. Since highly significant heterogeneity of regression coefficients was found for both age ($F = 16.0$, $p < .0001$) and gender

($F = 11.7$, $p < .0006$) in the analysis of total accidents, within-group coefficients were used for both covariates in computing the adjusted total accident means.   In the analysis of fatal/injury accidents, slope differences were found for gender ($F = 8.3$, $p < .004$) but not for age ($F = 0.3$, $p = .60$); therefore, within-group slopes were used for gender and a common (combined-groups) slope was used for age in computing the adjusted fatal/injury accident means.   In addition, since the homogeneity of slopes assumption was not violated for gender ($F = 0.1$, $p = .84$) or for age ($F = 1.9$, $p = .17$) with respect to total citations, common slopes were used for both covariates in computing adjusted total citation rates.

Table 3 presents the adjusted criterion means for each group.   The adjusted total and fatal/injury accident rates for the BTL group were 1.9 and 1.7 times higher than those for the comparison group, respectively.   However, an opposite result was found for citations; the adjusted rate for the BTL group was 0.7 of that for the comparison group.   All of the group differences were significant ($p < .001$).

The fact that the accident rates for the BTL group are substantially higher, in the face of a lower citation rate, tends to support the hypothesis that the higher accident rates may be due to a BTL-related visual impairment rather than to increased exposure or unlawful driving practices.   The importance of this distinction is explored more fully in the Discussion section of this report.

Table 3

Covariate-Adjusted 2-Year Total Accident, Fatal/Injury Accident,
and Total Citation Rates Per 100 Drivers by Group for the Total Sample

Group	Total accidents	Fatal/injury accidents	Total citations
BTL	15.08	3.99	22.30
Non-BTL	7.96	2.35	30.01

The results of the ANCOVAs are presented in Table A-1 in the Appendix.   The main effect of group on total accidents was highly significant ($p < .0001$), indicating that there was a real difference between the groups' total accident rates.   (Since Type III sum of squares was used in the ANCOVAs in this study, the main effect of group is adjusted for the effects of age, gender, and the interaction terms.   It should be noted, however, that there is some controversy over the most appropriate sum of squares in analysis of covariance [Nelder & Lane, 1995].   The adjustment of main effects for interactions alters the meaning of the main effect hypothesis.)   The Group x Age and Group x Gender interaction effects were also highly significant ($p < .0001$), indicating that the difference between the groups' total accident rates varied as a function of both age and gender.

For fatal/injury accidents, the main effect of group was again highly significant ($p < .0001$), indicating that BTL drivers differed from drivers in the comparison group on this measure. The Group x Gender interaction effect was also highly significant ($p<.0001$), reflecting the fact that the difference between the groups varied as a function of gender. No Group x Age interaction term appears in the table because the difference in group slopes for the age covariate (that is, the interaction between group and age) was not significant, as mentioned earlier.

The main effect of group membership on total citations was highly significant ($p < .0001$). As shown in Table 3, BTL drivers had significantly fewer citations compared to drivers in the comparison group. There were no interaction terms in this model because neither covariate violated the homogeneity of regression assumption.

Table A-2 in the Appendix presents the regression coefficients used in computing the adjusted criterion means. Because a common slope was used for age in the fatal/injury accidents ANCOVA model, and for both age and gender in the total citations ANCOVA model, the two groups have the same regression coefficients for these covariates.

The negative coefficient values indicate that the risk of accidents and citations for both BTL and non-BTL drivers tends to be higher for men than for women, and lower for older drivers than for younger ones. (Gender was coded "1" for men and "2" for women in the analysis, so a negative regression coefficient for gender indicates that being male––i.e., having a lower score on gender––tends to increase risk.) Differences in the groups' coefficients reflect the presence of significant Group x Covariate interaction effects, meaning as stated above that the differences between the groups vary as a function of the value of the covariates.

The presence of interaction effects is evident in the predicted levels of risk for BTL and non-BTL drivers at different ages for men and women separately. This is illustrated in Figure 1, which shows the predicted total accident risk for men and women BTL and non-BTL drivers at ages 40 and 60 using the regression coefficients shown in the table. (The levels of age used here were selected for illustrative purposes only.) As can be seen, for men the magnitude of the risk differential between the BTL and non-BTL groups is about the same regardless of age. However, for women the predicted level of risk is higher for the BTL group than it is for the comparison group when only younger drivers (40-year-olds) are being compared, but lower when one compares older (60-year-old) drivers. (Note the different scales on the ordinates of the two graphs, reflecting men's higher risk.)
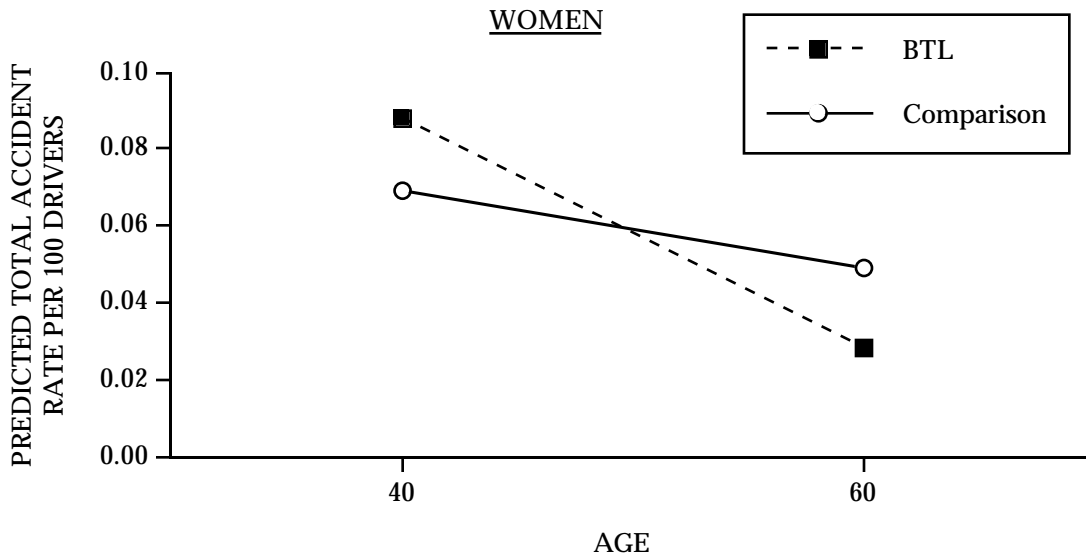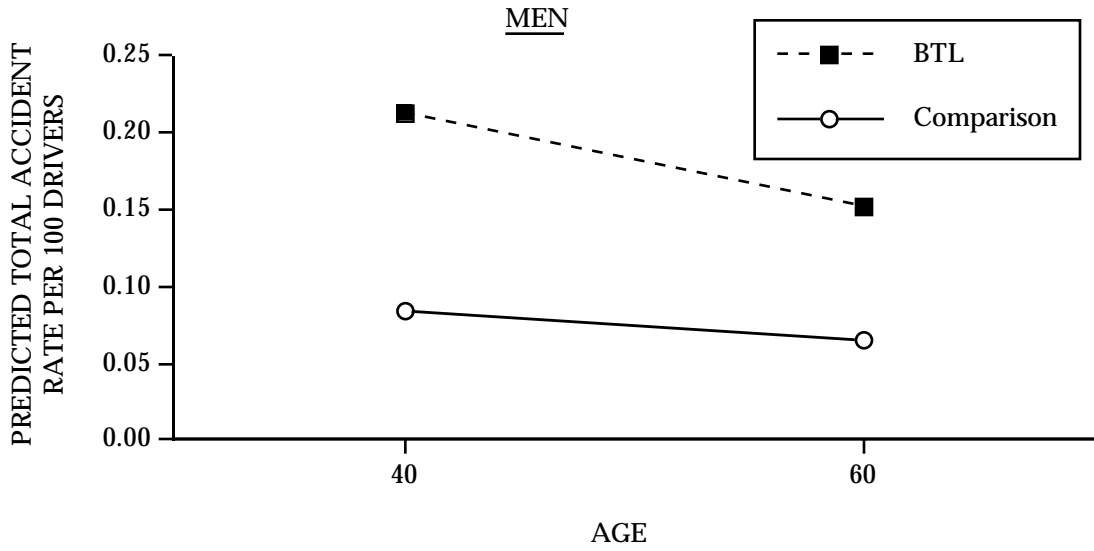
Figure 1. Predicted total accident rates for men and women at ages 40 and 60 in the BTL and comparison groups.

Evidence of night driving restriction. The check of driver records for subjects in the total BTL sample revealed that only 35% of the cases contained a sunrise-to-sunset license restriction code ("07"). This finding suggests that the official policy of restricting BTL drivers to daytime-only driving was not being adequately carried out.

Validly-Licensed Drivers

Age and gender. Table 4 presents the number of subjects, mean age, and percentage male for each group after excluding drivers with invalid licenses. The removal of these subjects from the total sample decreased the number of BTL subjects by 35%, and the number of subjects in the comparison group by 27%. The average age and percentage of men in each group decreased only slightly, and the group differences on these measures remained significant ($p<.004$).

Table 4

Number of Subjects (n), Mean Age, and Percentage Male
by Group for Drivers with Valid Licenses

Group	n	Mean age	% men
BTL	393	43.8	70.5
Non-BTL	20,587	40.6	52.1

Unadjusted accident and citation rates. Table 5 shows the 2-year unadjusted accident and citation rates for validly licensed drivers only. The BTL group had unadjusted total accident and fatal/injury accident rates that were 2.2 and 2.3 times higher, respectively, than the rates for the comparison group. The group differences on both measures were significant ($p<.006$). As with the original sample, the BTL group had an unadjusted total citation rate that was 0.7 of that had by the comparison group, and the difference was significant ($p<.002$).

Table 5

Unadjusted 2-Year Total Accident, Fatal/Injury Accident, and Total Citation Rates
Per 100 Drivers by Group for Drivers with Valid Licenses

Group	Total accidents	Fatal/injury accidents	Total citations
BTL	20.10	6.11	22.65
Non-BTL	9.30	2.61	31.71

<u>Adjusted accident and citation rates</u>. Table 6 presents the criterion means for the two reduced groups after statistically adjusting for age and gender. Significant heterogeneity of regression was found for age ($F = 24.0$, $p<.0001$) and gender ($F = 4.3$, $p<.04$) when analyzing total accidents, and for gender ($F = 8.34$, $p<.005$) but not age ($F = 2.0$, $p = .33$) when analyzing fatal/injury accidents. For total citations, neither gender ($F = 0.1$, $p = .80$) nor age ($F = 1.0$, $p = .33$) violated the regression homogenity assumption. In the instances in which there were heterogenous slopes, within-group regression coefficients were used to compute the adjusted criterion means. The BTL group's adjusted total and fatal/injury accident rates were 1.9 times higher than the rates for the comparison group, and the difference was highly significant ($p<.0002$). However, once again the BTL group's adjusted total citation rate was 0.7 of the comparison group's rate ($p<.004$).

Table 6

Covariate-Adjusted 2-Year Total Accident, Fatal/Injury Accident, and Total Citation Rates Per 100 Drivers by Group for Drivers with Valid Licenses

Group	Total accidents	Fatal/injury accidents	Total citations
BTL	18.12	5.04	21.71
Non-BTL	9.31	2.62	31.73

The ANCOVA summaries are presented in Table A-3 in the Appendix. Since the pattern of results and the main effects of group parallel closely those obtained from the analyses conducted on the total sample, these tables will not be discussed further. Suffice it to say that both the total-sample and valid-licensee analyses indicate that BTL drivers have much higher accident rates, but lower citation rates, than do non-BTL drivers, even after adjusting for differences in age and gender.

Appendix Table A-4 presents the regression coefficients for validly-licensed drivers. The coefficients are similar to those obtained for the total sample.

DISCUSSION AND RECOMMENDATIONS

The results of the raw and covariate-adjusted accident rate comparisons indicate that BTL drivers as a group are at greater accident risk than are non-BTL drivers. However, the lower citation rates for BTL drivers strongly suggest that they may be attempting to compensate for their increased risk by driving less and/or more lawfully. Normally, higher citation rates reflect greater driving exposure and

therefore are associated with higher accident rates. That this was not the case here suggests that the higher rate of accidents among BTL drivers was probably largely due to their having reduced vision and perceptual abilities. If BTL drivers in the sample did drive less and more carefully, this compensation was not entirely adequate. Its inadequacy would suggest that their perceptual deficit was substantial.

The findings evidence no real improvement in BTL-driver risk since Janke (1983) recommended greater use of appropriate license restrictions and more stringent post-licensing control for these drivers. This lack of risk reduction may be due in part to the fact that most BTL drivers continue to be licensed without appropriate restrictions. For example, only 35% of BTL subjects in the study were restricted from driving at night.

Given the above findings, it is recommended that the department review its policies with respect to BTL drivers, including revisiting the issue of whether drivers with uncorrectable substandard vision should even be licensed. Particular attention should be paid to the process of assigning and implementing licensing restrictions and the terms under which BTL drivers are to be reexamined. The apparent failure to implement existing policy calling for restricting the driving privilege of BTL drivers also needs to be investigated. The division of Program and Policy Administration has initiated the latter effort by sending memos to the Field Operations and Driver Safety divisions inquiring as to possible explanations for the low nighttime restriction rate, and will convene a task force to divise corrective measures.

There also appears to be a need to reformulate vision standards and guidelines to make them more fail-safe, so that problem BTL drivers cannot avoid appropriate treatment. This effort will probably require substantial involvement by high-level departmental management to be successful.

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Table A-1

ANCOVA Summary for Total Accidents, Fatal/Injury Accidents,
and Total Citations for the Total Sample

Total Accidents

Source	df	MS	F	p
Group	2	22.45	251.19	.0001
Group x Gender	2	1.89	21.13	.0001
Group x Age	2	4.21	47.11	.0001
Error	28712	0.09		

Fatal/Injury Accidents

Source	df	MS	F	p
Group	2	2.44	98.10	.0001
Group x Gender	2	0.35	14.09	.0001
Age	1	0.76	30.63	.0001
Error	28713	0.02		

Total Citations

Source	df	MS	F	p
Group	2	795.17	1501.37	.0001
Gender	1	238.55	450.41	.0001
Age	1	575.26	1086.16	.0001
Error	28714	0.53		

Table A-2

Group Regression Coefficients Used to Compute Adjusted
2-Year Total Accident, Fatal/Injury Accident, and Total
Citation Means for the Total Sample

Criterion measure	Variable	Group	
		BTL	Non-BTL
Total accidents	Intercept	0.456	0.141
	Gender	-0.124	-0.016
	Age	-0.003	-0.001
Fatal/injury accidents	Intercept	0.123	0.047
	Gender	-0.049	-0.008
	Age	-0.0003	-0.0003
Total citations	Intercept	0.841	0.918
	Gender	-0.184	-0.184
	Age	-0.009	-0.009

Table A-3

ANCOVA Summary for Total Accidents, Fatal/Injury Accidents,
and Total Citations for Drivers with Valid Licenses

Total Accidents

Source	df	MS	F	p
Group	2	17.60	171.93	.0001
Group x Gender	2	2.15	21.03	.0001
Group x Age	2	1.25	12.20	.0001
Error	20974	0.10		

Fatal/Injury Accidents

Source	df	MS	F	p
Group	2	1.77	65.28	.0001
Group x Gender	2	0.35	12.85	.0001
Age	1	0.18	6.60	.0102
Error	20975	0.03		

Total Citations

Source	df	MS	F	p
Group	2	555.34	1172.08	.0001
Gender	1	185.89	392.35	.0001
Age	1	338.96	715.40	.0001
Error	20976	0.47		

Table A-4

Group Regression Coefficients Used to Compute Adjusted
2-Year Total Accident, Fatal/Injury Accident, and Total
Citation Means for Drivers with Valid Licenses

Criterion	Variable	Group	
		BTL	Non-BTL
Total accidents	Intercept	0.509	0.148
	Gender	-0.153	-0.022
	Age	-0.0025	-0.0006
Fatal/injury accidents	Intercept	0.150	0.046
	Gender	-0.062	-0.009
	Age	-0.0002	-0.0002
Total citations	Intercept	0.811	0.911
	Gender	-0.189	-0.189
	Age	-0.008	-0.008