STATISTICAL EVALUATION OF THE EFFECTIVENESS OF FEDERAL MOTOR VEHICLE SAFETY STANDARD 108: SIDE MARKER LAMPS (ONLY)

Report No. 1 of 7

Jim C. Knoop John T. Ball Gaylord M. Northrop

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The Center for the Environment and Man, Inc. 275 Windsor Street Hartford, Connecticut 06120

Contract No. DOT HS-8-02014 Contract Amt. \$581,905



OCTOBER 1980 FINAL REPORT

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CONTRACT TECHNICAL MANAGER'S ADDENDUM

Prepared for the National Highway Traffic Safety Administration in support of a program to review existing regulations, as required by Executive Order 12044 and Department of Transportation Order 2100.5. Agency staff will perform and publish an official evaluation of Federal Motor Vehicle Safety Standard 108 based on the findings of this report as well as other information sources. The values of effectiveness and benefits found in this report may be different from those that will appear in the official Agency evaluation.

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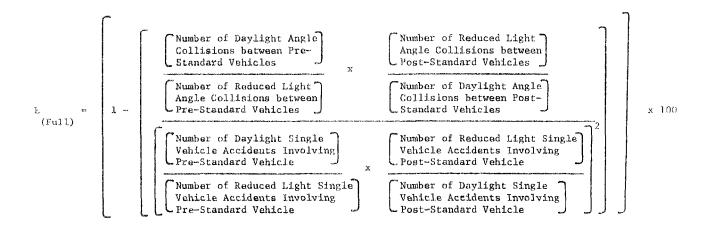
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This is the Final Report of the statistical evaluation of the effectiveness of Federal Motor Vehicle Safety Standard 108: Side Marker Lamps (Only).

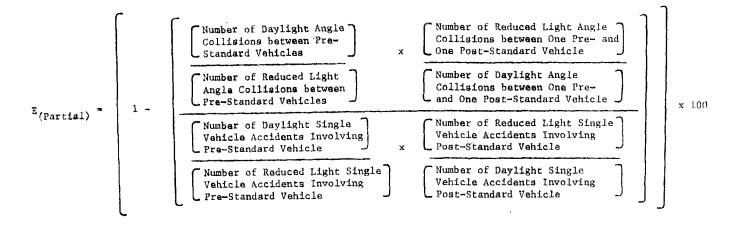
FMVSS 108 is an accident-avoidance Standard which mandates forward amber and rear red side marker lamps that are also reflective. The Standard became effective 1 January 1969. During 1969, the Standard could be met either by reflectors alone, or by lamps with reflective covers. After 1 January 1970, lamps with reflective covers were required.

The objective of this study is to statistically analyze a limited amount of mass accident data pertaining to angle collisions involving various configuration of Pre- and Post-Standard vehicles. Police-reported state accident data from Texas (1972-1974), New York (1974) and North Carolina (1973-1975) are statistically evaluated.

Since the purpose of the study is to evaluate the effectiveness of the FMVSS 108 side marker lamp requirements in reducing the frequency of angle collision accidents occurring during periods of reduced visibility, two distinct types of empirical estimates of side marker lamp effectiveness are derived. Estimates of full effectiveness represent the amount of accident avoidance realized when both vehicles involved in a potential reduced light angle collision situation satisfy the side marker lamp requirements of FMVSS 108. Thus, full effectiveness is defined as:



Estimates of *partial* effectiveness represent the amount of accident avoidance realized when <u>only one</u> of the vehicles in a potential reduced light angle collision situation is equipped with side marker lamps. Therefore, *partial* effectiveness is defined as:



Since the daylight and reduced light exposure risks of Pre- and Post-Standard vehicles are not necessarily the same in the population at large, the daylight-tereduced light involvement ratios for Pre- and Post-Standard vehicles involved in <u>single vehicle accidents</u> are explicitly incorporated into the effectiveness estimation equations to control for any observed effects which are not due to FMVSS 108. In this sense, single vehicle accidents are treated as a control group, and represent measures of relative exposure risk. By inference, any observed reduction in the frequency of reduced light angle collisions involving Post-Standard vehicles, after controlling for relative exposure risk, are attributed to the effect of side marker lamps.

Accidents, rather than vehicles, are used as the unit of analysis, since Pre-Standard vehicles can also benefit from FMVSS 108, to the extent that they are able to avoid collisions with Post-Standard vehicles during periods of reduced lighting as a result of the greater conspicuity of the latter. Before either *full* or *partial* effectiveness values were computed, however, hierarchical, log-linear models were fit to contingency tables composed of Light Condition, Vehicle Configuration (Pre-with-Pre, Pre-with-Post and Post-with- Post) and selected control variables for each state-year of data. Modeling served the dual purpose of smoothing the data by removing random variability due to small cell frequencies, and of revealing the strength and pattern of various interactions among the variables comprising the contingency tables.

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The smoothed data were then adjusted (standardized) to allow for the direct comparison of angle collision frequencies. Adjustment of the data was necessary in order to insure that the overall *full* and *partial* effectiveness estimates were not affected by different distributions of Pre-with-Pre, Pre-with-Post and Post-with-Post angle collisions occurring in daylight and reduced light periods across different levels of control variables. In most cases, the net impact of modeling and adjustment was to increase the value of effectiveness estimates by 1 to 3 percentage points, while slightly reducing the variability of these estimates.

Overall full and partial side marker lamp effectiveness values derived from smoothed, adjusted data (after controlling for relative exposure risk) are summarized in the following table for each sample. In the case of Texas and North Carolina, where multiple years of data were analyzed, weighted means of individual-year effectiveness values are also presented. Also, an overall weighted mean of all states' individual-year effectiveness values is presented. All effectiveness values are based upon the following number of accidents in each sample.

	Texas	North Carolina
1972:	34,011 cases	1973: 6,249 cases
1973:	34,255 cases	1974: 6,486 cases
1974:	30,545 cases	1975: 6,974 cases

New York

1974: 17,566 cases

On the average, overall full effectiveness values for each of the three states range from 12 to 27 percent with an overall mean value of 18 percent for all states, and represent the amount of accident avoidance realized when both of the vehicles involved in a potential reduced lighting angle collision situation satisfy the side marker lamp requirements of FMVSS 108. All average full effectiveness values obtained are statistically significant.

Average partial effectiveness values obtained from Texas 1972-1974 and North Carolina 1973-1975 samples represent significant reductions in the number of reduced light angle collisions of 12 and 16 percent, respectively. These values can be interpreted as the amount of accident avoidance realized in each state when <u>only one</u> of the vehicles involved in a potential reduced light angle collision eltuation is equipped with side marker lamps. The *partial* effectiveness found for the New York 1974 sample was not statistically significant.

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SUMMARY OF OVERALL FULL AND PARTIAL SIDE MARKER LAMP EFFECTIVENESS VALUES DERIVED FROM SMOOTHED, ADJUSTED STATE ACCIDENT DATA AFTER CONTROLLING FOR RELATIVE EXPOSURE RISK

			Fu	11 Eff	ectiv	eness		Partial	Effec	tivene	255	
State	Year	Effec- tive-	Standard Deviation	95% Con Inter		Is Effectiveness Significantly	Effec- tive-	Standard Deviation	95% Con Inte		Is Effectiveness Significantly	
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Texas	1972	18.63	4.03	12.00	25.27	Yes	14.61	2.70	9.83	19.38	Yes	
	1973	10.79	4.22	3.85	17.74	Yes	8,03	3.42	2.41	13.66	Yes	
	1974	22.19	4.02	15.57	28.81	Yes	11.26	3.88	4.87	17.64	Yes	
	1972- 1974	17.40	2.36	13,52	21.28	Yes	11.71	1.92	8.55	14.87	Yes	
New York	1974	12.54	5.64	3.26	21.81	Yes	1.46	5.37	-7.37	10.28	No	
North Carolina	1973	20.48	8.42	6.63	34.34	Yes	7.51	7.74	-5.22	20.25	No	
	1974	36.38	6.90	25.03	47.73	Yes	25.56	6.83	14.32	36.80	Yes	
	1975	15.45	9.69	-0.49	31.40	No	12.55	8.88	-2.06	27.16	No	
	* 1973- 1975	26.61	4.67	18.93	34.29	Yes	16.38	4.44	9.08	23.68	Yes	
All 3 States	All * Years*	18.45	1.97	15.21	21.69	Yes	11.38	1.67	8.63	14.13	Yes	

"Weighted mean, using the inverse of the variance of each year as a weighting factor.

Partial effectiveness values in almost all cases were between one-fifth to two-thirds less than the corresponding full effectiveness values. The only exceptions to this involved the New York 1974 sample, where the full effectiveness estimate was roughly nine times greater than the partial effectiveness value.

When extrapolating from these findings to the entire nation, it is estimated that roughly 64,000 reduced light angle collisions were actually prevented by FMVSS 108 in 1974, when the numbers of Pre- and Post-Standard vehicles driven were approximately the same. Had all of the vehicles driven in 1974 been equipped with side marker lamps, however, it is estimated that more than 103,000 reduced light angle collisions could have been prevented by FMVSS 108.

ACKNOWLEDGMENTS

The work performed by CEM in statistically evaluating the effectiveness of seven Federal Motor Vehicle Safety Standards is the product of an interdisciplinary team effort.

Dr. Gaylord Northrop is the Principal Investigator of this project, and participated in the development and implementation of the approach and the analyses of the results. Mr. Jim Knoop and Mr. John Ball are the principal authors of this report. Other members of the Study Team who contributed in various ways to the report include:

> Ms. Kayla Costenoble Mr. Thomas Bzik Mr. Edward Sweeton Mr. Joseph Reidy Dr. Michael Sutherland

CEM is grateful for assistance provided by the Texas Highway Department, the New York Department of Motor Vehicles and the Highway Safety Research Center (University of North Carolina) in the acquisition and processing of their state's accident data. Mrs. Carmela Miller, Ms. Marjorie Wallace, Mrs. Teresa Mayer and Mrs. Arlene Bene also provided invaluable clerical support in the preparation of this report.

This study has benefitted throughout from the detailed reviews and constructive comments of the NHTSA Contract Technical Manager, Dr. Charles Kahane. Any errors in analysis or interpretation of data and results are, of course, solely the responsibility of the authors of this report.

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ABBREVIATIONS USED

FMVSS Federal Motor Vehicle Safety Standard

- CEM The Center for the Environment and Man, Inc.
- HSRC Highway Safety Research Center
- HSRI Highway Safety Research Institute
- FARS Fatal Accident Reporting System
- NHTSA National Highway Traffic Safety Administration
- TAD Traffic Accident Data Vehicle Damage Scale

KABCO 'K" Killed; "A", "B", "C" Injury Levels; "O" No Injury

- LR Likelihood Ratio
- BMDP3F Biomedical Computer Program 3F
- df Degrees of Freedom

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1.0 INTRODUCTION

1.1 Background

This report is the first in a series of Final Reports of the statistical evaluation of the effectiveness of seven Federal Motor Vehicle Safety Standards (FMVSS). This work has been conducted under Contract DOT-HS-8-02014 by The Center for the Environment and Man, Inc. (CEM) and its subcontractor, the Highway Safety Research Center (HSRC) of the University of North Carolina. The seven FMVSS to be statistically evaluated are:

- FMVSS 108: Side Marker Lamps (Only)
- FMVSS 202: Head Restraints
- FMVSS 207: Seat Back Locks (Only)
- FMVSS 213: Child Restraints
- FMVSS 214: Side Door Strength
- FMVSS 222: School Bus Seating and Crash Protection
- FMVSS 301: Fuel System Integrity

The Final Report on the effectiveness of FMVSS 108 (Side Marker Lamps [Only]) is presented herein.

Side marker lamps are one of 15 separate lighting elements covered by FMVSS 108 (the formal title of this Standard is Lamps, Reflective Devices and Assorted Equipment). The overall purpose of the Standard is to prevent accidents by improving the driver's visual information during darkness or other conditions of reduced visibility. Side marker lamps are intended to help drivers notice the presence of, and judge the distance to, other vehicles when the vehicles are at an angle to one another during conditions of reduced visibility. FMVSS 108 was implemented in several phases, as outlined below.

- Before January 1, 1969, regular passenger vehicles were not required to have any side markers.
 However, due to styling considerations, some earlier models had various lights which were visible from the side.
- Between January 1, 1969 and December 31, 1969, passenger vehicles could satisfy the Standard with any combination of lamps or reflectors positioned front and rear as long as the colors were amber forward and red rear.
- <u>After January 1, 1970</u>, passenger vehicles had to have both lamps and reflectors for both forward and rear side markers. Some models achieved this by enlarging the front and/or rear lighting group so that it could be seen from the side; other models had totally separate side marker lamps. Usually, the lamp cover is both translucent and reflective.

1.2 Objective and Purpose

The objective of this study is to statistically analyze police-reported state accident data pertaining to angle collisions involving various configurations of Pre- and Post-Standard vehicles. Existing mass accident data from Texas (1972-1974), New York (1974) and North Carolina (1973-1975) were statistically evaluated.

The purpose of the study is to evaluate the effectiveness of the side marker lamp requirement of FMVSS 108 in reducing the frequency of side collisions during conditions of reduced visibility.

1.3 Scope

- This analysis involves the statistical analysis of state mass accident data concerning the frequency of side collisions occurring during conditions of reduced visibility in which either two Pre-Standard, two Post-Standard or one Pre- and one Post-Standard vehicles are involved.
- The mass accident data files used are those from Texas (1972-1974), New York (1974) and North Carolina (1973-1975).
- The analysis considers whether the incidence of side collision accidents under conditions of reduced visibility involving Post-Standard vehicles differs from the frequency of similar accidents involving Pre-Standard vehicles, after controlling for relevant vehicle, driver, highway and environmental factors; and taking into account the relative exposure risks of Pre- and Post-Standard vehicles during daylight or reduced light periods.

1.4 Approach

1.4.1 Background and Accident Data Populations

The statistical evaluation of the effectiveness of side marker lamps requires a large set of side collision accident data. Since the evaluation is based on a comparison of the incidence of side collision accidents involving Pre-Standard vehicles with the incidence of similar accidents involving Post-Standard vehicles, relatively old accident data bases are analyzed, in which numbers of Pre- and Post-Standard vehicles are roughly the same. Police-collected accident information from Texas, New York and North Carolina constitute the primary sources of evaluation statistics.

Table 1-1 below shows the size of the data bases used in the analyses. This population is described in greater detail in Section 3.2. In Table 1-1, the column labeled "Partial Data Base" contains the numbers of accidents which are applicable to the analysis of the effectiveness of side marker lamps--i.e., side collisions between two passenger vehicles approaching at an angle, occurring either at an intersection or driveway access.

TABLE 1-1

State	Year	Variahle	Full Data Base	Partial Data Base	Percentage
Texas	1972	Accidents Vehicles	432,997 744,697	34,637 69,274	8.0 9.3
	1973	Accidents Vehicles	464,225 800,543	35,019 70,038	7.5 8.8
·	1974	Accidents Vehicles	434,193 747,832	31,049 62,098	7.2 8.3
	1972-1974 (pooled)	Accidents Vehicles	1,331,415 2,293,072	100,705 201,410	7.6 8.8
New York	1974	Accidents Vehicles	377,818 704,477	18,913 37,826	5.0 5.4
North Carolina	1973	Accidents Vehicles	129,150 232,825	6,312 12,624	4.9 5.4
	1974	Accidents Vehicles	121,568 218,506	6,584 13,168	5.4 6.0
	1975	Accidents Vehicles	129,013 232,180	7,053 14,106	5.5 6.1
	1973-1975 (pooled)	Accidents Vehicles	379,731 683,511	19,948 39,898	5.3 5.8

NUMBER OF ACCIDENTS AND VEHICLES IN DATA BASES USED FOR THE ANALYSIS OF FMVSS 108

1.4.2 Analysis Approach

The basic hypothesis is that side marker lamps will prevent side collisions during periods of reduced visibility. Tests of this hypotheses will be conducted in reference to the primary table shown in Figure 1-1.

Since the final designation of which car is "struck" and which car is "striking" is in many instances determined during the last split second before a side collision accident occurs, no distinction is made between accidents in which Pre-Standard vehicles strike Post-Standard vehicles, or vice versa.

Vehicle	Light Condition					
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Pre with Post		gannag sandan kilonetan seringan gasakiloki natiking sang sagan kilon				
Post with Post		ge general de la constante de m				

Figure 1-1. Primary table.

The analysis of the effectiveness of side marker lamps is carried out in the following steps.

- 1. Select the full mass accident data base.
- 2. Extract the partial data set to be used directly in evaluating the effectiveness of side marker lamps.
- 3. Define a set of potential control variables.
- 4. Select the variables to be used for modeling and adjustment purposes.
- 5. Fit a hierarchical, log-linear model to the contingency table composed of Vehicle Configuration, Light Condition and the control variables selected in Step 4.
- 6. Adjust the smoothed cell frequencies to allow for the direct comparison of reduced lighting angle collision frequencies.
- 7. Examine single vehicle accident frequencies to determine whether the exposure risk for Pre- and Post-Standard vehicles during reduced lighting periods is the same.
- 8. Compute effectiveness values and confidence intervals.
- 9. Extrapolate the results to the nation.

1.5 Limitations of the Study

The study is subject to several limitations. We do not know from mass accident data whether the vehicles' lights were on or whether there were any obstructions blocking the view of either driver. We also do not always know if the cars were approaching at an angle--only that they struck each other from front to side.

An additional limitation of the study is that the single vehicle accident data are not modeled or adjusted prior to their use in the effectiveness estimation procedure to control for differential exposure risk.

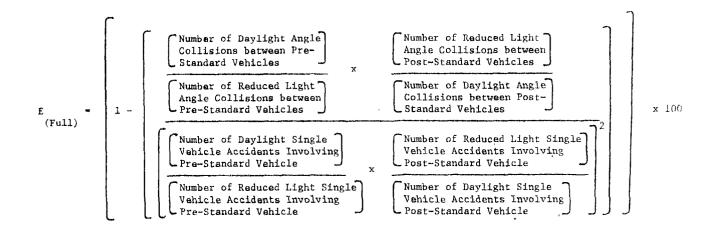
1.6 Outline of the Report

Section 2 of this report summarizes the analyses performed. It includes a discussion of the measure of effectiveness, the estimated effectiveness values and their confidence intervals, discussions of the overall success of the evaluation, the credibility of the analysis, and a comparison of results. Detailed analyses of the data are described in Section 3. Appendix A contains the fully cross-classified contingency tables derived from the state mass accident data bases. Appendix B summarizes the terms included in the various models fitted, along with their marginal associations. Appendix C contains a summary of all effectiveness values derived from both observed, unadjusted and smoothed, adjusted data.

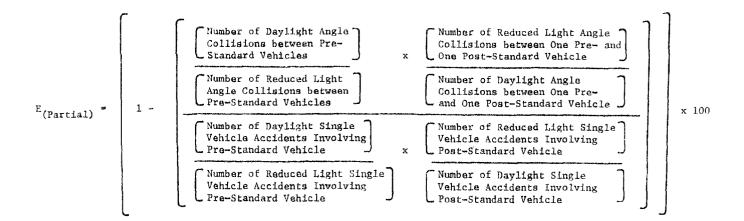
2.0 SUMMARY OF ANALYSIS

2.1 Measures of Effectiveness

The effectiveness measures used in the statistical evaluation of FMVSS 108 are defined as follows.



Full effectiveness represents the amount of accident avoidance realized when both vehicles involved in a potential reduced light angle collision satisfy the side marker lamp requirements of FMVSS 108.



Partial effectiveness represents the amount of accident avoidance realized when only one of the vehicles in a potential reduced light angle collision situation is equipped with side marker lamps.

Since the daylight and reduced light exposure risks of Pre- and Post-Standard vehicles are not necessarily the same in the population at large--i.e., Post-Standard cars may in fact be less likely (or more likely) to be driven during

periods of reduced lighting than Pre-Standard cars--the daylight-to-reduced light involvement ratios for Pre- and Post-Standard vehicles in <u>single vehicle accidents</u> are explicitly incorporated into the effectiveness measures to control for any observed "effect" that is <u>not</u> due to FMVSS 108. In this sense, single vehicle accidents are used as a control group. The overall magnitude of such "spurious" effects is negligible in all three years of Texas data, and approximately -4 percent in North Carolina for 1973 and 1975. However, in the case of both New York and North Carolina, single vehicle accident data reflect highly significant reductions in the number of reduced light angle collisions between Post-Standard vehicles of 6 and --16 percent, respectively, which <u>cannot</u> be attributed to FMVSS 108.

2.2 Estimated Effects of Side Marker Lamps

Tables 2-1 and 2-2 contain the *full* and *partial* effectiveness values obtained both prior to and after controlling for different exposure risks of Preand Post-Standard vehicles during periods of reduced lighting. Effectiveness values derived from both observed, unadjusted and smoothed, adjusted data are contained in these tables. Figure 2-1 places in perspective the various effectiveness values and their 95 percent confidence intervals.

The estimated overall effectiveness of side marker lamps in reducing the number of angle collisions occurring during periods of reduced lighting can be summarized as follows.

> 1. Full Effectiveness. After controlling for differential exposure risk, overall effectiveness values for the three states ranged, on the average, from 12 to 27 percent. This represents a 12 to 27 percent reduction in the number of reduced light angle collisions which can be attributed to both vehicles involved in a potential reduced light angle collision situation satisfying the side marker lamp requirements of FMVSS 108.

The mean full effectiveness values obtained for all individual state-years of data was approximately 18 percent. All weighted averages of full effectiveness values obtained, moreover, were statistically significant.

2. Partial Effectiveness. Based upon weighted averages of overall partial effectiveness values (after controlling for differential exposure) derived from Texas 1972-1974 and North Carolina 1973-1975 samples, significant reductions in the number of reduced light angle collisions of 12 and 6 percent, respectively, were obtained when only one of the vehicles involved in a potential reduced light angle collision situation was equipped with side marker lamps. No significant partial effectiveness was found for the New York 1974 sample.

		Prior	to Control Exposur		r Relative	After Controlling for Relative Exposure Risk						
State	Year	Observed, Unadjusted Data			Smoothed, Adjusted Data		Smoothed, Adjusted Data					
		Effec- tive-	Standard Deviation	Effec- tive-	Standard Deviation	Effec- tive-	LICC" Ctandand		ifidence erval	Is Effectiveness Significantly		
		ness		ness		ness	Deviation	From	To	Different from Zero?		
Texas	1972	18.86	3.33	20.11	3.28	18.63	4.03	12.00	25.27	Yes		
	1973	14.56	3.34	12.76	3.42	10.79	4.22	3.85	17.74	Yes		
	1974	17.77	3.59	20.54	3.46	22.19	4.02	15.57	28.81	Yes		
	1972- 1974	17.03	1.97	17.85	1.95	17.40	2,36	13.52	21.28	Yes		
New York	1974	22.78	4.06	23.08	4.05	12.54	5.46	3.26	21.81	Yes		
North Carolina	1973	10.44	8.01	13.25	7.75	20.48	8.42	6.63	34.34	Yes		
	1974	16.59	7.56	14.74	7.75	36.38	6.90	25.03	47.73	Yes		
	1975	5.08	9.29	7.75	8,99	15.45	9.69	-0.49	31.40	No		
	* 1973- 1975	11.46	4.73	12.30	4.68	26.61	4.67	18 .93	34.39	Yes		
All 3 States	All * Years*	17.30	1.66	18.03	1.64	18.45	1.97	15.31	21.69	Yes		

TABLE 2-1SUMMARY OF OVERALL FULL EFFECTIVENESS VALUES

*Weighted mean, using the inverse of the variance of each year as a weighting factor.

TABLE 2-2SUMMARY OF OVERALL PARTIAL EFFECTIVENESS VALUES

		Prior	to Control Exposur	ling fo e Risk	r Relative	After Controlling for Relative Exposure Risk						
State	Year		erved, sted Data		Smoothed, Adjusted Data		Smoothed, Adjusted Data					
		Effec- tive-	Standard Deviation	Effec- tive-	Standard Deviation	Effec- tive-	IIEC-leandard		nfidence erval	Is Effectiveness Significantly		
		ness		ness		ness		From	То	Different from Zero?		
Texas	1972	14.57	2.65	15.39	2.63	14.61	2.90	9.83	19.38	Yes		
	1973	10.49	3.10	9.05	3.16	8.03	3.42	2.41	13 .6 6	Yes		
	1974	8.42	3.82	10.32	3.72	11.26	3.88	4.87	17.64	Yes		
	1 972- 1974	11.88	1.78	12.23	1.78	11.71	1.92	'8.55	14.87	Yes		
New York	1974	6.69	4.78	7.59	4.73	1.46	5.37	-7.37	10.28	No		
North Carolina	1973	1.76	7.77	3.40	7.61	7.51	7.74	-5.22	20.25	No		
	1974	15.38	7.34	73.83	7.50	25.56	6.83	14.32	36.80	Yes		
	1975	6.62	9.11	8.65	8.87	12.55	8.88	-2.06	27.16	No		
	* 1 <u>973</u> - 1975	8.36	4.60	8.68	4.58	16.38	4.44	9.08	23.68	Yes		
All 3 States	All * Years*	10.91	1.57 .	11.31	1.57	11.38	1.67	8.63	14.13	Yes		

*Weighted mean, using the inverse of the variance of each year as a weighting factor.

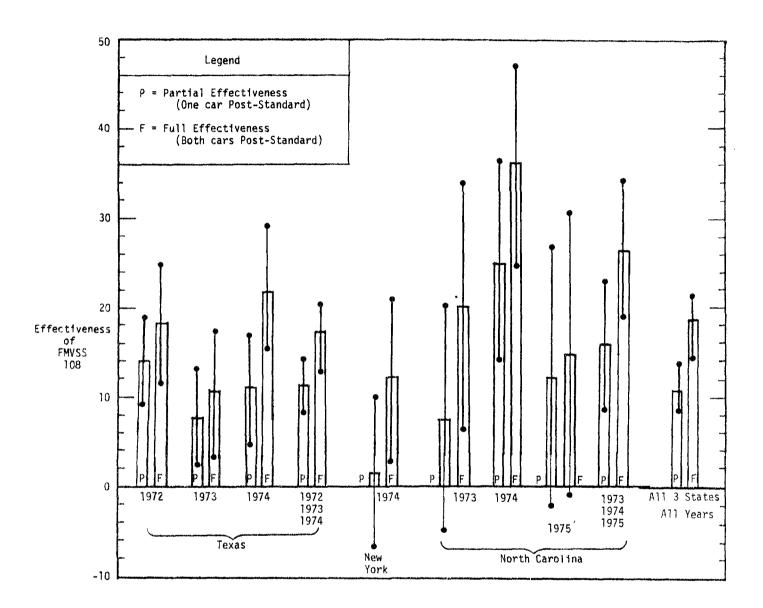


Figure 2-1. Summary of partial and full FMVSS 108 effectiveness values for two-car angle collisions in reduced light (smoothed, adjusted data, corrected for differential exposure risk).

As expected, these partial effectiveness values were in almost all cases between one-fifth to two-thirds less than the corresponding full effectiveness values. An overall average partial effectiveness value of 11 percent was obtained for all state-years of data analyzed, after controlling for exposure risk.

- 3. Impact of Adjustment of Data. Overall, the net impact of adjusting smoothed cell counts was to increase effectiveness values by roughly 1-3 percentage points, and to slightly reduce the variability of these estimates. However, in the case of Texas 1973 and North Carolina 1974 samples, smoothing and adjustment resulted in a decrease in effectiveness values of approximately 2 percentage points.
- Impact of Controlling for Exposure Risk. In the case of 4. North Carolina, where the analysis of single vehicle accidents revealed a significant over-representation of Post-Standard vehicles driven during periods of reduced lighting, full and partial effectiveness values were uniformly increased by an average of roughly 13 to 7 percentage points as a result of controlling for exposure risk. For the New York 1974 sample, where Post-Standard vehicles driven under reduced lighting conditions were under-represented in the population at large, full and partial effectiveness values were decreased by 10 to 5 percentage points, respectively. Controlling for exposure risk in the Texas samples, however, had no appreciable impact on effectiveness values, since both Pre- and Post-Standard cars driven during periods of reduced lighting were equally represented.

Using a weighted mean of 1974 effectiveness values for Texas, New York, and North Carolina to extrapolate to the nation, it is estimated that roughly 64,000 reduced light angle collisions were actually prevented by FMVSS 108 in 1974, when the numbers of Pre- and Post-Standard vehicles driven were approximately the same. Had <u>all</u> of the vehicles driven in 1974 been equipped with side marker lamps, however, it is estimated that more than 103,000 reduced light angle collisions could have been prevented by FMVSS 108.

2.3 Evaluation of the Analysis

2.3.1 Overall Success of the Analysis

The findings summarized in Tables 2-1 and 2-2 conclusively demonstrate the positive effectiveness of side marker lamps in preventing angle collisions occurring during periods of reduced lighting. The results of this analysis also indicate that, in many instances, side marker lamps are effective in preventing accidents even when only one vehicle in a potential reduced light collision situation satisfies the requirements of FMVSS 108.

2.3.2 Limitations of the Analysis

There are several potential limitations to this study which merit discussion. First, police-reported accident data are often lacking in detail and completeness. For example, we do not know from mass accident data whether the vehicle lights were on at the time of the accident. Furthermore, in New York, light condition information was not recorded in 1974, and had to be estimated from other information (county, time of day, month, etc.). Also, in New York, no record was made of whether the vehicles were approaching at an angle. However, information concerning the location of an accident (intersection or non-intersection), the vehicles' direction of travel, and the initial point of impact was available. The completeness of police accident reports was problematic insofar as many relevant accidents had to be excluded from the samples because information pertaining to vehicle model year, light condition or relevant control variables was unknown. In addition, a limitation which applies to the North Carolina data base concerns its relatively small sample size.

An additional limitation of the study is that the single vehicle accident data are not modeled or adjusted prior to their use in the effectiveness estimation procedure to control for differential exposure risk. Ideally, it would have been desirable to construct a Light Condition by Vehicle Configuration by Accident Type (angle collision or single vehicle) table stratified by relevant control variables for purposes of modeling, adjustment and computation of effectiveness values. Structural incompatibilities between the two groups of accidents, however, preclude this approach, as there is no vehicle configuration classification for single vehicles which is analogous to "Pre-with-Post."

2.3.3 Credibility of the Analysis

The results of the analysis of the effectiveness of side marker lamps are quite credible, given the overall size of the data bases, the general degree of consistency among the findings, the statistical significance of almost all effectiveness values obtained, and the straightforwardness of the analytic approach. The credibility of the analysis has been particularly enhanced by the use of single vehicle accidents as a control group.

2-7

3.0 ANALYSIS OF THE EFFECTIVENESS OF SIDE MARKER LAMPS

In this section, the effectiveness of side marker lamps in reducing the frequency of side collision accidents during periods of reduced lighting is empirically assessed, using police-reported state mass accident data. What follows is a brief description of CEM's approach for the analysis of side marker lamp effectiveness; a description of all relevant data bases used, along with information on how they were derived; a detailed presentation of the analysis; and finally, a summary of results.

3.1 Analysis Approach

The hypothetical impact of side marker lamps for three distinct scenarios of angle collisions occurring at intersections during periods of reduced lighting (night, dawn and dusk) is illustrated in Figure 3-1. ^{*} Since the purpose of the statistical evaluation of side marker lamp effectiveness is to test the hypothesis that side marker lamps reduce the frequency of reduced light angle collisions, this can be done by comparing the *observed* number of Post-Post

Scenario 1		Sce	nario	2	Scenario 3		
A PRE		A PRE			A POST		
P R E B	et all 10 and		O S T B			O S T B	
Neither vehicle ha any advantage in avoiding a collisi which can be attributed to side marker lamps.	on	Both vehi some adva Vehicle A Vehicle B due to Ve side mark Hence, Ve avoid a c Vehicle B Vehicle A	ntage, can s more hicle er lam hicle ollisi , ever does	since see readily B's mps. A can ion with	Both veh advantag can press the othe readily presence marker la	e, since umably s r more due to t of side	e each see the

Figure 3-1. Hypothetical expectations for the impact of side marker lamps in various scenarios for reduced light angle collisions at intersections.

^{*} Although each scenario allows for two possible collision outcomen (A upikes B, or B strikes A), no distinction is made between the "struck" and "striking" vehicles, since in many instances this is determined during the last split second before a side collision occurs, and is not necessarily directly related to the presence or absence of side marker lamps.

collisions with the *expected* number of such accidents, after controlling for relative exposure risk. Additionally, the *observed* number of reduced light Pre-Post collisions can be compared with the *expected* number of such collisions to test the partial effectiveness of FMVSS 108, again after controlling for relative exposure risk. By inference, the percent difference between the expected and observed number of reduced light angle collisions in each case can be attributed to the effect of side marker lamps.

Accidents, rather than vehicles, are used as the unit of analysis, since Pre-Standard vehicles can also benefit from FMVSS 108, to the extent that they are able to avoid collisions with Post-Standard vehicles during periods of reduced lighting due to the greater conspicuity of the latter. Figure 3-2 depicts the basic Vehicle Configuration-by-Light Condition table central to the analyses, which is stratified by a set of control variables selected according to the procedures outlined in Section 3.3 Figure 3-2 also contains the basic Pre-Post-by-Light Conditions table for single vehicle accidents, from which measures of relative exposure risk are derived for control purposes. Cell

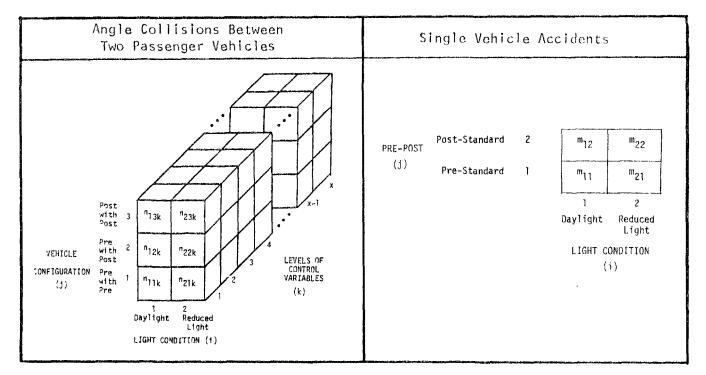
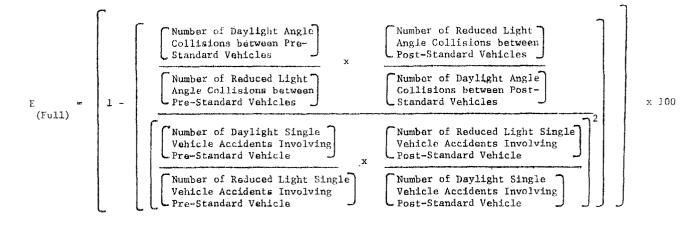


Figure 3-2. Basic contingency tables used to derive full and partial side marker lamp effectiveness estimates.

entries consist of observed counts $(n_{ijk}$'s and m_{ijk} 's), which are used to derive both "full" and "partial" effectiveness estimates. The former are based upon comparisons between Pre-Pre and Post-Post angle collision frequencies, after controlling for relative exposure risk, while the latter can be obtained by comparing the incidence of Pre-Pre and Pre-Post collisions across different light condition categories, again after controlling for relative exposure risk. Stated differently, *full* effectiveness represents the amount of accident avoidance realized when both vehicles in a potential reduced light angle collision satisfy the side marker lamp requirements of FMVSS 108, while *partial* effectiveness represents the amount of accident avoidance realized when only one of the vehicles satisfies FMVSS 108.

Full effectiveness can be defined as follows.

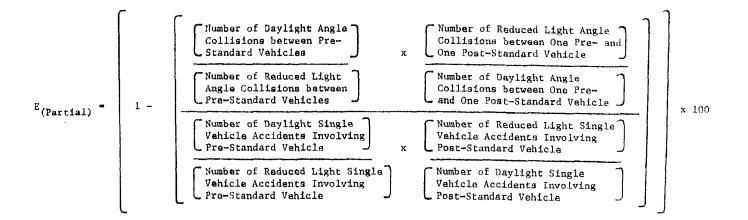


Using the notation in Figure 3-2, this can be expressed as:

$$E_{(Full)} = \left(1 - \left[\left(\frac{n_{11} \cdot n_{23}}{n_{13} \cdot n_{21}} \right) / \left(\frac{m_{11} \cdot m_{22}}{m_{21} \cdot m_{12}} \right)^2 \right] \right) \times 100$$

3-3

Partial effectiveness is defined as follows.



or:

$$E_{(Partial)} = \left(1 - \left[\left(\frac{n_{11} \cdot n_{22}}{n_{12} \cdot n_{21}} \right) / \left(\frac{m_{11} \cdot m_{22}}{m_{21} \cdot m_{12}} \right) \right] \right) \times 100$$

Since the daylight and reduced light exposure risks of Pre- and Post-Standard vehicles are not necessarily the same in the population at large-i.e., Post-Standard cars may, in fact, be less likely (or more likely) to be driven during periods of reduced lighting than Pre-Standard cars--the daylightto-reduced light involvement ratios for Pre- and Post-Standard vehicles in single vehicle accidents are explicitly incorporated into the preceding equations to control for any observed "effect" that is not due to FMVSS 108. In this sense, single vehicle accidents are used as a control group, and represent measures of relative exposure risk. In the case of the equation for estimating full effectiveness, it should be noted that the term $m_{11}m_{22}/m_{21}m_{12}$ in the denominator is squared. Since single vehicle accidents are used throughout the analysis as a measure of the reduced lighting exposure risk of Post-Standard vehicles relative to Pre-Standard vehicles, then the expectation (based upon exposure) of a reduced light angle collision between two Post-Standard vehicles can be expressed as the product of the expectations of each Post-Standard vehicle being involved in a reduced light angle collision--i.e., the square of $m_{11}m_{22}/m_{21}m_{12}$.

In addition to computing point estimates of effectiveness, an estimate of variability is necessary to generate the corresponding ranges of effectiveness (confidence intervals). Furthermore, in order to demonstrate that the observed effectiveness is significantly different from zero, one must reject the null hypothesis that there is no difference between the expected and observed incidence of angle collision accidents occurring under conditions of reduced lighting.

Prior to computing effectiveness values, however, the following preliminary treatment of the data must be carried out.

- Selection of a set of relevant control variables.
- · Smoothing of the data to remove chance variation.
- Adjustment of the data to allow for direct comparison of angle collision accidents.

Each of these procedures is described in detail later in this section. In general, the evaluation of the effectiveness of side marker lamps is carried out in the following steps.

- 1. Select the full mass accident data base. The data bases analyzed are Texas 1972-1974, New York 1974 and North Carolina 1973-1975.
- 2. Extract the partial data set to be used directly in evaluating side marker lamp effectiveness. The partial data set consists of side collision accidents involving two passenger vehicles.
- 3. Define a set of variables to be considered for modeling and adjustment purposes. In addition to Vehicle Configuration and Lighting Condition, all available variables that might represent possible confounding effects are considered for modeling and adjustment.
- 4. <u>Apply the variable selection procedure</u>. This procedure consists of ranking all potential variables according to the strength of their interactions with Vehicle Configuration and Lighting Condition, and choosing those variables with the highest overall degree of interaction.
- 5. Fit a hierarchical, log-linear model to the contingency table composed of Vehicle Configuration, Lighting Condition and those variables selected in Step 4. The purpose of modeling is to smooth the data and to remove random variability due to small cell frequencies that occur when a large number of control variables are used. Modeling also reveals the strength of various interactions among the variables.
- 6. Adjust the smoothed cell frequencies to allow for the direct comparison of side collision accidents. Adjustment is necessary to insure that the overall effectiveness estimates will not be affected by different distributions of Pre-Pre, Pre-Post and Post-Post accidents in daylight and reduced lighting conditions across different levels of the control variables identified in Step 4.

- 7. Examine single vehicle accident frequencies. The daylightto-reduced light ratios of Pre- and Post-Standard vehicles involved in single vehicle accidents provide the basis for determining the extent to which Post-Standard vehicles are either over- or under-represented during periods of reduced lighting in the population at large, relative to Pre-Standard vehicles.
- 8. Compute effectiveness values and confidence intervals. Values for both the full and partial effectiveness of side marker lamps are computed for each state-year of data, and an estimate made of their variances. Appropriate confidence intervals are determined, and the hypothesis that the obtained effectiveness values are significantly greater than zero is tested.
- 9. Extrapolate the results. A weighted mean of Texas 1972, 1973 and 1974 effectiveness values is used to extrapolate findings to a nationwide basis.

3.2 Data Characteristics

The data characteristics for each state are presented separately in this subsection. The generic tables that document each data set are the following.

- Relationship of partial data set to full data base.
- Univariate frequency distribution of relevant variables.
- Reduced lighting angle collision involvement rates for each level of vehicle configuration and relevant variables.

In each case, the data characteristics are discussed for three data sets:

- Texas 1972-1974
- New York 1974
- North Carolina 1973-1975.

The size of the partial data sets used in the analysis of side marker lamps relative to the entire state mass accident data bases can be characterized by noting the fraction of accidents and vehicles contained in the full data set as given in Table 3-1. All results are based on analyses of the partial data sets derived from the above listed police-reported mass accident data bases.

TABLE 3-1

NUMBER OF ACCIDENTS AND VEHICLES IN DATA BASES USED FOR THE ANALYSIS OF FMVSS 108

State	Year	Variable	Full Data Base	Partial Data Base	Percentage
Texas	1972	Accidents Vehicles	432,997 744,697	34,637 69,274	8.0 9.3
	1973	Accidents Vehicles	464,225 800,543	35,019 70,038	7.5 8.8
	1974	Accidents Vehicles	434,193 747,832	31,049 62,098	7.2 8.3
	1972-1974 (pooled)	Accidents Vehicles	1,331,415 2,293,072	100,705 201,410	7.6 8.8
New York	1974	Accidents Vehicles	377,818 704,477	18,913 37,826	5.0 5.4
North Carolina	1973	Accidents Vehicles	129,150 232,825	6,312 12,624	4.9 5.4
	1974	Accidents Vehicles	121,568 218,506	6,584 13,168	5.4 6.0
	1975	Accidents Vehicles	129,013 232,180	7,053 14,106	5.5 6.1
	1973-1975 (pooled)	Accidents Vehicles	379,731 683,511	19,948 39,898	5.3 5.8

As illustrated in Table 3-1, only a small subset of each state's yearly accident data base was used for the analysis of the effectiveness of side marker lamps. The criteria for the inclusion of accidents in the subsample for use in the analysis is the following.

- Accident type = Collision between motor vehicles.
- Manner of collision = Angle collision.
- Number of vehicles in accident = 2.
- Type of both vehicles in accident = Passenger car.
- Location of accident = Intersection or driveway access.
- Defects for both vehicles = None.
- Model year for both vehicles = Non-missing.
- Location of vehicle damage = One vehicle damaged in front, the other in the side.

The basic characteristics of the samples derived from Texas, New York and North Carolina can be seen from the univariate frequencies given in Tables 3-2, 3-3 and 3-4 of certain "key" variables used in the analysis of the effectiveness of side marker lamps. A critical variable in the analysis is Vehicle Configuration, which is classified relative to the Standard implementation date as Pre with Pre, Pre with Post or Post with Post. Texas accident data for 1072 through 1973 has the greatest representation of angle collisions in which both cars are Pre-Standard (25%); both New York (13% in 1974) and North Carolina (17% for 1973,1974,1975) have smaller representations of accidents in which both cars are Pre-Standard. The most frequent combination in all samples is Pre with Post, which includes roughly one-half of all accidents analyzed.

A second critical or "key" variable is Light Condition. The overall proportion of daylight accidents is 82 percent in Texas and 80 percent in North Carolina. In New York, 73 percent of all angle collisions occur in daylight. It is quite possible that there is a higher percentage of nighttime driving in New York. However, it should also be noted that Light Condition was a derived rather than an observed variable in New York. The proportion of accidents in Dawn/Dusk light conditions is 5.4 percent in New York compared with 2.4 percent in Texas and 4.2 percent in North Carolina. The proportion of accidents in dark conditions is 22 percent in New York compared with 16 percent in Texas and 15 percent in North Carolina.

3--8

TABLE 3-2

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM TEXAS 1972-1974 SAMPLES

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,		197	2	1973		1974		Total: 1972-1973	
Variable	Category	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	∜ of Known	Absolute Frequency	tof Known
Prepost	Pre with Pre Pre with Post Post with Post	12,142 16,193 6,302	35.1 46.8 18.2	8,429 16,888 9,702	24.1 48.2 27.7	5,031 14,621 11,397	16.2 47.1 36.7	25,602 47,702 27,401	25.4 47.4 27.2
Ligh t Condition	Daylight Dawn Dusk Dark - Road Lit Dark - Road Unlit	28,356 120 734 1,724 3,703	81.9 0.3 2.1 5.0 10.7	28,765 110 708 1,868 3,568	82.1 0.3 2.0 5.3 10.2	25,431 135 542 1,792 3,149	81.9 0.4 1.7 5.8 10.1	82,543 365 1,984 5,384 10,420	81.8 0.4 2.0 5.4 10.4
Road Classification	U.S. State Highway County Road City Street Farm-to-Market Other	8,160 526 23,117 1,218 1,616	23.6 1.5 66.7 3.5 4.7	8,503 481 23,139 1,231 1,665	24.3 1.4 66.1 3.5 4.8	7,453 428 20,569 1,066 1,533	24.0 1.4 66.2 3.4 4.9	24,116 1,435 66,825 3,515 4,814	24.0 1.4 66.3 3.5 4.8
Road Surface Condition	Dry Wet Snow-Ice Other	28,129 6,109 394 5	81.2 17.6 1.2 0.0	27,562 6,939 511 7	78.7 19.8 1.4 0.0	24,803 6,102 134 10	79.9 19.7 0.4 0.0	80,494 19,150 1,039 22	80.0 19.0 1.0 0.0
Weather	Clear-Cloudy Rain Snow Fog Dust	29,768 4,569 110 185 5	85.9 13.2 0.3 0.5 0.0	29,410 5,248 188 165 8	84.0 15.0 0.5 0.5 0.0	26,235 4,539 48 213 14	84.5 14.6 0.2 0.7 0.0	85,413 14,356 346 563 27	84.3 14.3 0.3 0.5 0.0
Traffic Control	None Signal Stop Sign Flashing Light Yield Sign Center Stripe/ Divider	8,006 8,258 15,162 657 1,793 675	23.1 23.8 43.8 1.9 5.2 1.9	7,935 8,701 15,256 635 1,723 661	22.7 24.8 43.6 1.8 4.9 1.9	4,202 8,537 13,005 612 1,486 3,109	13.5 27.5 41.9 2.0 4.8 10.0	20,143 25,496 43,423 1,904 5,002 4,445	20.0 25.3 43.1 1.9 5.0 4.4
Location of Accident	Other Intersection Driveway Access	86 30,798 3,839	0.2 88.9 11.1	108 30,816 4,203	0.3 88.0 12.0	98 27,363 3,686	0.3 88.1 11.9	292 88,977 11,728	0.3 88.3 11.7
Severity of Accident	Property Damage Only Type C Injury Type B Injury Type A Injury Fatality	26,450 3,040 3,758 1,269 120	76.4 8.8 10.8 3.7 0.3	26,994 2,920 3,855 1,116 134	77.1 8.3 11.0 3.2 0.4	23,843 2,820 3,507 820 59	76.8 9.1 11.3 2.6 0.2	77,287 8,780 11,120 3,205 313	76.8 8.7 11.0 3.2 0.3
City Size	Less than 5,000 5,000 - 9,999 10,000 - 24,999 25,000 - 49,999 50,000 - 99,999 100,000 - 249,999 250,000 or More	3,276 1,503 3,464 2,197 5,104 2,709 16,384	9.5 4.3 10.0 6.3 14.7 7.8 47.3	3,116 1,543 3,524 2,371 5,420 2,864 16,181	8.9 4.4 10.1 6.8 15.5 8.2 46.2	2,633 1,331 3,018 2,197 4,706 2,759 14,405	8.5 4.3 9.7 7.1 15.2 8.9 46.4	9,025 4,377 10,006 6,765 15,230 8,332 46,970	9.0 4.4 9.9 6.7 15.1 8.3 46.6
Worst TAD in Accident	0-1 2 3 4 5 6-7	5,743 11,009 11,187 3,943 1,573 1,182	16.6 31.8 32.3 11.4 4.5 3.4	6,299 11,686 11,206 3,564 1,319 945	18.0 33.4 32.0 10.2 3.8 2.7	5,822 10,512 9,813 3,185 1,069 648	18.8 33.9 31.6 10.3 3.4 2.1	17,864 33,207 32,206 10,692 3,961 2,775	17.7 33.0 32.0 10.6 3.9 2.8

Variable	Category	1972		1973		1974		Total: 1972-1974	
		Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known
Age of Driver of Striking Vehicle	15-24 25-34 35-54 55 or Older Missing	12,687 7,466 8,340 5,457 687	37.4 22.0 24.6 16.1	12,789 7,871 8,280 5,359 720	37.3 22.9 24.1 15.6	11,724 6,930 7,027 4,731 637	38.6 22.8 23.1 15.6	37,200 22,267 23,647 15,547 2,044	37.6 22.6 24.0 15.8
Age of Driver of Struck Vehicle	15-24 25-34 35-54 55 or Older Missing	11,684 7,336 8,855 6,136 626	34.4 21.6 26.0 18.0	12,148 7,434 8,685 6,136 616	35.3 21.6 25.2 17.8	10,929 6,954 7,261 5,401 504	35.8 22.8 23.8 17.7	34,761 21,724 24,801 17,673 1,746	35.0 22.0 25.1 17.9
Sex of Driver of Striking Vehicle	Male Female Missing	21,176 13,318 143	61.4 38.6 	21,306 13,559 154	61.1 38.9 	18,520 12,403 126	59.9 40.1 	61,002 39,280 423	60.8 39.2
Sex of Driver of Struck Vehicle	Male Female Missing	19,600 14,906 131	56.8 43.2 	19,655 15,244 120	56.3 43.7 	17,162 13,777 110	55.5 44.5 	56,417 43,927 361	56.2 43.8
Total Number of Cases		34,637		35,019		31,049		100,705	-+

.

TABLE 3-3

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM NEW YORK 1974 SAMPLE

Variable	Category	Absolute Frequency	% of Known
Prepost	Pre with Pre	2,478	13.1
	Pre with Post	8,770	46.4
	Post with Post	7,665	40.5
Light Condition	Daylight	13,715	72.5
	Dawn/Dusk	1,011	5.4
	Dark	4,187	22.1
Road Classification	U.SState Highway County Road Town Road City Street Limited Access Missing	5,245 2,169 2,359 7,937 255 948	29.2 12.1 13.1 44.2 1.4
Road Surface Condition	Dry Wet Snow/Ice/Slush Other Missing	12,463 5,019 1,307 49 75	66.2 26.6 6.9 0.3
Weather	Clear Cloudy Rain Snow/Sleet Other Missing	10,913 3,751 3,227 878 76 68	57.9 19.9 17.1 4.7 0.4
Traffic Control	None	5,241	28.2
	Signal	5,680	30.5
	Stop Sign	6,676	35.9
	Flashing Light	399	2.1
	Yield Sign	387	2.1
	Other	222	1.2
	Missing	308	
Location of Accident	Intersection	16,257	86.0
	Non-Intersection	2,656	14.0
Severity of Accident	Property Damage Only	6,331	33.5
	Personal Injury	12,527	66.2
	Fatality	55	0.3
Maximum Vehicle Damage	None	9	0.0
	Light	3,583	19.2
	Moderate	11,760	63.1
	Severe	3,185	17.1
	Demolished	88	0.5
	Missing	288	

Variable	Category	Absolute Frequency	% of Known	
Number of Towaways	None Only One Vehicle Both Vehicles	11,090 4,571 3,252	58.6 24.2 17.2	
Age of Driver of Striking Vehicle	15-24 25-34 35-54 55 or Older Missing	6,163 4,329 5,295 2,964 162	32.9 23.1 28.2 15.8	
Age of Driver of Struck Vehicle	15-24 25-34 35-54 55 or Older Missing	5,525 4,249 5,521 3,468 150	29.4 22.6 29.4 18.5	
Sex of Driver of Striking Vehicle	Male Female	12,643 6,270	66.8 33.2	
Sex of Driver of Struck Vehicle	Male Female	11,909 7,004	63.0 37.0	
Total Number of Case	18,913			

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TABLE 3	-3 (Continued)
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TABLE 3-4

FREQUENCY DISTRIBUTIONS OF KEY VARIABLES FROM NORTH CAROLINA 1973-1975 SAMPLES

		1973		1974		1975		Total: 1973-1975	
Variable	Category	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known
Prepost	Pre with Pre Pre with Post Post with Post	1,464 3,098 1,750	23.2 49.1 27.7	1,054 3,150 2,380	16.0 47.8 36.1	851 3,168 3,034	12.1 44.9 43.0	3,369 9,416 7,164	16.9 47.2 35.9
Light Condition	Daylight Dawn Dusk Dark-Road Lit Dark-Road Unlit	5,04 4 49 224 670 325	79.9 0.8 3.5 10.6 5.1	5,240 54 222 741 327	79.6 0.8 3.4 11.3 5.0	5,705 59 230 759 300	80.9 0.8 3.3 10.8 4.3	15,989 162 676 2,170 952	80.1 0.8 3.4 10.9 4.8
	U.S. Highway State Highway Rural Roads City Street Missing	887 512 717 4,148 48	14.2 8.2 11.4 66.2	822 462 729 4,557 14	12.5 7.0 11.1 69.4	834 543 746 4,895 35	11.9 7.7 10.6 69.8	2,543 1,517 2,192 13,600 97	12.8 7.6 11.0 68.5
Road Surface Condition	Dry Wet Snow-Ice Other Missing	5,100 1,074 123 12 3	80.8 17.0 2.0 0.2	5,213 1,350 12 4 5	79.2 20.5 0.2 0.1	5,536 1,475 25 8 9	78.6 20.9 0.4 0.1	15,849 3,899 160 24 17	79.5 19.6 0.8 0.1
Weather	Clear Cloudy Rain Snow/Sleet/Hail Fog Missing	4,267 1,126 787 53 35 44	68.1 18.0 12.6 0.8 0.5	4,281 1,272 943 15 53 20	65.2 19.4 14.4 0.2 0.8 	4,626 1,227 1,102 22 53 23	65.8 17.4 15.7 0.3 0.8 	13,174 3,625 2,832 90 141 87	66.3 18.2 14.3 0.4 0.7
Traffic Control	None Signal Stop Sign Flashing Light Yield Sign Other Missing	1,306 1,525 3,108 125 122 34 92	21.0 24.5 50.0 2.0 2.0 0.5	1,526 1,690 2,995 146 106 42 79	23.5 26.0 46.0 2.2 1.6 0.7	1,549 1,904 3,165 137 141 58 99	22.3 27.4 45.5 2.0 2.0 0.8 	4,381 5,119 9,268 408 369 134 270	22.3 26.0 47.1 2.1 1.9 0.6
Location of Accident	Intersection Driveway Access	5,362 950	84.9 15.1	5,458 1,126	82.9 17.1	5,893 1,169	83.6 16.4	16,713 3,236	83.8 16.2
Investigating Agency	Municipal Police Highway Patrol	4,461 1,851	70.7 29.3	4,818 1,766	73.2 26.8	5,169 1,884	73.3 26.7	14,448 5,501	72.4 27.6
City Size	Less than 5,000 5,000 - 9,999 10,000 - 24,999 25,000 - 49,999 50,000 - 74,999 Over 75,000	2,271 406 750 822 316 1,747	36.0 6.4 11.9 13.0 5.0 27.7	2,200 420 819 825 404 1,916	33.4 6.4 12.4 12.5 6.1 29.1	2,318 439 971 860 438 2,027	32.9 6.2 13.8 12.2 6.2 28.7	6,789 1,265 2,540 2,507 1,158 5,690	34.0 6.3 12.7 12.6 5.8 28.5
Severity of Accident	Property Damage Type C Injury Type B Injury Type A Injury Fatality	3,987 991 946 361 27	63.2 15.7 15.0 5.7 0.4	4,225 1,061 1,002 273 23	64.2 16.1 15.2 4.1 0.3	4,435 1,223 1,048 317 30	62.9 17.3 14.9 4.5 0.4	12,647 3,275 2,996 951 80	63.4 16.4 15.0 4.8 0.4

		1973		1974		1975		Total: 1973	3-1975
Variable	Category	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known	Absolute Frequency	% of Known
Maximum Vehicle Damage	Less than \$250 \$250 - \$499 \$500 - \$699 \$700 - \$999 \$1000 or More	1,123 2,212 1,129 853 995	17.8 35.0 17.9 13.5 15.8	1,080 2,365 1,109 886 1,144	16.4 35.9 16.8 13.5 17.4	1,088 2,340 1,265 962 1,398	15.4 33.2 17.9 13.6 19.8	3,291 6,917 3,503 2,701 3,537	16.5 34.7 17.6 13.5 17.7
Maximum Vehicle Speed	20 MPH or Less 21 - 29 MPH 30 - 40 MPH 41 - 49 MPH 50 MPH or More Missing	1,275 855 2,821 447 671 243	21.0 14.1 46.5 7.4 11.0	1,354 968 3,031 456 589 186	21.2 15.1 47.4 7.1 9.2 	1,343 1.041 3,342 532 613 182	19.5 15.2 48.6 7.7 8.9 	2,972 2,864 9,194 1,435 1,873 611	20.5 14.8 47.5 7.4 9.7
Age of Driver of Striking Vehicle	15 - 20 21 - 25 26 - 35 36 - 55 56 or Older Missing	1,377 1,084 1,319 1,467 1,011 54	22.0 17.3 21.1 23.4 16.2	1,468 1,191 1,307 1,523 1,042 53	22.5 18.2 20.0 23.3 16.0	1,483 1,218 1,490 1,678 1,153 31	21.1 17.3 21.2 23.9 16.4	4,328 3,493 4,116 4,668 3,206 138	21.8 17.6 20.8 23.6 16.2
Age of Driver of Struck Vehicle	15 - 20 21 - 25 26 - 35 36 - 55 56 or Older Missing	1,355 980 1,227 1,621 1,066 63	21.7 15.7 19.6 25.9 17.1	1,438 1,083 1,260 1,600 1,156 47	22.0 16.6 19.3 24.5 17.7	1,459 1,104 1,492 1,741 1,222 35	20.8 17.7 21.3 24.8 17.4 	4,252 3,167 3,979 4,962 3,444 145	21.5 16.0 20.1 25.1 17.4
Sex of Driver of Striking Vehicle	Male Female Missing	3,877 2,410 25	61.7 38.3 	3,901 2,661 22	59.4 40.6	4,115 2,932 6	58.4 41.6	11,893 8,003 53	59.8 40.2
Sex of Driver of Struck Vehicle	Male Female Missing	3,634 2,663 15	57.7 42.3 	3,736 2,828 20	56.9 43.1 	3,909 3,142 2	55.4 44.6 	11,279 8,633 37	56.6 43.4
Total Numb	per of Cases	6,312		6,584		7,053		19,949	~~~

TABLE 3-4 ((continued)
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Because of the importance of the Light Condition variable, it should be noted briefly how it was derived in New York. Using information on the County in which the accident occurred, the approximate latitude (LA) and longitude (LO) of the accident location was determined. The four relevant equations used for the computation of sunrise time (SRT) and sunset time (SST) are:

SRT =
$$12 - Y - ET - TZN + LO/15$$

 $Y = \frac{12}{\pi} \times \cos^{-1}$ (-tan LA x tan δ)
 $\delta = 23^{\circ} \times \sin \left[\left(\frac{n-80}{370} \right) 360 \right]$
SST = $24 - SRT$

where ET is a correction time for time zone TZN = 5, i.e., Eastern Standard Time, 6 is the declination, and n is the Julian Day. The values used for ET for each month are given in Table 3-5. It should also be noted that Daylight Savings Time was in effect from January 6, 1974, until the last Sunday of October in 1974. Light Condition was classified from the computations in the following manner.

- Daylight: Sunrise to sunset.
- Dawn: Forty minutes before sunrise to sunrise.
- Dusk: Sunset to 40 minutes after sunset.
- Dark: Forty minutes after sunset to 40 minutes before sunrise.

TABLE 3-5

MONTHLY VALUES USED FOR TIME CORRECTION

Month	ET Value (Hours)	Month	ET Value (Hours)
January	19	July	~.10
February	23	August	05
March	12	September	.11
April	.02	October	.26
May	.06	November	.23
June	03	December	.03

While the above computations may introduce some error to the Light Condition variable in New York, note that there are also some dissimilarities in the observed light conditions under which accidents occur in North Carolina and Texas. Basically, dawn/dusk appears to be considered a more extended period in North Carolina than in Texas. Also, a "night" accident is more likely than not to occur under a street light in North Carolina. The situation is reversed in the Texas samples.

Some additional comments on the univariate frequencies are listed briefly below.

- The percentages of Pre-Pre, Pre-Post and Post-Post accidents are roughly similar among matching years of Texas, New York and North Carolina data.
- Both North Carolina and Texas seem to experience similar weather conditions in terms of the percentage of accidents occurring for a given weather condition. In New York, a higher percentage of accidents occur in rain, and a far higher percentage (about five percent) of accidents occur in snow or sleet.
- In all three states, there is a greater proportion of male drivers in striking cars as compared to the proportion of male drivers in struck cars. There is also a tendency in all three states for younger drivers to be found in slightly higher proportions in striking cars as compared to struck cars.
- Also in all three states, about one-third or more of the drivers in striking cars and a similar fraction of drivers in struck cars were between 15 and 24 years of age (inclusive).

3.3 Variable Selection

The variable selection procedure is designed to select from a large group of potential variables a limited number that will be used to fit models to, and adjust, the data. The procedure, which is fairly straightforward, is detailed below.

- 1. For each potential variable, a three-variable saturated log-linear model containing Vehicle Configuration, Light Condition and Variable is fit.
- 2. Three likelihood ratio (LR) chi-square (χ^2) statistics are computed for the differences between the saturated model and three separate sub-models, the first of which differs from the saturated model only by the exclusion of the Variable x Vehicle Configuration interaction term, the second differing only by the exclusion of the Variable x Light Condition interaction term, and the third differing only by the exclusion of the Variable x Vehicle Configuration x Light Condition interaction term.
- 3. The harmonic mean of the three LR χ^2 statistics is computed.*
- 4. The variables are ordered according to the magnitude of the harmonic mean, and the highest ranked variables are selected for modeling and adjustment.

In addition to Vehicle Configuration and Light Condition, no more than five variables can be accommodated by the computer program used to fit hierarchical loglinear models to the data (BMDP: Biomedical Computer Program-P3F). Furthermore, to avoid problems of acute data sparsity in the contingency table to be modeled, the determination of the number of variables to be selected <u>must</u> take into account both the size of the sample from which the table is constructed <u>and</u> the number of categories characterizing each variable selected.

With regard to the latter, it should be emphasized that the choice of cutting points used to categorize a variable was not completely arbitrary. Whenever appropriate (and possible), several different "versions" of a given variable--each with different cutting points, and in many cases, with a different number of categories--were input into the variable selection procedure. Only one "version" of a variable, that with the highest harmonic mean of $LR\chi^2$'s, was used in subsequent analyses.

Figure 3-3 illustrates a typical example of the effort involved in determining the "optimal" .cutting points of the variable "Age of Driver of Struck Vehicle" in the New York 1974 sample (the tetrachotomy is chosen).

The harmonic mean of a set of n values, a_i , is found from evaluating $n/\Sigma 1/a_i$.

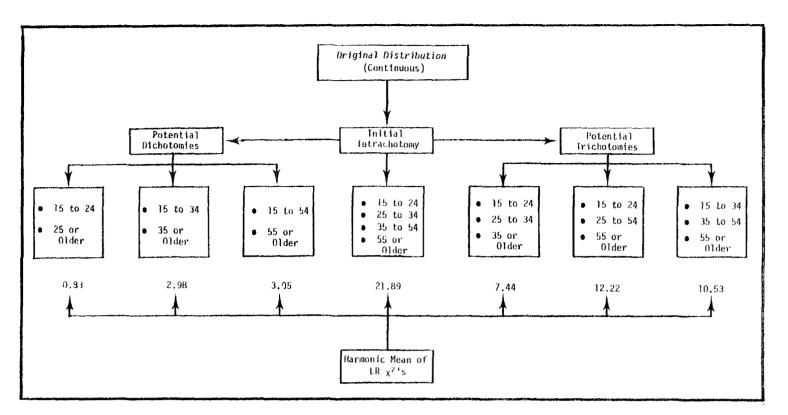


Figure 3-3. Example of determination of "optimal" cutting points of categorical variables.

Tables 3-2, 3-3 and 3-4 contain the variables which were candidates for selection in the Texas, New York and North Carolina samples. Reduced Lighting angle collision involvement rates, along with the number of angle collisions in each Vehicle Configuration category, are presented separately for each variable in Tables 3-6 through 3-12 for Texas 1972, 1973, 1974; New York 1974; and North Carolina 1973, 1974, 1975 samples, respectively.

As noted previously, the <u>overall</u> reduced lighting angle collision rates for Texas, New York and North Carolina are 18.2 percent, 27.5 percent and 19.9 percent, respectively. These figures can be kept in mind in the brief discussion below.

In the Texas sample, reduced lighting angle collision rates range from a high of 36.6 percent in 1974 collisions between Pre-Standard vehicles with at least one TAD between 5-7, to a low of 8.2 percent in collisions in the same year between Post-Standard vehicles when at least one driver was 55 years of age or older. Reduced lighting angle collision rates tend to be higher for accidents involving at least one young driver, at least one male driver, accidents involving injuries or fatalities and accidents with a high TAD for at least one of the vehicles. Reduced lighting angle collision rates tend to be lower for accidents occurring on

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PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR TEXAS 1972 SAMPLE

	Catacanu		Collision Lighting C (Percent)	onditions	Number of Angle Collisions			
Variable	Category	Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post	
Road Classification (N = 34,637)	City Street U.S. State Highway Other	17.9 24.4 22.5	15.6 20.7 22.0	15.5 18.6 19.0	8,262 2,802 1,078	10,747 3,839 1,607	4,108 1,519 675	
Age of Driver of Struck Vehicle (N = 34,011)	15-24 25-54 55 or Older	24.1 20.2 11.1	21.5 17.2 10.4	21.6 15.7 10.3	4,252 5,332 2,304	5,428 7,671 2,818	2,004 3,188 1,014	
City Size (N = 34,637)	Less than 100,000 100,000 or More	17.7 21.8	15.7 18.8	15.9 17.2	5,740 6,402	7,213 8,980	2,591 3,711	
Age of Driver of Striking Vehicle (N ≖ 33,950)	15-24 25-54 55 or Older	22.9 20.8 10.6	20.3 18.1 9.1	20.3 16.4 9.6	4,622 5,182 2,057	5,972 1,335 2,529	2,093 530 871	
Sex of Driver of Struck Vehicle (N = 34,506)	Male Female	23.7 14.1	21.7 11.6	21.0 11.5	7,090 4,996	9,124 7,011	3,386 2,899	
Location of Accident (N = 34,637)	Intersection Driveway Access	19.5 23.0	17.3 19.0	16.7 16.2	10,911 1,231	14,368 1,825	5,519 783	
Road Surface Condition (N = 34,637)	Dry Other	19.3 22.2	16.8 20.3	16.5 17.3	9,876 2,266	13,114 3,079	5,139 1,163	
Sex of Driver of Striking Vehicle (N = 34,494)	Male Female	23.8 12.9	20.9 11.8	20.3 11.2	7,600 4,477	9,865 6,268	3,711 2,573	
Worst TAD in Accident (N = 34,637)	0-2 3-4 5-7	17.0 21.0 30.3	14.6 19.0 26.2	14.8 16.9 26.5	5,872 5,310 960	7,828 7,061 1,304	3,052 2,759 491	
Severity of Accident (N = 34,637)	Property Damage Only Injury or Fatality	18.2 24.8	15.8 22.7	15.4 21.3	9,096 3,046	12,403 3,790	4,951 1,351	
Traffic Control Sign/Signal/Device Present? (N = 34,637)	Yes No	20.0 19.3	17.8 16.5	17.0 15.5	8,933 3,209	12,210 3,983	4,766 1,536	
Weather (N ≈ 34,637)	Clear-Cloudy Other	19.5 21.9	17.1 19.6	16.5 17.6	10,455 1,687	13,895 2,295	5,418 384	

PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR TEXAS 1973 SAMPLE

Vanish 1a	C = h = +		Collision Lighting C (Percent)	onditions	Number of Angle Collisions			
Variable	Category	Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post	
Sex of Driver of Striking Vehicle (N = 34,865)	Male Female	23.2 11.9	20.9 12.4	20.5 11.9	5,412 2,961	10,261 6,558	5,633 4,040	
Road Classification (N = 35,019	City Street U.S. State Highway Other	17.4 24.4 20.4	16.1 20.5 21.2	15.5 19.6 20.0	5,707 2,002 720	11,146 4,127 1,615	6,286 2,374 1,042	
Age of Driver of Striking Vehicle (N ≈ 34,299)	15-24 25-54 55 or Older	21.9 20.3 10.6	20.6 17.9 9.7	20.5 16.6 9.3	3,275 3,544 1,392	6,171 7,755 2,629	3,343 4,852 1,338	
Worst TAD in Accident (N = 35,019)	0-2 3-4 5-7	15.9 21.5 33.2	14.9 19.6 27.2	14.4 19.2 22.9	4,299 3,621 509	8,693 4,090 1,105	4,993 4,059 650	
City Size (N = 35,019)	Less than 100,000 100,000 or More	16.7 21.8	16.0 19.1	15.4 18.1	4,104 4,325	7,772 9,116	4,098 5,604	
Traffic Control Signal/Sign/Device Present? (N = 35,019)	Yes No	19.5 18.8	17.8 17.2	18.0 13.7	6,287 2,142	12,737 4,151	7,336 2,366	
Age of Driver of Struck Vehicle (N = 34,403)	15-24 25-54 55 or Older	23.4 19.8 10.6	21.8 17.6 9.6	21.0 16.6 9.7	3,106 3,498 1,651	5,849 7,758 2,990	3,193 4,863 1,495	
Sex of Driver of Struck Vehicle (N = 34,899)	Male Female	24.0 12.5	21.8 12.0	21.4 11.7	4,893 3,498	9,566 7,268	5,196 4,478	
Severity of Accident (N = 35,019)	Property Damage Only Injury or Fatality	17.7 23.9	16.2 22.7	15.9 21.0	6,299 2,130	13,036 3,852	7,659 2,043	
Road Surface Condition (N = 35,019)	Dry Other	18.7 21.7	17.3 18.9	16.3 19.3	6,607 1,822	13,304 3,584	7,651 2,051	
Weather (N = 35,019	Clear-Cloudy Other	18.8 22.2	17.3 19.6	16.5 19.6	7,085 1,344	14,198 2,690	8,127 1,575	
Location of Accident (N = 35,019)	Intersection Driveway Access	19.2 20.7	17.5 19.1	17.4 14.3	7,548 881	14,891 1,997	3,377 1,325	

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PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR TEXAS 1974 SAMPLE

N. askel N	C. Augusta		Collision Lighting C (Percent)	Conditions	Number of Angle Collisions			
Variable	Category	Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post	
Age of Driver of Struck Vehicle (N = 30,545)	15-24 25-54 55 or Older	24.4 20.4 10.4	22.3 18.4 11.1	21.7 16.1 8.2	1,825 2,094 1,014	5,252 6,461 2,655	3,852 5,660 1,732	
Worst TAD in Accident (N = 31,049)	0-2 3-4 5-7	16.5 21.5 36.6	15.6 20.9 27.1	14.4 18.4 30.1	2,510 2,237 284	7,723 6,060 838	6,101 4,701 595	
Road Classification (N = 31,049)	City Street U.S. State Highway Other	17.6 24.8 25.4	16.7 22.4 20.8	15.6 19.0 19.2	3,489 1,152 390	9,683 3,547 1,391	7,397 2,754 1,246	
City Size (N = 31,049)	Less than 100,000 100,000 or More	16.9 22.5	16.4 20.2	15.6 17.8	2,365 2,666	6,770 7,851	4,750 6,647	
Age of Driver of Striking Vehicle (N = 30,412)	15-24 25-54 55 or Older	23.1 20.7 10.7	21.8 18.7 8.9	20.6 16.3 9.0	1,967 2,016 933	5,613 6,420 2,298	4,144 5,521 1,500	
Traffic Control Signal/Sign/Device Present? (N = 31,049)	Yes No	20.7 17.3	19.1 16.2	17.1 16.0	3,783 1,248	11,201 3,420	8,713 2,684	
Weather $(N = 31,049)$	Clear-Cloudy Other	18.9 25.5	17.6 23.4	16.2 20.1	4,273 758	12,386 2,235	9,576 1,821	
Sex of Driver of Striking Vehicle (N = 30,923)	Male Female	23.9 12.6	22.1 12.4	20.7 11.7	3,147 1,862	8,873 5,682	6,500 4,859	
Severity of Accident (N = 31,049)	Property Damage Only Injury or Fatality	17.9 25.3	17.0 23.0	15.5 22.0	3,709 1,322	11,174 3,447	8,960 2,437	
Road Surface Condition (N = 31,049)	Dry Other	18.8 24.0	17.4 22.7	16.0 20.1	4,027 1,004	11,723 2,898	9,053 2,344	
Sex of Driver of Struck Vehicle (N = 30,939)	Male Female	24.1 13.4	22.9 12.5	21.3 11.8	2,943 2,062	8,187 8,376	6,032 5,339	
Location of Accident (N = 31,049)	Intersection Driveway Access	19.6 21.7	18.5 17.8	16.9 16.8	4,505 526	12,945 1,676	9,913 1,484	

PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR NEW YORK 1974 SAMPLE

Variable	Cotonomy		Collision Lighting ((Percent)	Conditions	Number o	of Angle Co	llisions
Variable	Category	Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post
Age of Dri ve r of Struck Vehicle (N = 18,763)	15-24 25-34 35-54 55 or Older	35.3 32.0 31.2 18.1	33.4 29.1 29.0 19.8	29.7 27.6 23.5 18.5	811 506 673 465	2,635 1,912 2,571 1,573	2,079 1,831 2,277 1,430
Road Classification (N = 17,710)	State Highway County Roads Town Roads City Streets	33.2 30.4 24.1 31.8	29.9 26.9 21.8 21.6	27.2 21.4 20.6 26.7	632 299 365 1,044	2,320 973 1,127 3,802	2,293 897 867 2,091
Number of Towaways (N = 18,913)	None One Vehicle Only Both Vehicles	28.8 30.0 35.9	26.3 30.7 34.0	24.0 26.8 27.2	1,514 527 437	5.118 2,157 1,495	4,458 1,887 1,320
Maximum Vehicle Damage (N = 18,625)	None-Light Moderate Severe-Demolished	27.2 29.8 34.3	25.4 28.4 32.6	24.2 25.0 26.9	419 1,583 440	1,622 5,476 1,544	1,551 4,701 1,289
Age of Driver of Striking Vehicle (N = 18,751)	15-24 25-34 35-54 55 or Older	33.9 33.4 28.5 21.2	31.8 33.0 27.4 17.5	29.0 28.2 24.5 15.5	912 515 666 354	2,997 1,982 2,394 1,324	2,254 1,832 2,235 1,286
Road Surface Condition (N = 18,838)	Dry Other	28.6 33.1	26.6 32.8	24.3 27.1	1,596 875	5,764 2,971	5,103 2,529
Sex of Driver of Struck Vehicle (N = 18,913)	Male Female	34.7 21.8	32.4 22.1	29.5 18.5	1,637 841	5,600 3,170	4,672 2,993
Traffic Control Signal/Sign/Device Present (N = 18,605)	No Yes	26.6 31.6	25.8 30.0	23.6 25.9	698 1,751	2,496 6,128	2,263 5,269
Weather (N = 18,845)	Clear-Cloudy Other	29.2 33.8	27.4 33.2	24.5 28.0	1,884 589	6,788 1,948	5,992 1,644
Location of Accident (N = 18,913)	At Intersection Non-Intersection	30.0 32.5	28.7 28.8	24.9 27.3	2,155 323	7,556 1,214	6,546 1,119
Severity of Accident (N = 18,813)	Property Damage Only Injury or Fatality	24.5 32.6	23.7 31.0	21.3 27.5	695 1,783	2,796 5,974	2,840 4,825
Sex of Driver of Striking Vehicle (N = 18,913)	Male Female	33.8 21.7	32.1 21.3	28.9 18.6	1,758 720	5,979 2,791	4,906 2,759

PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR NORTH CAROLINA 1973 SAMPLE

Variable	Category		Collision Lighting ((Percent)	Conditions	Number of Angle Collisions		
		Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post
Age of Driver of Struck Vehicle (N = 6,249)	15-25 26-55 56 or Older	25.0 20.4 13.2	24.1 19.4 14.8	25.0 16.0 13.4	532 629 280	1,162 1,368 540	641 851 246
City Size (N = 6,312)	Less than 50,000 50,000 or More	20.9 20.4	19.6 21.7	17.3 22.3	1,063 401	2,104 994	1,082 668
Maximum Vehicle Damage (N = 6,312)	Less than \$350 \$350 - \$899 \$900 or More	18.1 22.3 25.7	19.6 20.4 21.3	18.3 19.0 20.6	652 668 144	1,103 1,400 595	529 785 436
Road Surface Condition (N = 6,309)	Dry Other	19.4 26.2	18.5 27.7	18.6 22.0	1,163 301	2,501 595	1,436 313
Age of Driver of Striking Vehicle (N = 6,258)	15-25 26-55 56 or Older	24.0 21.1 13.7	24.0 20.2 11.6	22.2 19.6 9.33	550 630 270	1,237 1,323 516	674 833 225
Severity of Accident (N = 6,312)	Property Damage Injury or Fatality	18.2 24.7	19.2 22.1	17.8 21.8	889 575	1,966 1,132	1,132 618
Weather (N = 6,268)	Clear-Cloudy Other	19.4 28.1	19.2 25.5	19.0 21.3	1,251 203	2,628 447	1,514 225
Road Classification (N = 6,247)	U.S. State Highway City Street Rural Paved Road	23.7 20.0 19.9	24.9 18.7 20.2	21.4 19.2 14.6	317 957 171	694 2,041 331	388 1,150 198
Maximum Vehicle Speed (N = 6,111)	Less than 30 MPH 30-49 MPH 50 MPH or More	16.3 21.6 28.3	15.9 22.1 26.5	17.0 19.8 21.6	509 749 152	1,051 1,617 325	612 902 194
Sex of Driver of Striking Vehicle (N = 6, 287)	Male Female	23.3 16.1	23.0 15.8	22.6 14.1	927 528	1,921 1,167	1,029 715
Sex of Driver of Struck Vehicle (N = 6,297)	Male Female	24.2 15.1	23.4 16.1	22.6 14.9	900 562	1,757 1,334	977 767
Traffic Control Signal/Sign/Device Present? (N= 6,220)	No Yes	19.3 21.2	21.7 19.8	22.8 18.3	296 1,149	650 2,398	360 1,367
(N= 6,220) Location of Accident (N = 6,312)	Intersection Driveway Access	21.3 17.6	20.1 21.0	19.3 18.5	1,265 199	2,622 476	1,475 275
Investigating Agency (N = 6,312)	Municipal Police Highway Patrol	20.1 22.4	19.4 22.3	18.9 20.0	1,035 429	2,191 907	1,235 515

PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR NORTH CAROLINA 1974 SAMPLE

Variable	Category		Collision Lighting ((Percent)	Conditions	Number of Angle Collisions			
		Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post	
Age of Driver of Struck Vehicle (N = 6,537)	15-25 26-55 56 or Older	26.6 23.6 14.3	25.3 18.6 11.4	21.8 20.7 12.4	414 416 217	1,221 1,341 569	886 1,103 370	
Road Classification (N = 6,555)	U.S. State Highway City Street Rural Paved Road	26.1 20.1 33.9	23.3 19.2 20.4	24.1 18.9 16.1	211 712 127	617 2,159 363	456 1,686 224	
Sex of Driver of Striking Vehicle (N = 6,562)	Male Female	24.8 19.3	23.9 14.1	22.7 15.8	673 379	1,877 1,262	1,351 1,020	
Investigating Agency (N = 6,584)	Municipal Police Highway Patrol	20.1 30.1	18.9 23.1	19.3 21.0	755 299	2,283 867	1,780 600	
Maximum Vehicle Damage (N = 6,584)	Less than \$350 \$350 - \$899 \$900 or More	20.6 23.3 31.7	19.2 18.0 26.4	18.0 18.3 24.2	461 489 104	1,092 1,441 617	768 988 624	
Sex of Driver of Struck Vehicle (N = 6,564	Male Female	25.6 18.0	22.7 16.3	24.0 14.8	669 383	1,786 1,352	1,281 1,093	
City Size (N = 6,584)	Less than 5,000 5,000 or More	27.2 20.6	21.0 19.6	20.1 19.6	379 675	1,091 2,059	730 1,650	
Severity of Accident (N = 6,584)	Property Damage Injury or Fatality	20.1 28.3	17.2 25.0	18.1 22.8	683 371	1,995 1,155	1,547 833	
Age of Driver of Striking Vehicle (N = 6,531)	15-25 26-55 56 or Older	27.3 22.4 14.6	24.3 19.9 11.0	23.3 19.2 9.5	429 420 199	1,253 1,321 547	977 1,089 296	
Road Surface Condition (N = 6,579)	Dry Other	21.0 31.6	18.4 26.5	17.6 27.9	858 196	2,481 665	1,874 505	
Traffic Control Signal/Sign/Device Present? (N = 6,505)	No Yes	22.0 23.3	18.3 20.5	16.7 20.7	246 791	705 2,418	575 1,770	
Maximum Vehicle Speed (N = 6,415)	Less than 30 MPH 30-49 MPH 50 MPH or More	17.8 25.4 31.6	15.8 20.2 33.3	16.8 20.7 25.4	381 551 95	1,108 1,676 285	850 1,260 209	
Weather (N = 6,564)	Clear-Cloudy Other	21.6 29.6	18.8 26.6	18.2 27.8	898 152	2,655 489	2,000 370	
Location of Accident (N = 6,584)	Intersection Driveway Access	23.3 21.4	20.4 18.1	20.4 16.8	881 173	2,637 513	1,940 440	

PERCENT OF ANGLE COLLISIONS OCCURRING DURING PERIODS OF REDUCED LIGHTING FOR NORTH CAROLINA 1975 SAMPLE

Variable	Category		Collision Lighting C (Percent)	onditions	Number of Angle Collisions			
		Pre with Pre	Pre with Post	Post with Post	Pre with Pre	Pre with Post	Post with Post	
Age of Driver of Striking Vehicle (N = 7,022)	15-25 26-55 56 or Older	24.5 21.2 9.3	24.0 18.3 8.8	25.1 17.0 11.0	323 354 172	1,241 1,369 536	1,137 1,445 445	
Road Classification (N = 7,005)	U.S. State Highway City Street Rural Paved Road	24.3 18.0 23.0	20.9 18.5 18.0	21.3 19.0 15.1	181 567 100	623 2,165 355	573 2,163 278	
Severity of Accident (N - 7,053)	Property Damage Injury or Fatality	18.2 22.9	16.8 22.4	19.1 19.0	528 323	1,967 1,201	1,940 1,094	
Sex of Driver of Struck Vehicle (N = 7,051)	Male Female	23.0 15.2	22.0 14.7	23.9 13.9	521 330	1,818 1,349	1,570 1,463	
Age of Driver of Struck Vehicle (N = 7,018)	15-25 26-55 56 or Older	24.6 20.4 11.5	22.6 18.8 12.4	23.2 18.7 10.5	301 358 183	1,139 1,432 582	1,123 1,443 457	
Maximum Vehicle Speed (N = 6,887)	Less than 30 MPH 30-49 MPH 50 MPH or More	15.2 23.6 19.2	16.2 20.2 22.4	16.4 20.0 24.7	295 449 78	1,089 1,743 272	1,016 1,682 263	
Maximum Vehicle Damage (N ≠ 7,053)	Less than \$350 \$350 - \$899 \$900 or More	19.0 20.6 21.4	17.2 18.5 22.2	18.3 18.6 20.6	378 384 89	1,024 1,431 713	878 1,327 829	
Road Surface Condition (N = 7,044)	Dry Other	19.5 21.5	17.5 24.1	17.1 26.1	673 177	2,499 665	2,364 666	
City Size (N = 7,053)	Less than 75,000 75,000 or More	19.6 21.3	18.8 19.2	18.2 20.9	673 178	2,315 853	2,038 996	
Weather (N = 7,030)	Clear-Cloudy Other	20.1 19.4	18.0 23.4	17.7 25.5	713 134	2,632 526	2,508 517	
Investigating Agency (N = 7,053)	Municipal Police Highway Patrol	18.7 23.0	18.7 19.4	18.9 19.7	603 248	2,294 874	2,272 762	
Sex of Driver of Striking Vehicle (N = 7,047)	Male Female	22.2 16.2	21.9 14.7	22.4 14.7	537 314	1,856 1,309	1,722 1,309	
Traffic Control Signal/Sign/Device Present? (N = 6,954)	No Yes	24.4 18.2	19.1 19.1	19.6 18.8	193 648	681 2,439	675 2,318	
Location of Accident (N = 7,053)	Intersection Driveway Access	18.5 27.5	18.9 19.0	19.0 19.4	713 138	2,652 516	2,528 506	

city streets, involving at least one older driver, at least one female driver, and involving no personal injuries and minimal vehicle damage.

In the New York sample, reduced lighting angle collision rates range from a high of 35.9 percent in towaway accidents in which both cars are Pre-Standard to a low of 15.5 percent for collisions in which both cars are Post-Standard and the age of at least one driver is 55 years or older. Rates tend to be higher when young drivers and male drivers are involved, and when accidents occur on state highways, involve an injury or fatality, result in extensive vehicle damage, result in both vehicles being towed, and occur when the environmental condition is other than dry.

In the North Carolina sample, reduced lighting angle collision rates range from a high of 33.9 percent for collisions between Pre-Standard cars on rural paved roads in 1974, to a low of 8.8 percent for collisions between one Pre-Standard and one Post-Standard car in 1975 in which the age of at least one driver is 56 years or older. Higher reduced lighting angle collision rates are associated with young drivers, male drivers, high speed accidents, precipitating conditions and wet surfaces, high dollar amounts of vehicle damage and accidents involving injuries or fatalities.

The information used in the variable selection procedure to determine those variables selected for modeling and adjustment purposes in the Texas, New York and North Carolina samples is given in Tables 3-13 through 3-19. In each table, the variables analyzed are listed in descending order of the magnitude of the harmonic mean of the $LR\chi^2$'s of the partial association of the following three interaction terms: Variable x Vehicle Configuration, Variable x Light Condition, and Variable x Vehicle Configuration x Light Condition. For the convenience of the reader, the variables selected in each sample are listed below in the same order as they appear in the tables.

3-26

Texas 1972

- Road Classification
- Age of Driver of Struck Vehicle

Texas 1973

- Sex of Driver of Striking Vehicle
- Road Classification
- Age of Driver of Striking Vehicle
- Worst TAD in Accident

Texas 1974

- Age of Driver of Struck Vehicle
- Worst TAD in Accident
- Road Classification

North Carolina 1973

- Age of Driver of Struck Vehicle
- •City Size
- •Maximum Vehicle Damage

North Carolina 1974

- •Age of Driver of Struck Vehicle
- •Road Classification
- •Sex of Driver of Striking Vehicle

North Carolina 1975

- ●Age of Driver of Striking Vehicle ●Road Classification
- •Severity of Accident

New York 1974

- Age of Driver of Struck Vehicle
- Road Classification
- Number of Towaways

Thus, the most frequently used variables for modeling and adjustment are Road Classification, Age of Driver, Worst TAD in Accident (or Maximum Vehicle Damage), and Sex of Driver.

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE TEXAS 1972 SAMPLE

antan galan yang dari yang dari L			ms from the 3 epost, Light		Saturated Mode and Variable	2]	Harmonic Mean of	
Vartable	Variable x	Variable x Prepost		Light condition	Variable x Pr Light Cond	Interaction Terms		
	LR x ²	df	LR X ²	df	LR x ²	df		
Road Classification	27.24	4	137.23	2	6.23*	4	14.67	
Age of Driver of Struck Vehicle	78.25	4	407.33	2	5.01*	4	13.96	
City Size	68.96	2	56.33	1	3.93*	2	10.46	
Age of Driver of Striking Vehicle	125.47	4	386.60	2	3.50*	4	10.13	
Sex of Driver of Struck Vehicle	31.54	2	566.28	1	2.70*	2	7.43	
Location of Accident	23.84	2	8.'04	1	3.85*	2	7.04	
Road Surface Condition	1.24*	2	28.07	1	3.12*	2	2.58	
Sex of Driver of Striking Vehicle	20.48	2	544.51	1	0.90*	2	2.58	
Worst TAD in Accident	0.80*	4	249.12	2	4.15*	4	2.01	
Severity of Accident	27.27	2	177.76	1	0.55*	2	1.61	
Traffic Control	15.65	2	5.51	1	0.58*	2	1.52	
Weather	0.66*	2	13.79	1	0.60*	2	0.92	

 \mathbb{P}^{1}

*p >0.05

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE TEXAS 1973 SAMPLE

1			ms from the C epost, Light		Saturated Mode and Variable	el	Harmonic	
Vartable	Variable x Prepost		Variable x_(Light Condition	Variable x Pi Light Cond	Mean of Interaction Terms		
ىرىكى دەرىپى يىلىغىنىيى بىلىغىنىيى بىلىغىنىيى قىلىغىنىيى بىلىغىنىيى بىلىغىنىيى بىلىغىنىيى بىلىغىنىيى بىلىغىنى ب	LR x ²	df	LR x ²	df	LR x ²	df	1	
Sex of Driver of Striking Vehicle	70.66	2	498.16	1	5.38*	2	14.85	
Road Classification	32.01	4	120.51	2	5.96*	4	14.47	
Age of Driver of Striking Vehicle	111.03	4	353.25	2	3.49*	4	10.06	
Worst TAD in Accident	5.83*	4	273.20	2	8.02*	4	10.00	
City Size	81.18	2	70.89	1	3.47*	2	9.54	
Traffic Control	3.16*	2	11.58	1	13.50	2	4.36	
Age of Driver of Struck Vehicle	141.63	4	443.30	2	1.28*	4	3.80	
Sex of Driver of Struck Vehicle	36.79	2	625.09		1.26*	2	3.65	
Severity of Accident	41.77	2	148.05	1	0.99*	2	2,88	
Road Surface Condition	0.57*	2	20.39	1	1.84*	2	1.28	
Weather	0.57*	2	24.40	1	0.71*	2	0.94	
Location of Accident	44.70	2	0.06*	1	11.92	2	0.18	

*p >0.05

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE TEXAS 1974 SAMPLE

			ms from the S repost, Light		Saturated Mod and Variable	el	Harmonic
Vartable	Variable x	Prepost	Variable x _{.(}	Light Condition	Variable x P Light Cond		Mean of Interaction Terms
an a	LR x ²	df	LR x ²	df	LR x ²	df	
Age of Driver of Struck Vehicle	137.70	4	396.45	2	7.07*	4	19.84
Worst TAD in Accident	19.12	4	257.67	2	9.51	4	18.60
Road Classification	55.38	4	115.41	2	6.15*	4	15.85
City Size	71.83	2	64.42	1	5.73*	2	14.71
Age of Driver of Striking Vehicle	147.04	4	387.80	2	4.41*	4	12.70
Traffic Control	4.61*	2	21.80	1	2.84*	2	4.88
Weather	4.10*	2	70.69	1	1.78*	2	3.66
Sex of Driver of Striking Vehicle	51.18	2	492.91	1	1.14*	2	3.34
Severity of Accident	44.23	2	146.98	1	0.84*	2	2.46
Road Surface Condition	2.99*	2	75.63	1	0.41*	2	1.08
Sex of Driver of Struck Vehicle	45.24	2	539.57	7	0.18*	2	0.54
Location of Accident	26.34	2	0.01*	1	1.64*	3	0.03

*p >∩.95

na na na kata na kata na kata na kata na kata kat	Intera Cont	ction Ter aining Pr	ms from the epost, Light	3-Variable Condition	Saturated Moc and Variable	le1	Harmonic
Variable	Variable x	Prepost	Variable x	Light Condition	Variable x P Light Cond		Mean of Interaction Terms
	LR x ²	df	LR x ²	df	LR x ²	df	
Age of Driver of Struck Vehicle	39.96	6	197.41	3	9.35*	6	21.89
Road Classification	55.43	6	74.54	3	5.55*	6	14.18
Number of Towaways	14.46	4	50.14	2	6,18*	4	11.96
Maximum Vehicle Damage	15.78	4	25.09	2	3.39*	4	7.53
Age of Driver of Striking Vehicle	64.22	6	240.62	3	2.37*	6	6.79
Road Surface Condition	3.45*	2	44.95	1	4.08*	2	5.38
Sex of Driver of Struck Vehicle	20.02	2	271.00	1	1.93*	3	5.25
Traffic Control	2.56*	2	23.87	1	1.60*	2	2.84
Weather	4.67*	2	35.23	1	1.18*	2	2.75
Location of Accident	4.62*	2	2.22*	1	1,51*	2	2.26
Severity of Accident	79.51	2	103.28]	0.34*	2	1.01
Sex of Driver of Striking Vehicle	44.80	2.	251.32	414-214-14-24 (1994) 9 9	0.24*	2	0.72

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE NEW YORK 1974 SAMPLE

*p >0.05

INTERACTION TERMS EVALUATED IN VARIABLE SELECTION PROCEDURE NORTH CAROLINA 1973 SAMPLE

			ms from the 3 epost, Light		Saturated Mode and Variable	3]	Harmonic
Variable	Variable x	Prepost	Variable x ₍	Light Condition	Variáble x Pi Light Cond		Mean of Interaction Terms
	LR χ^2	df	LR x ²	df	LR x ²	df	
Age of Driver of Struck Vehicle	21.17	4	57.99	2	4.23*	4	9.97
City Size	43.53	2	5,17	1	3.40*	2	5.88
Maximum Vehicle Damage	153.17	4	4.76	2	2.72*	4	5.14
Road Surface Condition	3.38*	2	29.49	1	2.88*	2	4.43
Age of Driver of Striking Vehicle	26.63	4	69.12	2	1.42*	4	3.98
Severity of Accident	5.73*	2	14.84	1	1.78*	2	3.68
Weather	2,29*	2	15.,0	1	1.99*	2	2.98
Road Classification	1.29*	4	14.17	2	4.01*	4	2.18
Maximum Vehicle Speed Prior to Impact	0.99*	4	35.14	2	2.99*	4	2.18
Sex of Driver of Striking Vehicle	7.64	2	54.61	1	0.55*	2	1.52
Sex of Driver of Struck Vehicle	11.51	2	60.13	1	0.49*	2	1.40
Traffic Control	0.46*	2	1.93*	1	3.38*	2	1.00
Location of Accident	3.32*	2	0.17*	1	1.47*	2	0.44
Investigating Agency	0.02*	2	4.01	1	0.37*	2	0.06

* p > 0.05

INTERACTION TERMS EVALUATED IN VARIABLE SFLECTION PROCEDURE NORTH CAROLINA 1974 SAMPLE

αφθα κατά την Πρωτερικέ κατά το μετα δροβουρίας του στο 2 πάβθηθαία στα στο το Ναιάθουβα στα που					Saturated Mod and Variable	el	Harmonic
Variable	Variable x	Prepost	Variable x	Light Condition	Variable x P Light Cond		Mean of Interaction Terms
	$LR \chi^2$	df	LR x ²	df	LR x ²	df]
Age of Driver of Struck Vehicle	22.46	4	76.21	2	5.70	4	12.87
Road Classification	8.98*	4	14.51	2	10.95	4	11.05
Sex of Driver of Striking Vehicle	13.86	2	65.64]	3.72*	2	8.42
Investigating Agency	4.95*	2	14.06	1	4.92*	2	6.30
Maximum Vehicle Damage	145.27	4	32.76	2	2.21*	4	6.12
Sex of Driver of Struck Vehicle	26.10	2	58.08	1	1.72*	2	4.71
City Size	13.05	2	3.49*	1	3.35*	2	4.53
Severity of Accident	2.01*	2	42.02	ſ	1.87*	2	2.84
Age of Driver of Striking Vehicle	38.76	4	89.12	2	0.95*	4	2.75
Road Surface Condition	4.54*	2	54,60	1	0.72*	2	1.85
Traffic Control	2.88*	2	5.38	1	0.91*	2	1.84
Maximum Vehicle Speed Prior to Impact	0.65*	4	56.16	2	5.41*	4	1.72
Weather	1.16*	2	35.72	1	0.43*	2	0.93
Location of Accident	4.91*	2	4.42	1	0.35*	2	0.91

p >0.05

Note: The variables above the heavy line were selected for modeling.

i.

INTERACTION TERMS EVALUATED IN VARIABLE SFLECTION PROCEDURE NORTH CAROLINA 1975 SAMPLE

, , , , , , , , , , , , , , , , , , ,	Intera Conta	ction Ter aining Pr	ms from the 3 epost, Light	-Variable Condition	Saturated Mode and Variable	1	Harmonic
Variable	Variable x	Prepost	Variable x _. C	Light condition	Variable x Pr Light Condi		Mean of Interaction Terms
والمراجع وال	LR x ²	df	LR x ²	df	LR x ²	df	
Age of Driver of Striking Vehicle	23.96	4	128.03	2	4.28*	4	10.59
Road Classification	12.95	4	6.60	2	4.15*	4	6.39
Severity of Accident	2.57*	2	9.97	1	7.94	2	4.88
Sex of Driver of Struck Vehicle	33.18	2	83.31	1	1.61*	2	4.52
Age of Driver of Struck Vehicle	25.35	4	76.74	2	1.18*	4	3.33
Maximum Vehicle Speed Prior to Impact	1.51*	4	24.20	2	3.66*	4	3.07
Maximum Vehicle Damage	143.66	4	7.89	2	1.16*	4	3.01
Road Surface Condition	1.07*	2	36.84	1	3.45*	2	2.40
City Size	56.49	2	2.38*	1	1.03*	2	2.04
Weather	0.86*	2	19.95	1	3.93*	2	2.04
Investigating Agency	7.74	2	1.32*	1	1.09*	2	1.66
Sex of Driver of Striking Vehicle	10.83	2	59.57	df LR x ² 2 4.28* 2 4.15* 1 7.94 1 1.61* 2 1.18* 2 1.18* 2 1.16* 1 3.45* 1 1.03* 1 0.38*	0.38*	2	1.05
Traffic Control	0.71*	2	0.94*	٦	2.70*	2	1.05
Location of Accident	0.21*	2	1.00*	2	4.55*	2	0.50

*p >0.05

3.4 Analysis of Mass Accident Data

Following completion of the variable selection procedure, the analytical steps that remain are modeling, adjustment of data, computation of effectiveness values, error estimation, and extrapolation of results to the nation. Each of these steps, along with the results, is described in the following subsections.

3.4.1 Modeling

The basic purpose of modeling as it is applied to the evaluation of side marker lamp effectiveness is twofold:

- 1. To "smooth" the data--i.e., remove random variation due to small cell counts.
- 2. To compensate for the uneven distribution of data across cells, especially the sparsity of data which characterizes the reduced light categories for certain subpopulations.

CEM used the log-linear modeling routine (BMDP3F) of the Biomedical Computer Program's P-Series to generate smoothed or "fitted" cell frequencies. The BMDP3F program, which is based on an iterative proportional fitting (IPF) algorithm, was chosen for the number of dimensions in contingency tables (up to seven) which it can handle, as well as for its model screening capability.

The fitting of log-linear models to the data involves several steps. First, fully cross-classified contingency tables--i.e., containing no missing data for any of the variables--were constructed, using Lighting Condition, Vehicle Configuration and all variables selected by the procedure discussed in Section 3.3. Appendix A contains complete listings of each of these contingency tables.

Next, a description of the relationships among variables (or "effects") was obtained, consisting of a test of the significance of the main effects and of the various interactions between these effects.* This provided a basis for ordering the interaction terms by their importance (significance). Using this information, a model was fit according to the following iterative procedure:

- 1. As many significant effects as required were first specified in an attempt to derive a model with an optimal fit. Optimal fit refers to the situation in which the magnitude of the model's LR chi-square is roughly similar to its number of degrees of freedom.
- 2. Effects were either deleted or added to the model in a stepwise fashion until the deletion of any one effect would result in a significant worsening of the fit, whereas the addition of any single effect would not significantly improve the model's fit.

The terminology used here (main effects, interaction terms, etc.) is analogous to that used in an Analysis of Variance model. A major difference involves the fact that in the log-linear modeling approach, it is the *logarithm* of the expected cell frequency which is an additive function of both main effects and interaction terms.

This approach represents a compromise of sorts between the two considerations of parsimony and goodness-of-fit. In all cases, residuals were examined to detect possible systematic patterns in the error terms, which might necessitate the respecification of the model.

Tables 3-20 to 3-22 summarize the models fit to data from Texas, New York and North Carolina samples. The likelihood ratio (LR) chi-square values were derived from tests of <u>marginal</u> association for each effect, in which the cell counts for the complete contingency table were summed over all unspecified margins, after which the effect (interaction term) was tested to be zero, using a LR chi-square statistic.

Since the log-linear models fitted are hierarchical models, the specification of a given effect forces all lower-order effects which are subsets of the effect into the model. For example, if a "Vehicle Configuration x Light Condition x Road Type" effect is specified, the following additional terms are hierarchically included:

- Vehicle Configuration x Light Condition
- Vehicle Configuration x Road Type
- Light Condition x Road Type
- Vehicle Configuration
- Light Condition
- Road Type

Therefore, Tables 3-20 to 3-22 contain the LR χ^2 values and significant levels of the directly specified effects only. A complete enumeration of both specified and hierarchically included model effects can be found in Appendix B. Chi-square values marked with an asterisk in Appendix B represent effects which were specified. All other chi-square values denote those effects which were included due to the hierarchical nature of the log-linear models.

3.4.2 Adjustment of Data

Prior to computing the actual effectiveness values, the smoothed (or "fitted") data were adjusted to allow for the direct comparison of angle collision frequencies. Such adjustment is necessary to insure that the overall effectiveness estimate will not be affected by a potentially different distribution of Pre-with-Pre, Pre-with-Post and Post-with-Post collisions across all levels of the pre-crash control variables identified by the variable selection procedure (described in Section 3.3).

Effect *	Те	xas 19	72	Te	exas 19	73	Te	xas 19	74
L) CC L	LR x ²	df	Prob.	LR x ²	df	Prob.	$LR \chi^2$	df	Prob.
Veh Mix x Light Cond	36.28	2	0.000	17.15	2	0.000	22.12	2	0.000
Veh Mix x Road Type	24.54	4	0.000	30.61	4	0.000	49.90	4	0.000
Veh Mix x Dr Age	76.26	4	0.000	108.97	4	0.000	133.23	4	0.000
Light Cond x Road Type	134.56	2	0.000	123.57	2	0.000	114.06	2	0.000
Light Cond x Dr Age	405.35	2	0.000	349.91	2	0.000	391.95	2	0.000
Road Type x Dr Age	126.87	4	0.000	73.42	4	0.000	39.79	4	0.000
Road Type x Max TAD	-	-		338.29	4	0.000	247.97	4	0.000
Max TAD x Dr Age	-	-	÷	56.42	4	0.000	18.47	4	0.001
Veh Mix x Dr Age x Dr Sex	~	-	u	19.28	4	0.001	-	-	-
Veh Mix x Light Cond x Max TAD	-				-	-	9.40	4	0.052
Light Cond x Max TAD x Dr Age	-	-	-	10.60	4	0.032	-	~	-
Light Cond x Max TAD x Dr Sex	~	-	-	8.38	2	0.015	-	-	-
Light Cond x Dr Age x Dr Sex	-			21.54	2	0.000	-	-	-
Light Cond x Road Type x Dr Age	-	-	~	-	-		9.18	4	0.057
Road Type x Dr Age x Dr Sex	-			13.35	4	0.010	-	-	-
Max TAD x Jr Age x Dr Sex	-	-		9.76	4	0.045	-	-	-
SUMMARY OF MODEL	36.28	28	0.138	260.81	256	0.405	125.97	112	0.17

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR TEXAS 1972-1974 SAMPLE

*For the Texas 1972 and 1974 models, driver characteristics refer to drivers of the struck vehicles, whereas for the Texas 1973 model, they refer to drivers of the striking vehicle.

3-37

Effect *	Ne	w York 19	974
	LR x ²	df	Prob.
Vehicle Mix x Light Condition	37.04	2	0.000
Vehicle Mix x Dr Age x Towaways	21.65	12	0.042
Vehicle Mix x Road Type x Towaways	40.63	12	0.000
Light Condition x Dr Age x Road Type	13.99	9	0.123
Light Condition x Dr Age x Towaways	21.10	6	0.002
Light Condition x Road Type x Towaways	25.80	18	0.104
Dr Age x Road Type x Towaways	172.60	166	0.347
SUMMARY OF MODEL		1	

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR NEW YORK 1974 SAMPLE

* Driver Age refers to drivers of struck vehicles.

TABLE 3-22

SUMMARY OF TESTS OF MARGINAL ASSOCIATION OF DIRECTLY SPECIFIED MODEL EFFECTS FOR NORTH CAROLINA 1973-1975 SAMPLE

Effect *	North C	arolir	ia 1973	North Ca	rolina	1974	North Ca	nrolina	1975
	LR χ ²	df	Prob.	LR χ^2	df	Prob.	LR x ²	df	Prob.
Veh Mix x Light Cond	1.96	2	0.376	4.46	2	0.107	.0.49	2	0.782
Veh Mix x Dr Age	20.72	4	0.000	21.77	4	0.000	.22.83	4	0.000
Veh Mix x City Size	41.76	2	0.000	-	-	-	-	-	-
Veh Mix x Damage	147.83	4	0.000	-	-	-	-	-	-
Veh Mix x Road Type	-	-	-	9.72	4	0.045	13.39	4	0.010
Light Cond x City Size	4.36	1	0.037	-	-	-	-	-	-
Light Cond x Dr Age	57.53	2	0.000	70.30	2	0.000	126.72	2	0.000
Dr Age x City Size	16.14	2	0.000	-		-	~	-	-
Dr Age x Road Type	-	-	-	19.18	4	0.001	19.01	4	0.001
City Size x Damage	9.30	2	0.010		-	-	-	-	-
Light Cond x Dr Age x Damage	12.11	4	0.016		-	-	-	-	-
Light Cond x Road Type x Severity	-	-	12	-	-	-	6.81	2	0.033
Jr Age x Road Type x Dr Sex	~	-	~	10.29	4	0.036	-	-	-
Veh Mix x Light Cond x Severity	-	-	n		-	-	7.85	2	0.020
Veh Mix x Light Cond x Road Type x Dr Sex	-	-	~	20.74	4	0.000	-	-	
SUMMARY OF MODEL	68.11	70	0.542	49.49	54	0.649	73.24	72	0.437

For the North Carolina 1973 and 1975 models, driver characteristics refer to the drivers of the struck and striking vehicles, respectively. For the North Carolina 1974 model, Age refers to drivers of struck vehicles, while Sex refers to drivers of striking vehicles. Each smoothed cell count (n_{ijk}) was adjusted to yield a corresponding smoothed, adjusted cell count (n'_{ijk}) as follows (notation is presented in Figure 3-4).

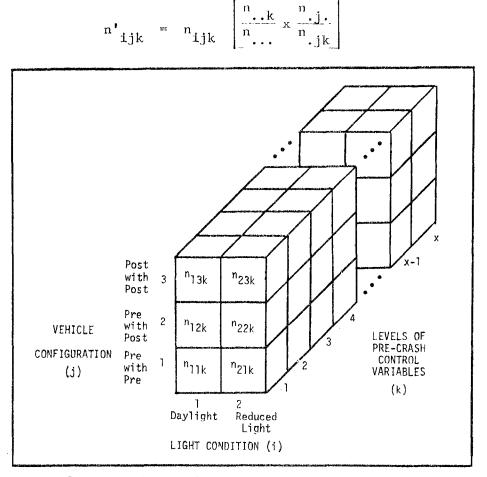


Figure 3-4. Summary of notation used to describe the data adjustment procedure.

By adjusting cell counts in this manner, the total sample size remains the same--i.e., n'... = n... Additional relations between adjusted and unadjusted cell counts are as follows:

(1) $n'_{i..} = n_{i..}$ (2) $n'_{.j.} = n_{.j.}$ (3) $n'_{..k} = n_{..k}$ (4) $n'_{i..k} = n_{i..k}$ (5) $n'_{ij.} = n_{ij.}$

In other words, the <u>total</u> number of accidents in each light condition category does not change, nor does the <u>total</u> number of accidents in each vehicle configuration or within each level of every control variable change. It should be noted, however, that within each <u>combination</u> of Vehicle Configuration (j) and Level of Control Variables (k), the adjusted count will <u>not</u> equal the unadjusted count:

$$n'_{jk} = n_{jk} \left[\frac{\binom{(n_{j})(n_{k})}{n_{k}}}{n_{k}} \right]$$

However, even under these conditions, the cross-product ratios that serve as a basis for computing both full and partial effectiveness values remain unchanged:

$$\frac{n_{11k}' n_{23k}'}{n_{21k}' n_{13k}'} = \frac{n_{11k}' n_{23k}}{n_{21k}' n_{13k}'} \quad (full \text{ effectiveness})$$

$$\frac{n_{11k}' n_{22k}'}{n_{21k}' n_{12k}'} = \frac{n_{11k}' n_{22k}}{n_{21k}' n_{12k}'} \quad (partial \text{ effectiveness})$$

After all cell counts were adjusted, the data were aggregated over all levels of all control variables, resulting in a simple Light Condition x Vehicle Configuration table for each sample. These tables served as the basis for all subsequent effectiveness computations and error estimations.

By way of summary, Table 3-23 contains the pre-crash variables which, in conjunction with Light Condition and Vehicle Configuration, were used in adjusting the smoothed cell counts.

PRE-CRASH CONTROL VARIABLES USED IN DATA ADJUSTMENT PROCEDURE

State	Year	Variables	Categories
Texas	1972	Road Type	City Street U.S./State Highway Other
		Age of Driver of Struck Vehicle	15 to 24 25 to 54 55 or Older
	1973	Road Type	City Street U.S./State Highway Other
		Age of Driver of Striking Vehicle	15 to 24 25 to 54 55 or Older
		Sex of Driver of Striking Vehicle	Male Female
	1974	Road Type	City Street U.S./State Highway Other
		Age of Driver of Struck Vehicle	15 to 24 25 to 54 55 or Older
New York	1974	Age of Driver of Struck Vehicle	15 to 24 25 to 34 35 to 54 55 or Older
		Road Type	State Highway County Road Town Road City Street
North Carolina	1973	Age of Driver of Struck Vehicle	15 to 25 26 to 55 56 or Older
		City Size	LT 50,000 50,000 or More
	1974	Age of Driver of Struck Vehicle	15 to 25 26 to 55 56 or Older
	``````````````````````````````````````	Road Type	U.S./State Highway City Street Rural Road
		Sex of Driver of Striking Vehicle	Male Female
	1975	Road Type	U.S./State Highway City Street Rural Road

6

### 3.4.3 Effectiveness and Error Estimation

## Estimation of Effectiveness Values

As noted previously, the overall effectiveness of side marker lamps (E) in preventing angle collisions during periods of reduced lighting, after controlling for differential exposure risk, can be expressed as:

$$E_{(Full)} = \left( 1 - \left[ \left( \frac{n_{11} \cdot n_{23}}{n_{13} \cdot n_{21}} \right) / \left( \frac{m_{11} \cdot m_{22}}{m_{21} \cdot m_{12}} \right)^2 \right] \right) \times 100 \quad \text{, and}$$

$$E_{(Partial)} = \left( 1 - \left[ \left( \frac{n_{11} \cdot n_{22}}{n_{12} \cdot n_{21}} \right) / \left( \frac{m_{11} \cdot m_{22}}{m_{21} \cdot m_{12}} \right) \right] \right) \times 100 \quad \text{,}$$

using the notation depicted in Figure 3-5. The  $n_{ijk}$ 's represent smoothed adjusted counts, while the  $m_{ij}$ 's consist of observed, unadjusted frequencies.

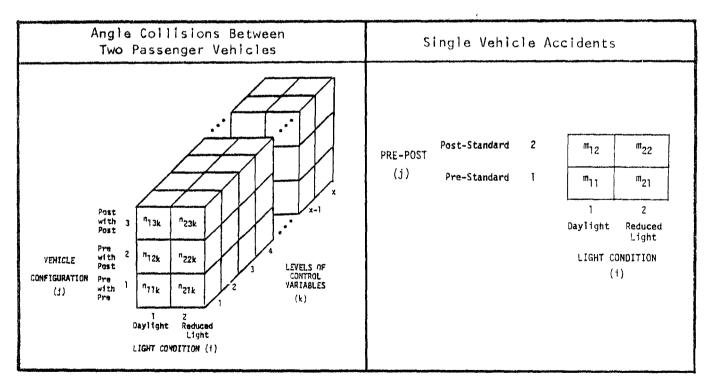


Figure 3-5. Summary of notation used to describe the effectiveness and error estimation procedures.

### Data

1

For purposes of reference, Tables 3-24 to 3-30 contain the daylight and reduced light frequencies of angle collisions between two Pre-Standard vehicles, between two Post-Standard vehicles, and between one Pre- and one Post-Standard vehicle (smoothed, adjusted), as well as the daylight and reduced light distributions of single vehicle accidents (neither smoothed nor adjusted) for each sample. Tables 3-24 to 3-26 summarize this information for Texas 1972, 1973 and 1974 samples, respectively. Table 3-27 pertains to the New York 1974 sample. Finally, Tables 3-28 to 3-30 correspond to North Carolina 1973, 1974 and 1975 samples, respectively.

DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR TEXAS 1972 SAMPLE (Total Cases = 34,011)

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### **TABLE 3-25**

DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR TEXAS 1973 SAMPLE (Total Cases = 34,255)

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DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR TEXAS 1974 SAMPLE (Total Cases = 30,545)

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### **TABLE 3-27**

DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR NEW YORK 1974 SAMPLE (Total Cases = 17,566)

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DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR NORTH CAROLINA 1973 SAMPLE (Total Cases = 6,249)

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### TABLE 3-29

DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR NORTH CAROLINA 1974 SAMPLE (Total Cases = 6,487)

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DISTRIBUTION OF SMOOTHED, ADJUSTED ANGLE COLLISION FREQUENCIES AND OBSERVED, UNADJUSTED SINGLE VEHICLE ACCIDENT FREQUENCIES FOR NORTH CAROLINA 1975 SAMPLE (Total Cases = 6,974)

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## Effectiveness Values Prior to Controlling for Exposure Risk

In terms of the amount of accident avoidance realized when <u>both</u> vehicles in a potential reduced light angle collision are equipped with side marker lamps (*full* effectiveness), Table 3-31 indicates that, <u>before controlling</u> for differential exposure risk, estimates of the percent reduction in the number of reduced light angle collisions due to FMVSS 108 on the average range from 12 percent in the 1973-1975 North Carolina samples to 23 percent in the New York 1974 sample, with the overall Texas 1972-1974 effectiveness value falling roughly midway between these extremes (18 percent). Table 3-32, on the other hand, contains estimates of the percent reduction in the number of reduced light angle collisions realized when only one of the vehicles involved in a potential reduced light angle collision situation is equipped with side marker lamps (*partial* effectiveness)-again prior to controlling for differential exposure risks of Pre- and Post-Standard vehicles during periods of reduced lighting. On the average, the overall values of *partial* effectiveness range from 8 and 9 percent in New York and North Carolina, respectively, to 12 percent in Texas. These *partial* effectiveness values are in all cases less than the corresponding  $\int ull$  effectiveness values, which conforms to intuitive expectations that the effectiveness of FMVSS 108 in preventing reduced light angle collisions is lessened when only one accidentinvolved vehicle is equipped with side marker lamps.

### TABLE 3-31

## SUMMARY OF OVERALL FULL EFFECTIVENESS VALUES PRIOR TO CONTROLLING FOR RELATIVE EXPOSURE RISK

			Observe	ed, Unad	justed [	Data		Smoot	hed, Adj	usted Di	ata
State	Year	Effec- tive-	Standard Deviation		fidence rva1	Is Effectiveness Significantly	cive-	Standard Deviation	Inte	fidence rval	Significantly
		ness		From	To	Different from Zero?	ness		From	То	Different from Zero?
Texas	1972	18.86	3.33	13.38	24.34	Yes	20.11	3.28	14.71	25.51	Yes
	1973	14_56	3.34	9.06	20.06	Yes	12.76	3.42	7.14	18.38	Yes
	1974	17.77	3.59	11.86	23.68	Yes	20.54	3.46	14.84	26.23	Yes
	1972- 1974	17.03	1.97	13.79	20.27	Yes	17.85	1.95	14.64	21.06	Yes
New York	1974	22.78	4.06	16.09	29.47	Yes	23.08	4.05	16.42	29.73	Yes
North Carolina	1973	10.44	8.01	-2.73	23.61	No	13.25	7.75	0.50	26.01	Yes
	1974	16.59	7.56	4.15	29.02	Yes	14.74	7.75	1.99	27.48	Yes
	1975	5.08	9.29	-10.20	20.37	No	7.75	8.99	-7.03	22.54	No
	1973- 1975	11.46	4.73	3.68	19.24	Yew	12.30	4.68	4.60	20.00	Yes

*Weighted mean, using the inverse of the variance of each year as a weighting factor.

## SUMMARY OF OVERALL PARTIAL EFFECTIVENESS VALUES PRIOR TO CONTROLLING FOR RELATIVE EXPOSURE RISK

State	Year	Observed, Unadjusted Data					Smoothed, Adjusted Data				
		Effec- tive- ness	Standard Deviation	95% Confidence Interval		pryntricanciy	tive-	Standard Deviation	95% Confidence Interval		Is Effectiveness Significantly
				From	То	Different from Zero?	ness		From	To	Different from Zero?
Texas	1972	14.57	2.65	10.21	18.94	Yes	15.39	2.63	11.07	19.70	Yes
	1973	10.49	3.10	5 <b>.3</b> 8	15.59	Yes	9.05	3.16	3.85	14.25	Yes
	1974	8.42	3.82	2.14	14.70	Yes	10.32	3.72	4.20	16.44	Yes
	* 1972~ 1974	11.88	1.78	8.95	14.81	Yes	12.33	1.78	9.30	15.16	Yes
New York	1974	6.69	4.78	-1.17	14.55	Νο	7.59	4.73	-0.19	15.37	No
North Carolina	1973	1.76	7.77	-11.02	14.53	No	3.40	7.61	-9.13	15.92	No
	1974	15.38	7.34	3.30	27.45	Yes	13.83	7.50	1.49	26.16	Yes
	1975	6.62	9.11	-8.37	21.61	No	8.65	8.87	-5.94	23.24	No
	1973- 1975	8.36	4.60	0.79	15.93	Yes	8.68	4.58	1.15	16.21	Yes

 * Weighted mean, using the inverse of the variance of each year as a weighting factor.

To obtain the effectiveness estimates in Table 3-31 and 3-32 without controlling for differential exposure risk, simplified versions of the previously defined effectiveness measures were applied, as follows.

$$\hat{E}(Full) = \left[ 1 - \left(\frac{n_{11} \cdot n_{23}}{n_{13} \cdot n_{21}}\right) \right] \times 100 , \text{ and}$$

$$\hat{E}(Partial) = \left[ 1 - \left(\frac{n_{11} \cdot n_{22}}{n_{12} \cdot n_{21}}\right) \right] \times 100 ,$$

using the notation depicted in Figure 3-5.

Given the stochastic nature of the phenomenon under study, the crossiveness values computed prior to controlling for differential exposure risk ( $\hat{F}$ ) can be written to explicitly include an error term ( $\chi$ ) as

$$\hat{E}'(Full) = 100 \times \left[ 1 - \left( \frac{N_{23} \cdot N_{11}}{N_{21} \cdot N_{13}} \cdot \frac{(1 + \chi_{23}) \cdot (1 + \chi_{11})}{(1 + \chi_{21}) \cdot (1 + \chi_{13})} \right) \right]$$

$$\hat{E}'(Partial) = 100 \times \left[ 1 - \left( \frac{N_{22} \cdot N_{11}}{N_{21} \cdot N_{12}} \cdot \frac{(1 + \chi_{22}) \cdot (1 + \chi_{11})}{(1 + \chi_{21}) \cdot (1 + \chi_{12})} \right) \right]$$

and

where the  $N_{ij}$  are the expected values of the  $n_{ij}$ .

It is assumed that the observed frequencies  $n_{ij}$  are independent and Poissondistributed with expected values of  $N_{ij}$ , and further assumed that the Poisson distribution can be approximated by a normal distribution. In other words,  $n_{ij}$  is assumed to be approximately normally-distributed with mean  $N_{ij}$ and  $\sigma_{ij} = \sqrt{N_{ij}}$ . Therefore,  $\chi_{ij} = \frac{n_{ij} - N_{ij}}{N_{ij}}$  is normally distributed with mean 0 and  $\sigma_{(\chi_{ij})} = \frac{1}{\sqrt{N_{ij}}}$ . Using  $\hat{E}'_{(Full)}$  as an example, the term

$$r = \frac{(1+\chi_{23.}) (1+\chi_{11.})}{(1+\chi_{21.}) (1+\chi_{13.})}$$

can be approximated by expanding the fraction in power series  $\chi_{21}$ , and  $\chi_{13}$ . These series expressions hold only if  $|\chi_{ij}| < 1$ , a restriction which is violated only by a minimal fraction of all cases.

An expansion of r up to second order terms is  $r = 1 + \chi_{23}$ .  $+ \chi_{11}$ .  $- \chi_{21}$ .  $- \chi_{13}$ .  $+ \chi_{23}$ .  $\chi_{11}$ .  $- \chi_{23}$ .  $\chi_{21}$ .  $- \chi_{23}$ .  $\chi_{13}$ .  $- \chi_{11}$ .  $\chi_{21}$ .  $- \chi_{11}$ .  $\chi_{13}$ .  $+ \chi_{21}$ .  $\chi_{13}$ .  $+ \chi_{21}$ .  $\chi_{13}$ .

Taking expectations (independence among the  $\chi_{ii}$  was assumed), one obtains

$$E(r) = 1 + E(\chi_{21}^2) + E(\chi_{13}^2)$$
,

which can be written as

$$\overline{r} = 1 + \frac{1}{N_{21}} + \frac{1}{N_{13}}$$

Squaring the difference between r and r, and taking expectations, one obtains

$$E(r - \overline{r})^{2} = E(\chi_{23}, 2) + E(\chi_{11}, 2) + E(\chi_{21}, 2) + E(\chi_{13}, 2) + \left(\frac{1}{N_{21}} + \frac{1}{N_{13}}\right)^{2} ,$$
  
$$E(r - \overline{r})^{2} = \frac{1}{N_{23}} + \frac{1}{N_{11}} + \frac{1}{N_{21}} + \frac{1}{N_{13}} + \left(\frac{1}{N_{13}} + \frac{1}{N_{13}}\right)^{2} .$$

Since  $\sigma_r^2 = E(r-r)^2$ , then the variance of  $\hat{E}'$  (Full) is

$$\sigma^{2}_{\hat{E}'(Full)} = \left(\frac{N_{23}, N_{11}}{N_{21}, N_{13}}\right)^{2} \sigma_{r}^{2}$$

or

The above can be easily adapted to the measure of partial effectiveness (prior to controlling for exposure risk) by substituting the terms  $N_{22}$ ,  $n_{22}$ , and  $\chi_{22}$ . for  $N_{23}$ ,  $n_{23}$ , and  $\chi_{23}$ ; and the terms  $N_{12}$ ,  $n_{12}$ , and  $\chi_{12}$ . for  $N_{13}$ ,  $n_{13}$ , and  $\chi_{13}$ , respectively.

#### Effectiveness Values After Controlling for Exposure Risk

Table 3-33 contains estimates of the extent to which Post-Standard vehicles driven during periods of reduced light are either over-represented (negative value) or under-represented(positive value) in the population at large. Essentially, these estimates represent the percent difference between the daylight-to-reduced light ratio of accident-involved Pre-Standard vehicles and the corresponding ratio for accident-involved Post-Standard vehicles. Stated differently, these estimates represent the percent reduction in the number of reduced light angle collisions which <u>cannot</u> be attributed to FMVSS 108, since they are derived from single vehicle accident data.

From Table 3-33, it can be seen that differences in the reduced light exposure risks for Pre- and Post-Standard vehicles are negligible in all three years of Texas data, and approximately -4 percent in North Carolina for 1973 and 1975. However, in the case of both New York 1974 and North Carolina 1974, the estimated differences in reduced light exposure risks between Pre- and Post-Standard vehicles are highly significant, and represent values of 6 and -16 percent, respectively.

#### TABLE 3-33

			Dayl	ight		Re	educed L	lght			Differ-	
State	Year	ear Pre		Post		Pre		Post		Total Number	ential Exposr.	Standard
		Number	%	Number	×	Number	%	Number	×	of Cases	Risk	Deviation
Texas	1972	26,287	29.6	15,985	18.0	29,023	32.7	17,488	19.7	88,783	0.91	1.37
	1973	22,912	25.1	20,303	22.2	25,619	28.1	22,450	24.6	91,284	1.11	1.31
	1974	17,515	20.9	20,980	25.1	20,438	24.4	24,740	29.6	83,673	-1.06	1.41
North	1973	4,301	21.5	4,447	22.2	5,429	27.1	5,863	29.3	20,040	-4.45	2.98
Carolina	1974	3,460	18.0	4,517	23.5	4,479	23.3	6,769	35.2	19,225	-15.76	3.44
	1975	2,926	15.1	5,166	26.6	3,974	20.5	7,329	37.8	19,395	-4.46	3.18
New York	1974	9,778	19.9	16,532	33.7	8,805	17.9	13,961	28.4	49,076	6.22	1.75

#### ESTIMATED DIFFERENCES IN REDUCED LIGHTING EXPOSURE RISKS FOR PRE- AND POST-STANDARD VEHICLES DERIVED FROM OBSERVED SINGLE-VEHICLE ACCIDENT DATA

Table 3-34 contains the *full* and *partial* effectiveness values obtained after controlling for different exposure risks of Pre- and Post-Standard vehicles during periods of reduced lighting. On the average, *full* effectiveness values derived from smoothed, adjusted data range from 12 and 17 percent in New York and Texas , to 27 percent in North Carolina. Individual effectiveness values for the three years of Texas data are roughly the same for the 1972 and 1974 samples (19 vs. 22 percent), although for the 1973 sample, the *full* effectiveness value is almost one-half of these values (11 percent). On the other hand, effectiveness values for individual years of North Carolina data vary considerably, from 20 to 36 to 15 percent for 1972, 1973 and 1974 samples, respectively. With the exception of the North Carolina 1975 sample, however, all *full* effectiveness values reported in Table 3-34 are statistically significant.

Table 3-34 also summarizes the overall *partial* effectiveness values obtained after controlling for differential exposure risk. On the average, the overall reduction in the number of reduced light angle collisions realized when only one vehicle involved in a potential reduced light angle collision situation was equipped with side marker lamps was 12 percent for Texas samples and 16 percent for North Carolina samples. In the case of the New York 1974 sample, the amount of *partial* effectiveness was negligible and most likely due to chance (1.5 percent). Again, all *partial* effectiveness values obtained after controlling for differential exposure risk were less than the corresponding *full* effectiveness values.

### TABLE 3-34

## SUMMARY OF OVERALL FULL AND PARTIAL EFFECTIVENESS VALUES DERIVED FROM SMOOTHED, ADJUSTED DATA AFTER CONTROLLING FOR RELATIVE EXPOSURE RISK

			Fu	ll Eff	ective	eness		Partial	Effec	tivene	SS
State	Year	Effec- tive-	Standard	95% Con Inter		Is Effectiveness Significantly	Effec- tive-	scandaru	95% Confidence Interval		Is Effectiveness Significantly
		ness	Deviation	From	То	Difforent	ness	Deviation	From	То	Different
Texas	1972	18.63	4.03	12.00	25.27	Yes	14.61	2.70	9.83	19.38	Yes
	1973	10.79	4.22	3.85	17.74	Yes	8.03	3.42	2.41	13.66	Yes
	1974	22.19	4.02	15.57	28.81	Yes	11.26	3.88	4.87	17.64	Yes
	1972 [*] 1974	17.40	2.36	13.52	21.28	Yes	11.71	1.92	8.55	14.87	Yes
New York	1974	12.54	5.64	3.26	21.81	Yes	1.46	5.37	-7.37	10.28	No
North Carolina	1973	20.48	8.42	6,63	34.34	Yes	7.51	7.74	-5.22	20.25	٩٥
	1974	36.38	6.90	25.03	47.73	Yes	25.56	6.83	14.32	3 <b>6.</b> 80	Yes
	1975	15.45	9.69	-0.49	31.40	No	12.55	8.88	-2.06	27.16	Ino
	* 1973- 1975	26.61	4.67	18,93	34.29	Yes	16.38	4.44	9.08	23.68	Yes
411 3 States	All * Years	18.45	1.97	15.21	21.69	Yes	17.38	1.67	8.63	14.13	Yes

*Weighted mean, using the inverse of the variance of each year as a weighting factor.

The variance of values of  $E_{(Full)}$  and  $E_{(Partial)}$  obtained after controlling for relative exposure risk were obtained as follows (see Figure 3-5 for notation).

$$\sigma_{E}^{2}(Ful1) = \left(\frac{\frac{n_{11} \cdot n_{23}}{n_{13} \cdot n_{21}}}{\left[\frac{m_{11} \cdot m_{22}}{m_{21} \cdot m_{12}}\right]^{2}}\right)^{2} \left(\frac{1}{n_{11}} + \frac{1}{n_{23}} + \frac{1}{n_{13}} + \frac{1}{n_{21}} + \frac{4}{m_{11}} + \frac{4}{m_{21}} + \frac{4}{m_{22}} + \frac{4}{m_{12}}\right), \text{ and}$$

$$\sigma_{E}^{2}_{(Partial)} = \left(\frac{\frac{n_{11}, n_{22}}{n_{12}, n_{21}}}{\frac{m_{11}, m_{22}}{m_{21}, m_{12}}}\right)^{2} \left(\frac{1}{n_{11}} + \frac{1}{n_{12}} + \frac{1}{n_{22}} + \frac{1}{n_{21}} + \frac{1}{m_{11}} + \frac{1}{m_{21}} + \frac{1}{m_{22}} + \frac{1}{m_{12}}\right).$$

These equations are based on the assumption that the  $m_{11}m_{22}/m_{21}m_{12}$  term is close to 1, with a relatively small error.

Having derived  $\sigma_E^2$ , 95 percent confidence intervals were computed as follows. Lower Limit = E - 1.64 $\sigma_E$ Upper Limit = E + 1.64 $\sigma_E$ 

Furthermore, separate tests of the hypothesis that the obtained level of effectiveness is significantly greater than zero were also carried out, since interval estimation and hypothesis testing are generally not equivalent. In an attempt to reject the null hypothesis that the observed effectiveness values are equal to zero in the population, the following test statistic was used:

$$t = \frac{E - 0}{s.e._E}$$

where E represents a given effectiveness value. A one-tailed test required a t-value greater than 1.64 in order to reject the null hypothesis, since without exception the number of cases (and hence, degrees of freedom) exceeded 120 by a considerable margin. By way of summary, the following conclusions can be drawn from the preceding findings.

> Full Effectiveness. After controlling for differential exposure risk, overall effectiveness values for the three states ranged, on the average, from 12 to 27 percent. This represents a 12 to 27 percent reduction in the number of reduced light angle collisions which can be attributed to both vehicles involved in a reduced light angle collision situation satisfying the side marker lamp requirement of FMVSS 108.

The average full effectiveness value obtained for all individual state-years of data was approximately 18 percent.* Furthermore, all mean full effectiveness values obtained were statistically significant.

- 2. Partial Effectiveness. Based upon weighted averages of overall partial effectiveness values (after controlling for differential exposure risk) derived from Texas 1972-1974 and North Carolina 1973-1975 samples, significant reductions in the number of reduced light angle collisions of 12 and 16 percent, respectively, were obtained when only one of the vehicles involved in a potential reduced light angle collision situation was equipped with side marker lamps. No significant partial effectiveness was found for the New York 1974 sample.
  - As expected, these partial effectiveness values were in almost all cases between one-fifth to two-thirds less than the corresponding *full* effectiveness values. An overall average partial effectiveness value of 11 percent was obtained for all state-years of data analyzed, after controlling for exposure risk.*
- 3. Impact of Adjustment of Data. Overall, the net impact of adjusting smoothed cell counts was to increase effectiveness values by roughly 1 to 3 percentage points, and to slightly reduce the variability of these estimates. However, in the case of Texas 1973 and North Carolina 1974 samples, smoothing and adjusting resulted in a decrease in effectiveness values of approximately 2 percentage points.
- 4. Impact of Controlling for Exposure Risk. In the case of North Carolina, where the analysis of single vehicle accidents revealed a significant over-representation of Post-Standard vehicles driven during periods of reduced lighting, full and partial effectiveness values were uniformly increased by an average of roughly 13 and 7 percentage points as a result of controlling for exposure risk. For the New York 1974 sample, where Post-Standard vehicles driven under reduced lighting conditions were under-represented in the population at large, full and

^{*} Weighted mean, using the inverse of the variance of each year as a weighting factor.

partial effectiveness values were decreased by 10 and 5 percentage points, respectively. Controlling for exposure risk in the Texas samples, however, had no appreciable impact on effectiveness values, since both Pre- and Post-Standard cars driven during periods of reduced lighting were equally represented.

While interpreting these and other findings, the reader should keep in mind the various limitations of the analysis discussed in Sections 1.5 and 2.3.

#### 3.4.4 Extrapolation to the Nation

Using a weighted mean of the 1974 side marker lamp effectiveness values for Texas, New York and North Carolina, it is possible (for heuristic purposes) to extrapolate to the nation, although the resulting estimates are obviously approximate. No single state was used for extrapolation purposes, since the relationship between light condition and traffic density in either Texas or New York is not representative of the nation at large. Furthermore, North Carolina sample sizes are smaller than the other two states. Hence, a combination of all three states' effectiveness values was used. The year 1974 was chosen as a basis for extrapolating to the nation for the simple reason that it is the only year common to all three state data bases used in the analysis. During 1974, moreover, the numbers of Pre- and Post-Standard vehicles driven were approximately equal.

In order to derive estimates of the total number of reduced light angle collisions which were actually prevented nationwide in 1974, along with the number which could have potentially been prevented had all vehicles been equipped with side marker lamps, extrapolations were carried out in the following steps.

- The total number of motor vehicle accidents [N] occurring nationwide in 1974 was estimated, along with the number of these which were angle collisions occurring during periods of reduced lighting [N'].
- 2. Three-state averages of the proportions of all reduced light angle collisions involving Pre with Pre, Pre with Post, and Post with Post vehicle configurations were computed  $(\bar{r}_i 's)$ .
- 3. Weighted means for Texas, New York and North Carolina 1974 effectiveness values were computed, after controlling for differential exposure risk (E_(Full) and E_(Partial).

- Based on the preceding information, extrapolated values were derived for the number of reduced light angle collisions:
  - Expected if no vehicles had been equipped with side marker lamps [X (None)].
  - Expected if all vehicles had side marker lamps [X (A11)].

N. .

- Actually prevented by FMVSS 108 [S (Actual)].
- Potentially prevented by FMVSS 108 at full implementation [S (Potential)].

Since available estimates of the total number of motor vehicle accidents in 1974 vary considerably, accident statistics from 13 states were used as a basis for approximating the national total. From Table 3-35 it can be seen that these 13 states account for 45 percent of both the total number of fatalities and the total number of motor vehicle registrations recorded in 1974.

#### TABLE 3-35

ESTIMATION OF THE NUMBER OF REDUCED LIGHTING ANGLE COLLISIONS NATIONWIDE IN 1974, BASED UPON DATA FROM 13 STATES

State (1974)	Number Of Reported Accidents		Occurring During duced Lighting Number	Number of b Fatalities	Number of Motor Vehicle Registrations ^c
California	496,577	9.89 ^{° d}	49,132	4,019	13,684,399
Illinois	486,812	6.38	31,085	2,007	6,174,102
Michigan	296,936	5.98	17,745	1,875	5,400,904
Missouri	30,406	1.98	600	1,042	2,825,461
New Hampshire	18,520	13.81	2,558	166	490,303
New Mexico	39,741	5.97	2,371	540	763,452
New York	377,818	6.62	25,014	2,620	7,457,802
North Carolina	121,568	5.46	6,633	1,580	3,569,769
Oregon	45,476	7.44	3,384	670	1,579,736
Tennessee	10,302	6.94	714	1,285	2,568,381
Texas	434,194	5.98	25,968	3,046	8,053,269
Virginia	144,537	5.10	7,366	1,050	3,171,744
Washington	106,242	7.30	7,761	759	2,444,446
13-State Total	2,609,129	6.91	1.80,331	20,659	58,183,768
Nationwide Total	5,798,064	6.91	400,736	46,200	129,893,311

a. Numbers in *italics* are *estimates* derived from reports of state authorities.

b. Source: Accident Facts, 1975, National Safety Council.

c. Source: *Highway Statistics 1974*, U.S. Department of Transportation, Federal Highway Administration. Therefore, by inflating the 13-state accident totals by a factor of 2.22, one obtains a national estimate of 5,798,064 (=N) accidents in 1974, of which 400,736 (=N') were angle collisions under reduced light conditions.

The formulas used to carry out Step 4 above are:

$$X_{\text{(None)}} = N' \left[ \overline{r_1} + \frac{\overline{r_2}}{1 - [E_{\text{(Partial)}}/100]} + \frac{\overline{r_3}}{1 - [E_{\text{(Full)}}/100]} \right]$$

$$X_{\text{(All)}} = N' \left[ \overline{r_1} \left( 1 - E_{\text{(Full)}}/100] \right) + \overline{r_2} \left( \frac{1 - [E_{\text{(Full)}}/100]}{1 - [E_{\text{(Partial)}}/100]} \right) + \overline{r_3} \right]$$

$$S_{\text{(Actual)}} = X_{\text{(None)}} - N'$$

$$S_{\text{(Potential)}} = X_{\text{(None)}} - X_{\text{(All)}}$$

Using the notation depicted in Figure 3-6,  $\overline{r}_{i} = \frac{n_{2i}}{n_{21} + n_{22} + n_{23}}$ 

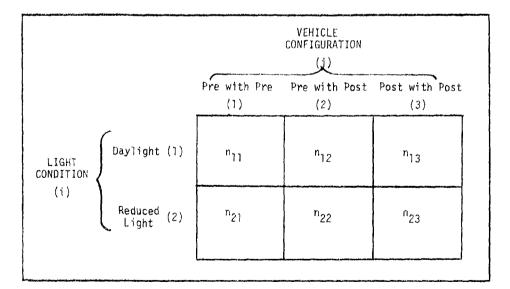


Figure 3-6. Summary of notation used in extrapolation to the nation.

Also, N' refers to the national estimate of reduced light angle collisions for 1974 (N' = 400,736). Values for  $\overline{r_i}$  can be found in Table 3-36, whereas values for  $E_{(Full)}$  and  $E_{(Partial)}$  are contained in Table 3-37. By substituting these values in the above equations, one finds that in 1974, when the numbers of

Pre- and Post-Standard vehicles driven were roughly the same, approximately 64,000 reduced light angle collisions were actually prevented by the side marker lamp requirement of FMVSS 108. At this time, had the Standard been fully implemented--i.e., had all vehicles driven been equipped with side marker lamps--it is estimated that almost twice as many reduced light angle collisions (~103,000)would have been prevented. These extrapolations of both the actual and potential numbers of accidents prevented by FMVSS 108 are summarized in Table 3-38.

#### TABLE 3-36

#### PROPORTIONS OF ALL REDUCED LIGHT ANGLE COLLISIONS CORRESPONDING TO EACH VEHICLE CONFIGURATION CATEGORY (1974)

Vehicle	Tex	a 5	New '	York	North C	arolina	All Thre	e States
Configuration (j)	ⁿ 2j	rj	ⁿ 2j	rj	ⁿ 2j	r _j	ⁿ 2j (Pooled)	$\overline{r}_{j}$
Pre with Pre (1)	966	0.18	715	0.15	233	0.18	1914	0.17
Pre with Post (2)	2657	0,48	2378	0.48	619	0.47	5654	0.48
Post with Post (3)	1882	0.34	1814	0.37	461	0.35	4157	0.35

#### TABLE 3-37

SUMMARY OF 1974 SIDE MARKER LAMP EFFECTIVENESS VALUES USED FOR EXTRAPOLATIONS

(Conservations and a service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the service of the	Effectiveness Values Corrected for Bias							
State (2074)	Fu	11	Par	tial				
(1974)	Ê	s.d.	Ê	s.d.				
Texas	22.19	4.02	11.26	3.88				
New York	12.54	5.64	1.46	5.37				
North Carolina	36.38	6.90	25.56	6.83				
All Three States [*]	22.14	2.96	10.99	2.86				

Weighted mean, using the inverse of the variance as a weighting factor.

#### **TABLE 3-38**

ESTIMATED NUMBER OF REDUCED LIGHT ANGLE COLLISIONS ACTUALLY AND POTENTIALLY PREVENTED NATIONWIDE IN 1974 BY SIDE MARKER LAMPS

Expected Number of Reduced Light Angle Collisions If <u>No</u> Vehicles Had Side Marker Lamps	Actual Number of * Reduced Light Angle Collisions	Expected Number of Reduced Light Angle Collisions If <u>All</u> Vehicles Had Side Marker Lamps	Estimated Actual Number of Reduced Light Angle Collisions Prevented By FMVSS 108	Potential Number of Reduced Light Angle Collisions Prevented By FMVSS 108 at Full Implementation
464,369	400,736	361,558	63,633	102,811

APPENDIX A

FULLY CROSS-CLASSIFIED CONTINGENCY TABLES DERIVED FROM STATE MASS ACCIDENT DATA BASES

## TABLE A-1

#### FULLY CROSS-CLASSIFIED TABLE OF TEXAS 1972 RAW DATA

DHVAGE2	KOADTYPE R	LIGHTINGI L I	STATUS (S PRE-PRE	) Phe-Pust	POSTPOST
15-24	CITY	DAYLIGHTI REDUCED I	2319 634	2996 728	1039 267
	US-STATE	DAYLIGHTÎ REDUCED I I	625 291	872 294	356 121
	UTHER	DAYLIGHTI REDUCED I	282 101	392 146	176 45
25=54	CITY	DAYLIGHTI Reduced I	3017 674	4303 758	1829 300
	US-STATE	DAYLIGHTI REDUCED I	865 295	1419 386	580 130
	UTHEN	DAYLIGHTI REDUCED I	370 110	629 176	277 72
55 +	CITY	DAYLIGHTI REDUCED I	1308 145	1614 164	544 63
	US-STATE	DAYLIGHTI REDUCED I	576 88	696 105	286 31
	UTHEN	DAVLIGHTI REDUCED I	164 23	215 24	80 10

**FON ANALYSIS, 0.001 IS ADDED TO EACH CELL ABOVE

THE TOTAL FREQUENCY IS 34011

	T	ABLE A-	-2				
FULLY	CROSS-CLASSIFIED	TARLF	0F	TEXAS	1973	RAW	DATA

DKA	SEN1 X	UFVAGE1 A	* 4 X 1 4 U T		LIGHTINGI L I	STATUS (S PRE-PRE	} _ PKE⇔PUSĭ	POSTPOST
MALI	E	15-24	0+2	CITY	DAVLIGHTI HERUCED I	152	1092 241	540 119
				US-8147E	I DAYLIGHTI Reduced I	154 54	279 89	138 55
				UTHEN	I DAVLIGHTI REDUCED I	66	132 41	55
			3-4	CITY	DAYLIGHTI REDUCED I	173	867 257	420 147
				U9-51A1E	T DAVLIGHTI REDUCED 1	162 79	328 142	167 60
				ОТНЕК	I DAYLIGHTI Reduced I	74	117 57	57 35
استلارزن بالديناليمريم كالشرير			5=7	C]}v	DAYLIGHTI REDUCED I	33	119 52	58 17
				US+STATE	I DAYLIGHTI REDUCED I	59 59	44 36	38 19
				0THEK	I DAYLIGHTI REDUCED I	4	24 14	17 10
		25=54	6-5	CITY	DAYLIGHTI REDUCED I	130	1245 250	783 153
				US-SIATE	I CAYLIGHTI REDUCED I	179 57	418 116	256 66
				OTHER	I DAYLIGHTI REPUCED J	52	172 36	123
and the second second second second second second second second second second second second second second secon	***	and a second second second second second second second second second second second second second second second	3=4	CITY	DAYLIGHTI REDUCED 1	167	915 280	523 149
				US-STATE	I DAYLIGHTI REDUCED I	190 87	378 145	265 93
				<b>UTHE</b> K	I DAYLIGHTI Reduced 1	76	143 62	9C 42
and a second second second second second second second second second second second second second second second	ing ages of some		5=7	CITY	CAYLIGHTI REDUCED I	27	104 57	73 21
				US-STATE	I DAYLIGHTI REDUCED I		93 45	49 21
				UTHEN	1 CAYLIGHTI REDUCEL 1	) 6 7	33 16	17 10
	***********	55 +	0=5	CITY	DAYLIGHTI Reduced I	283 33	510 60	245
				USPSTATE	Ī	115 19	211 24	17 99 14
				OTHEN	I PAYLIGHTI REDUCED I	32	6 57	47
مىنىيە <del>مەركەتكەن يەركە</del> <del>ئەلەل</del> تۇرىمىك		الان المالية بين من المالية المالية بين من الم	3-4	CITY	OAVLIGHTI HEDUCED I	190 22	357 36	179 23
				US#STATE	I DAYLIGHTI Reduced i	88 17	174 24	88 31
				OTHEN	I Daylighti Reduced i	5 35	46 9	29 8
فيتشود الكافر ويترك التكريب			5=7	CITY	DAYLIGHTI Reduced I	17	2 A 8	16 2
				US=STATE	I NAVLIGHTI HEDUCER I	11 5	37 6	16 3
				итнен	I DAVLIGHTI Reduced 1	2	14	7 0

TABLE A-2 (Continued)

DHVSEX1	DHVABE1 A	raxiau ĭ	HÜADIYP K	L LIGHTINGI L I	I STATUS () PRE-PRE		I POSTPOST
FEMALE	15=24	S=0	LIIY	DAYLIGHTI Reduced I	554 37	749 120	445 445
			U8-81A1E	I DAYLIGHTI Reduced I	7 U 1 3	194 34	911 22
			OTHEN	I DAYLIGHTI REDUCED I	43 7	68 19	60 15
	an an an an an an an an an an an an an a	5-4	CITY	DAVLIGHTI HEDUCED I	253 50	524 97	307 49
			US-STATE	I DAVLIGHTI REDUCED I	67 20	169 33	106 25
			UTHEN	I DAYLIGHTI REDUCED I	2.B 4	75 14	56
		5-7	ÇIIY	DAYLIGHTI HEDUCED I	21 8	57 9	43 9
			US⇒9TATE	I DAYLIGHTI HEDUCED J	1 <del>6</del> 6	39 8	17 4
			UTHER	T DAYLIGHIT REDUCLO I		15 8	7 3
۵۰۰ - ۱۹۵۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ - ۱۹۹۵ -	25-54	5-0	CITY	DAYLIGHTI Reduced I	506 44	1084 107	720 73
			USHSTATE	I DAYLIGHTI REDUCED I	120 17	312 47	05 26
			UTHEN	DAYLIGHTI Reduced I	31	129 19	93 14
ni da fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de fan de	ſ «ŊŦġĸĸ.ja-Ja-Ja,ŭ/A-sky=25;an,ta-	3=4	CITY	DAYLIGHTI Neduced I	362 46	790 101	485 62
		•	US-STATE	I DAYLIGHTI PEDUCED I	103 21	275 47	178 27
			UTHEN	I DAYLIGHTT REDUCED [	50 11	131 20	95 11
Min a a la faite d'ann a faite anns a faite anns a faite anns a faite anns a faite anns a faite anns a faite a	**************************************	5-7	CITY	RAYLIGHTI Reduced I	/i () 5	87 16	57 14
			US-STATE	DAYLIGHII Reduced I	1.5	39 17	33 8
			ปรายห สาสสุดสุดสุดสุดสุด	I DAYLIGHTI Reduced I	ta eo ju or ca en cu ar en en en 1	14 2	19 4
۵۰۰۰۰۱۰۹۰ - ۲۰۰۰۰۹۰ - ۲۰۰۰۹۹ - ۲۰۰۹۹ - ۲۰۰۹۹ - ۲۰۰۹۹ - ۲۰۰۹۹ ۰	35 +	0-5	CITY	DAYLIGHTI Reduced I	180 14	583 52	179 14
			US-STATE	I Daylighti Heduced I	70 15	134 10	62 3
			ИТНЕН	I DAYLIGHTI Reduced I	21 0	31 2	81 5
SE FREAREN LINES, ann an Dùthan Lachadh ann an Eastairtin	ar ya a da a a a a a a a a a a a a a a a a	3-4	CITY	DAYLIGHTI Heduced I	125 4	50 550	117 12
			US-9141E	I CAVLIGHTI REDUCED I	43 4	85 7	51 6
			<b>ПТНЕН</b>	I DAYLIGHTI Renuced I	51 0	2 A 4	19 C
	ann an an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna an Anna	5 - 7	CITY	DAYLIGHTI Reduced I	10 U	5 24 2	19 1
			us=state	I Daylighti Reduced I	13	16 3	1 C 3
			OTHER	I Caylighti Reduced I	1	ь 1	e C

**FOR ANALYSIS, C.CO1 IS ADUED TO EACH CELL ABOVE

DHVAGE2	МАХТАР Т	RUAUTYPE R	LIGHTINGI L I	STATUS (S PRE=PRE		POSTPUST
15=24	U=2	CITY	DAYLIGHTI REDUCED I	536 111	1565 303	1172 224
		US#STATE	I DAYLIGHTI REDUCED I	129 42	426 150	346 97
		ОТНЕН	I DAYLIGHTI REDUCED I	44 19	197 38	156 49
	3=4	CITY	DAYLIGHTI Reduced I	424 133	1158 333	765 220
		US-STATE	I DAYLIGHTI REDUCED I	132 70	359 170	275
		OTHER	I DAYLIGHTI REDUCED I	49 25	181 64	151 49
	5=7	CITY	DAYLIGHTI REDUCED I	39 23	114 67	80 45
		LS-STATE	I UAYLIGHTI HEUGCED I	12	61 35	44 27
		OTHER	I DAYLIGHTI REDUCED I	1 u 1 C	9 22	15 54
25=54	5=0	СІТҮ	DAYLIGHTI Reduced I	670 116	2094 347	1806 286
		LSESTATE	I DAYLIGHTI REDUCED I	168 49	603 146	565 100
		DTHER	I DAYLIGHTI REDUCED I	62 16	239 61	250 50
a na dia minina dia mandri dia mpika m	3-4	CITY	DAYLIGHTI REDUCED I	485 122	1365 326	1212 236
		US-STATE	I DAYLIGHTI REUUCED I	161 64	498 149	490 108
		Стнен	I DAYLIGHTI REDUCED I	49 15	207 69	233 50
ىيى كەلەر مەرىخىنى قىلىغ يېرىمى ^{يىر} ىكى بىرى يېرىكى بىرى يېرىكى بىرى يېرىكى بىرى يېرىكى بىرى يېرىكى بىرى يېرى ي	5=7	CITY	DAYLIGHTI Reduced I	43 22	138 41	98 41
		US=STATE	REDUCED I	20 17	98 38	72
		OTHER	I UAYLIGHTI REDUCED I	5j F	31 13	21 15

## TABLE A-3 FULLY CROSS-CLASSIFIED TABLE OF TEXAS 1974 RAW DATA

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TABLE A-3 (Continued)

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CRVAGE2	МАХТАЛ Т	RUAUTYPE	LIGHTINGI L I	STATUS (S Pre-Fre	) PRE=POST	POSTPOS
55 +	U=2	CITY	DAYLIGHTÎ Reduced î	517 39	856 85	586 36
		I S-STATE	DAYLIGHTI REDUCED 1	104 7	308 35	187 18
		PTHER	DAYLIGHTI REDUCED I	30 2	104 13	62 6
aar genergen andred beiek op mannen	5=4	CITY	DAYLIGHTI REDUCED I	85 883	578 70	403 47
		L5=STATE	DAYLIGHTI HEDULED I	108 11	292 52	505 505
		OTHER	DAYLIGHTI REDUCED I	27	85 15	7 2 1 0
arthan the second second second second second second second second second second second second second second s	5=/	CITY	DAYLIGHTI REDUCED I	5 5 7	61 12	38 2
		US-STATE	DAYLIGHTI REDUCED I	13 8	60 8	19
	,	DTHER	I DAYLIGHTI REDUCED I	3	17	11

**FOR ANALYSIS, C.OCI IS ADDED TO EACH CELL ABOVE

THE TRIAL FREQUENCY 15 30545

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#### TABLE 4-4

## FULLY CROSS-CLASSIFIED TABLE OF NEW YORK 1974 RAW DATA

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NUMTOWED T	NDADTYPE N	DKVAGE2	LIGHTINGI L I		) PRE-POST	POSTPOST
NUNE	STATE	15-24	DAYLIGHTI REDUCED I I	47 37	269 111	266
		25-34	DAYLIGHTI Reduced 1	54 17	161 68	201 - 68
		35-54	I DAYLIGHTI REDUCED I	52 28	265 75	82 82
		55 +	I DAYLIGHTI REDUCED I	56 12	189 38	189 52
	COUNTY	15=24	DAYLIGHTI REDUCED I	46 15	129 56	98 31
		25-34	I DAYLIGHTI REDUCED I I	2 C	73 23	84 18
		35-54	DAYLIGHTI NEDUCED I I	26 11	110 27	131 25
		55 +	DAYLIGHTI REDUCED I	2 C 4	60 19	82 19
	TOWN	15=24	DAYLIGHTI REDUCED I 1	6C 12	169 53	103 34
		25=34	DAYLIGHTI REDUCED I I	34 7	105 21	84 22
		35=54	DAYLIGHTI Reduced i I	50 15	151 28	131 27
		55 +	DAYLIGHTI REDUCED I	27 5	88 13	64 11
	CITY STR	15=24	DAYLIGHTI REDUCED I I	138 69	378 232	317 131
		25-34	DAYLIGHTI REDUCED I I	113 57	444 179	336 154
		35-54	DAYLIGHTI Reduced I I	137 74	484 231	437 150
		55 +	DAYLIGHTI REDUCED I	111 31	348 86	276 59

NU	MTDWED T	NDADTYPE N	DKVAGE2 A	LIGHTINGI L I	STATUS (S PRE-PRE	•	PUSTPUST
ÛN	E DNLY	STATE	15=24	DAYLIGHTI REDUCED I	35 21	125	110 58
			25-34	I UAYLIGHTI REDUCED I I	1 <i>4</i> 1 1	78 45	75 38
			35-54	UAYLIGHTI NEDUCED 1 I	29 10	106 60	122 46
			55 +	DAYLIGHTI REDUCED I	5 1 5	97 36	91 26
		COUNTY	15-24	DAYLIGHTI REDUCED I I	2C 14	44 23	40 20
			25-34	DAYLIGHTI REDUCED I I	12 9	36 11	39 16
			35-54	DAYLIGHTÎ Reduced î I	13	52 27	5 R 1 4
			55 +	DAYLIGHTÎ REDUCED I	1 C 5	48 10	35 3
		10#N	15-24	DAYLIGHTI REDUCED I I	8 S 7	69 21	53 18
			25+34	DAYLIGHTI REDUCED I I	7	50 13	43 11
			35+54	DAYLIGHTI Reduced I I	15 11	63 25	58 18
	1999 10 - 11 - 11 - 11 - 11 - 11 - 11 -		55 *	DAYLIGHTÍ NEDUCED I	9 2	27 8	23 2
		CITY STR	15-24	DAYLIGHTI REDUCED I	43 23	146 93	128 67
			25-34	UAYLIGHTI HEDUCED I 1	23 11	145 72	149 58
			35-54	DAYLIGHTI NEDUCED I 1	31 13	166 96	151 59
			55 +	DAYLIGHTI REDUCED I	37 3	144 30	123 29

TABLE A-4 (continued)

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NUMTOWED T	NDADTYPE N	DHVAGE2	LIGHTINGI L I	STATUS (S PRE-PRE	) Pre~post	POSTPOST
BUTH	STATE	15-24	UAYLIGHTI Neduceu I	32 25	45 86	72 58
		25=34	I DAYLIGHTI NEDUCED J	19 13	50 32	68 32
		35-54	I DAYLIGHTI REDUCED I I	23 22	100 56	105 40
		55 +	DAYLIGHTI REDUCED I	32 3	75 22	87 25
	COUNTY	15-24	DAYLIGHTI REDUCED I I	e 14	58 23	38 21
		25-34	DAYLIGHTI REDULED I 1	6 5	27 15	24 14
		35-54	DAYLIGHTI Reduced I I	13 1	40 19	43 8
		55 +	DAYLIGHTI REDUCED I	13 1	27 9	50
	TOWN	15-24	DAYLIGHTI Reduced i I	16 12	53 26	44 11
		25=34	DAYLIGHTI REDUCED I I	7 4	24 15	25 8
		35-54	UAYLIGHTI REDUCED I I	10 6	49 16	33 9
an an an an an an an an an an an an an a	7.30 <del>0</del>	55 .+	UAYLIGHTI REDUCED 1	13 4	27 6	25 7
	CITY STR		DAYLIGHTI REDUCED I I	16 21	80 60	80 - 32
		25=34	DAYLIGHTI Reduced I I	17 14	81 42	91 40
		35+54	DAYLIGHTI REDUCED I I	8	86 50	78 28
		55 +	DAYLIGHTI REDUCED I	21 3	72 16	82 13

TABLE A-4 (Concluded)

**FOR ANALYSIS, 0.001 IS ADDED TO EACH CELL ABOVE

THE TOTAL FREQUENCY IS 17566

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## TABLE A-5

MAXUAMA6         CIIVSIZE         DAVAGE2         LIBHINGI         STATUS         (S)           0         C         A         L         I         PRE-PRE         PRE-POST POSTPOS           50-344         LT 50K         15-25         DAVLIGHTI         129         194         86           50-344         LT 50K         15-25         DAVLIGHTI         147         271         127           26-55         UAVLIGHTI         147         271         127         141           26-55         UAVLIGHTI         147         271         127           56         DAVLIGHTI         116         3         3           50K         15-25         DAVLIGHTI         56         114         52           26-55         DAVLIGHTI         56         114         52         15           26-55         DAVLIGHTI         56         120         103           4EDUCED         1         17         45         26           56         DAYLIGHTI         128         282         144           4EDUCED         48         94         51           26-55         DAYLIGHTI         128         282         144		-	والمراقع المراجع والمراجع والم	and the second second statement of the second			
HEDUCED         1         37         55         22           26-55         UAYLIGHTI         147         271         127           56         HEDUCED         36         57         25           56         DAYLIGHTI         91         115         41           HEDUCED         1         16         38         57         25           56         DAYLIGHTI         91         115         41           HEDUCED         1         16         38         37           50K         15-25         DAYLIGHTI         56         114         52           26-55         DAYLIGHTI         34         59         23           56         HEDUCED         17         45         26           1         76         134         59         23           56         HEDUCED         17         48         94         51           26-55         DAYLIGHTI         128         282         144           900         15-25         DAYLIGHTI         181         143         60           HEDUCED         12         29         14         143         60           15         15-25 <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>POSTPOST</th>							POSTPOST
26-55 UAYLIGHTI 147 271 127 HEDUCED 1 38 57 25 56 + DAYLIGHTI 91 115 41 HEDUCED 1 1C 16 3 50K + 15-25 DAYLIGHTI 56 114 52 1 26-55 UAYLIGHTI 68 120 103 HEDULED 1 17 45 26 56 + DAYLIGHTI 34 59 23 HEDUCED 1 5 10 6 	50-349	LT 50K	15-25	REDUCED 1	37		
56 +         DAYLIGHTI         91         115         41           MEDULED I         1C         36         3           50K +         15=25         DAYLIGHTI         56         114         52           26-55         DAYLIGHTI         66         120         103           8350-894         LT         50K         15-25         DAYLIGHTI         66         120         103           8350-894         LT         50K         15-25         DAYLIGHTI         34         59         23           8350-894         LT         50K         15-25         DAYLIGHTI         128         282         144           MEDUCED         1         5         10         6           26-55         DAYLIGHTI         128         282         144           MEDUCED         48         94         51           26-55         DAYLIGHTI         176         334         194           MEDUCED         1         29         14           56         HOAYLIGHTI         81         143         20           50K         15-25         DAYLIGHTI         48         94         21           56         HAYLIGHTI			26=55	UAYLIGHTI REDUCED I	147 38		
NEDUCED I       1C       32       15         26-55       DAYLIGHTI       66       120       103         56 +       DAYLIGHTI       34       59       23         56 +       DAYLIGHTI       34       59       23         8350-894       LT       50K       15-25       DAYLIGHTI       128       282       144         NEDUCED I       5       10       6       144       144       194         26-55       DAYLIGHTI       128       282       144         NEDUCED I       48       94       51         26-55       DAYLIGHTI       176       334       194         900       15-25       DAYLIGHTI       81       143       60         NEDUCED I       12       29       14       143       60         900 +       15-25       DAYLIGHTI       81       143       25         26-55       DAYLIGHTI       16       50       33       34       29         26-55       DAYLIGHTI       16       50       33       34       25         26-55       DAYLIGHTI       16       50       33       37       22         26			56 +	DAYLIGHTI	91		
26-55 DAYLIGHTI 68 120 103 HEDULED I 17 45 26 56 + DAYLIGHTI 34 59 23 REDUCED I 5 10 6 		50K +	15+25	REDUCED I	10		
REDUCED I       5       10       6         \$350-899 LT SOK       15-25       DAYLIGHTI       128       282       144         \$8350-899 LT SOK       15-25       DAYLIGHTI       128       282       144         \$8350-899 LT SOK       15-25       DAYLIGHTI       128       282       144         \$8350-899 LT SOK       15-25       DAYLIGHTI       128       282       144         \$26-55       DAYLIGHTI       81       143       60         HEDUCED I       49       76       21         56 +       DAYLIGHTI       81       143       60         REDUCED I       12       29       14         50K +       15-25       DAYLIGHTI       48       118       79         NEDUCED I       19       42       28       1       26-55       24       1         26-55       DAYLIGHTI       63       175       123       23         REDUCED I       13       37       22       1         56 +       DAYLIGHTI       30       120       82         26-55       DAYLIGHTI       29       141       111         26-55       DAYLIGHTI       29 <t< td=""><td></td><td></td><td>26-55</td><td>DAYLIGHTI</td><td>68</td><td></td><td></td></t<>			26-55	DAYLIGHTI	68		
REDUCED I       48       94       51         26-55       DAYLIGHTI       176       334       194         REDUCED I       49       76       21         I       1       176       334       194         S0K +       15-25       DAYLIGHTI       81       143       60         REDUCED I       12       29       14         S0K +       15-25       DAYLIGHTI       48       118       79         REDUCED I       19       42       28       1         26-55       DAYLIGHTI       63       175       123         REDUCED I       11       34       25       1         56 +       DAYLIGHTI       16       50       33         REDUCED I       5       9       4			56 4		-		
26-55       DAYLIGHTI       176       334       194         NEDUCED       49       76       21         56       PAYLIGHTI       81       143       60         S0K       15-25       PAYLIGHTI       81       143       60         S0K       15-25       PAYLIGHTI       81       143       60         S0K       15-25       PAYLIGHTI       48       118       79         REDUCED       19       42       28       1         26-55       PAYLIGHTI       63       175       123         S6       PAYLIGHTI       16       50       33         S900       S0K       S7       S2       22       24         S900       S0K       S2       S2       25       25         S900       S2       S2       S2       26       26	\$350-894	LI SUK	15=25	REDUCED I	48		
REDUCED I       12       29       14         50K +       15-25       DAYLIGHTI       48       118       79         NEDUCED I       19       42       28         I       19       42       28         I       11       34       25         S6 +       DAYLIGHTI       63       175       123         S6 +       DAYLIGHTI       16       50       33         REDUCED I       1       30       120       82         S900 +       LT 50×       15-25       DAYLIGHTI       30       120       82         KEDUCED I       5       9       4       111       37       22         I       13       37       22       1       11       111       111         26-55       DAYLIGHTI       29       141       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111       111			26-55	DAYLIGHTI	176	-	
NEDUCED I       19       42       28         I       1       19       42       28         I       1       63       175       123         REDUCEU I       11       34       25         56 +       DAYLIGHTI       16       50       33         8900 +       LT 50K       15-25       DAYLIGHTI       30       120       82         KEDUCEU I       5       9       4       13       37       22         26-55       DAYLIGHTI       29       141       111         REDUCED I       8       35       20         1       16       70       46			56 +			-	
26-55       DAYLIGHTI       63       175       123         REDUCEU I       11       34       25         1       1       34       25         56       +       UAYLIGHTI       16       50       33         76       +       UAYLIGHTI       16       50       33         76       +       UAYLIGHTI       16       50       33         76       +       UAYLIGHTI       16       50       33         70       40       -       -       10       10         70       15-25       DAYLIGHTI       16       70       46	er 1922 - F. 1960 - Elsen Lander, 1923 - Elsen Lander, 1924 - Hard Marshall,	50K +	15-25	REDUCED 1	19	-	
REDUCED 1       5       9       4         \$900 + LT 50*       15-25       DAYLIGHTI       30       120       82         ***       KEDUCED I       13       37       22         **       1       13       37       22         **       1       13       37       22         **       1       13       37       22         **       1       141       111         **       26-55       DAYLIGHTI       29       141       111         **       8       35       20       1       16       70       46			26=55	DAYLIGHTI	63		
KEDUCED I     13     37     22       I     I     13     37     22       I     I     11     111       REDUCED I     8     35     20       I     I     16     70     46			56 +				
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56 + DAYLIGHTI 16 70 46			26-55	REDUCED I	8		
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56 + DAYLIGHTI 5 23 10 Reduced I 2 5 0			56 +				

FULLY CROSS-CLASSIFIED TABLE OF NORTH CAROLINA 1973 RAW DATA

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> THE TOTAL FREQUENCY IS 6249

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FULLY CROSS-CLASSIFIED TABLE OF NORTH CAROLINA 1974 RAW DATA

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MALE	US-5141E	15=25	UAYLIGHTI REDUCED I	39 18	125 52	52 35
		26+55	I DAYLIGHTI REUUCED I I	39 21	112 35	94 38
		56 +	DAYLIGHTI REDUCED I	23	75 8	38 8
	CITY STR	15+25	DAYLIGHTI HEUUCED I I	122 39	322 135	280 78
		26=55	DAYLIGHTI REDUCED I 1	144 33	427 129	337 97
		56 +	DAYLIGHTI REDUCED I	80 15	200 52	129 21
	RUNAL RD	15=25	DAYLIGHTI REDUCED I	24 1 P	70 35	43 8
		26-55	I DAYLIGHTI REDUCED I	2C 1C	67 16	4 A 1 2
		56 +	I DAYLIGHTI HEDUCED I	10	16	11 2
FEMALE	US-STATE	15-25	DAYLIGHTI REDUCED I	, <u>16</u> 3	60 23	59 14
		26=55	I DAYLIGHTI REDUCED I	24 6	72 18	74 12
		56 +	I DAYLIGHTI REDUCED I	15 C	24 4	56
9	CITY STR	15-25	DAYLIGHTI REDUCED I	8.8 2.4	284 53	221 43
		26=55	I DAYLIGHTI REDUCEU I	79 23	345 40	276 64
		5ь +	I DAYLIGHTI Reduced I	52 5	158 15	106 12
	HUKAL HD	15-25	DAYLIGHTI Reduced I	14 7	47 7	34 8
		26+55	I DAYLIGHTI Reduced I	11	61 10	3.P 4
		56 +	I Daylighti Reduced I	5	26	11

**FOR ANALYSIS, C.OO1 IS ADDED TO EACH CELL ABOVE

THE TOTAL FREQUENCY IS 6486

## TABLE A-7

FULLY CROSS-CLASSIFIED TABLE OF NORTH CAROLINA 1975 RAW DATA

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ACCSEV 1	HUADTYPE	DRVAGE1 A	LIGHTINGI L I		(S) E PRE-POST	PUSTPOST
K+A+B+C	US-STATE	15-25	UAYLIGHTI REDUCEU I 1	8		53 19
		26-55	DAYLIGHTI REDUCED I I	29 7	105 26	90 24
		56 +	DAYLIGHTI REDUCED I	15 C	4	32 5
	CITY STR	15-25		59 28	211	212 76
		26-55	I DAYLIGHTI REDUCED I	7 1 2 1		327 52
		56 +	I DAYLIGHTI REDUCED I	37 4		95 14
ti hal βαλάλβα βαλά μεταλογικά τι παια −υμά του του βάλογβουρουμβ	RUHAL RD	15-25	DAYLIGHTI REDUCED 1	7	45 19	19 5
		26=55	I DAYLIGHTI REDUCED I	е З		39 11
		56 +	I UAYLIGHTI REDUCED I	5 1	1 1 1	6 C
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NONE	US-SIATE	15-25	DAYLIGHTI REDUCED I 1	31 10		101 38
		20=55	DAYLIGHTI Reduced 1	14	122 31	134 29
		56 +	I DAYLIGHTI REDUCED I	18		4 C 7
lan an mar i foi ta fan an mar an an an an an an an an an an an an an	CITY STR	15+25	DAYLIGHTI REDUCED I	24		395 130
		26-55	I DAYLIGHTI REDUCED I	121 21		517 120
		56 +	I DAYLIGHTI REDUCED I	73	226 16	196 20
	RUNAL RD	15-25	DAYLIGHTI REDUCED I	27 7	87 18	67 15
		26=55	I DAYLIGHTI REDUCED I	23 9	82 13	82 9
		50 +	I DAYLIGHTI REDUCED I	۲ ح	27 3	22 2
**FDH ANA	LYSIS,	0.001 IS	S ADDED TO I	EACH CELL	ABDVE	

THE TOTAL FREQUENCY IS 6974

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APPENDIX B

1

SUMMARY OF THE MARGINAL ASSOCIATION OF MODEL EFFECTS

#### TABLE B-1

Effect [†]	Te	xas 19	972	Τe	exas 19	73	Te	exas 19	74
	LR x ²	df	Prob.	LR x ²	df	Prob.	$LR \chi^2$	df	Prob.
Veh Mix x Light Cond	36.28	2	0.000	17.15	2	0.000	22.12*	2	0.000
Veh Mix x Road Type	24.54	4	0.000	30.61	4	0.000	49.90	4	0.000
Veh Mix x Dr Age	76.26	4	0.000	108.97*	4	0.000	133.23	4	0.000
Veh Mix x Dr Sex	-	-	~	73.59*	2	0.000	-	-	-
Veh Mix x Max TAD	-	-	-			-	19.87*	4	0.000
Light Cond x Road Type	134.56	2	0.000	123.57	2	0.000	114.06*	2	0.000
Light Cond x Dr Age	405.35	2	0.000	349.91*	2	0.000	391.95*	2	0.000
Light Cond x Max TAD	~	-	-	271.82*	2	0.000	265.06*	2	0.000
Light Cond x Dr Sex	-	-	-	512.37*	1	0.000	-		-
Road Type x Dr Age	126.87	4	0.000	73.42*	4	0.000	39.79*	4	0.000
Road Type x Max TAD		-		338.29	4	0.000	247.97	4	0.000
Road Type x Dr Sex	-	-	-	66.25*	2	0.000	~	-	-
Max TAD x Dr Age		-	-	56.42*	4	0.000	18.47	4	0.001
Max TAD x Dr Sex	-	-	-	52.66*	2	0.000	-	-	-
Dr Age x Dr Sex	-	-		99.15*	2	0.000	-	-	-
Veh Mix x Dr Age x Dr Sex		-		19.28	4	0.001	-	-	-
Veh Mix x Light Cond x Max TAD	-	-		~	-	-	9.40	4	0.052
Light Cond x Max TAD x Dr Age	_	-	-	10.60	4	0.032	-	-	-
Light Cond x Max TAD x Dr Sex	-	-	-	8.38	2	0.015	-	-	-
Light Cond x Dr Age x Dr Sex	-	-	-	21.54	2	0.000		-	-
Light Cond x Road Type x Dr Age	-	-	-	-	-	-	9.18	4	0.057
Road Type x Dr Age x Dr Sex		-	-	13.35	4	0.010		-	-
Max TAD x Dr Age x Dr Sex	-	-	-	9.76	4	0.045	-	-	-
SUMMARY OF MODEL	36.20	28	0.138	260.81	256	0,405	125.97	112	0.173

#### SUMMARY OF TESTS OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS TEXAS 1972-1974 SAMPLE

[†]For the Texas 1972 and 1974 models, driver characteristics refer to drivers of the <u>struck</u> vehicles, whereas for the Texas 1973 model, they refer to drivers of the <u>striking</u> vehicle.

*Effect is specified directly in the model.

#### TABLE R-2

Effect ⁴	Ne	w York 1	974
Effect	LR 2 X	df	Prob.
Vehicle Mix x Light Condition	37.04	2	0.000
Vehicle Mix x Dr Age	38.98*	6	0.000
Vehicle Mix x Road Type	52.40*	6	0.000
Vehicle Mix x Towaways	13.04*	4	0.011
Light Condition x Dr Age	210.91*	3	0.000
Light Condition x Road Type	71.75*	3	0.000
Light Condition x Towaways	44.86*	2	0.000
Dr Age x Road Type	135.81*	9	0.000
Dr Age x Towaways	15.79*	6	0.015
Road Type x Towaways	260.51*	6	0.000
Vehicle Mix x Dr Age x Towaways	21.65	12	0.042
Vehicle Mix x Road Type x Towaways	40.63	12	0.000
Light Condition x Dr Age x Road Type	13.99	9	0.123
Light Condition x Dr Age x Towaways	13.83	6	0.032
Light Condition x Road Type x Towaways	21.10	6	0.002
Dr Age x Road Type x Towaways	25.80	18	0.104
SUMMARY OF MODEL	172.60	166	0.347

#### SUMMARY OF TESTS OF MARGINAL ASSOCIATIONS OF MODEL EFFECTS NEW YORK 1974 SAMPLE

⁴Driver Age refers to drivers of struck vehicles.

*Effect is specified directly in the model.

#### TABLE B-3

#### SUMMARY OF TESTS OF MARGINAL ASSOCIATIONS OF MODEL NORTH CAROLINA 1973-1975 SAMPLE

Effect	North Ca	irolin	a 1973	North Car	olina	1974	North Ca	rolina	1975
	LR x ²	df	Prob.	LR x ²	df	Prob.	$LR x^2$	df	Prob.
Veh Mix x Light Cond	1.96	2	0.376	4.46*	2	0.107	0.49*	2	0.782
Veh Mix x Dr Age	20.72	4	0.000	21.77	4	0.000	22.83	4	0.000
Veh Mix x City Size	41.76	2	0.000	-	-			-	~
Veh Mix x Damage	147.83	4	0.000		-	-	-	-	
Veh M1x x Road Type	-	-		9.72*	4	0.045	13.39	4	0.010
Veh Mix x Dr Sex	-	-	-	14.60*	2	0.001	-	-	-
Veh Mix x Severity	und <u>an in the second second</u>	-			-	-	3.16*	2	0.206
Light Cond x Dr Age	57.53*	2	0.000	70.30	2	0.000	126.72	2	0.000
Light Cond x City Size	4.36	1	0.037		-	-	-	-	-
Light Cond x Damage	3.71*	2	0.156	-	-		-	-	-
Light Cond x Road Type		-	-	14.88*	2	0.001	6.66*	2	0.036
Light Cond x Dr Sex	-	-	-	65.30*	1	0.000	-	-	-
Light Cond x Severity	-	-		-		-	9.22*	1	0.002
Dr Age x City Size	16.14	2	0.000		-	-		-	-
Dr Age x Damage '	6.27*	4	0.180	-	-	-	-	-	
,Dr Age x Road Type		-		19.18*	4	0.001	19.01	4	0.001
,Dr Age x Dr Sex	-	-	-	0.25*	2	0.883		-	-
City Size x Damage	9.30	2	0.010		-	-		-	-
Road Type x Dr Sex		-		16.78*	2	0.000	-	-	-
Road Type x Severity	-				-	-	16.29*	2	0.000
Light Cond x Dr Age x Damage	12.11	4	0.016		-	-		-	-
Light Cond x Road Type x Dr Sex	-	-	-	0.44*	2	0.803	~	-	
Light Cond x Road Type x Severity	-	-		-	-	-	6.81	2	0.033
Veh Mix x Light Cond x Road Type	-	-	-	10.81*	4	0.029	-	-	-
Veh Mix x Light Cond x Dr Sex	-	-		4.46*	2	0.108	-	-	-
Veh Mix x Road Type x Or Sex	-	-		6.32*	4	0.177	-	-	~
Veh Mix x Light Cond x Severity	-	† -			-	-	7.85	2	0.020
Dr Age x Road Type x Dr Sex	-	-	-	10.29	4	0.036	-	-	-
Veh Mix x Light Cond x Road Type x Dr Sex	-	-		20.74	4	0.000	-	-	-
SUMMARY OF MODEL	68.11	70	0.542	49.49	54	0.649	73.24	72	0.437

⁴For the North Carolina 1973 and 1975 models, driver characteristics refer to the drivers of the struck and striking vehicles, respectively. For the North Carolina 1974 model, Age refers to drivers of struck vehicles, while Sex refers to drivers of striking vehicles.

*Effect is specified directly in the model.

. N.

APPENDIX C

SUMMARY OF EFFECTIVENESS RESULTS FOR OBSERVED, UNADJUSTED STATE MASS ACCIDENT DATA

SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING TEXAS 1972 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 34,011

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SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING TEXAS 1973 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 34,255

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## SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING TEXAS 1974 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 30,545

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## SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NEW YORK 1974 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 17,566

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# SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NORTH CAROLINA 1973 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 6,249

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# SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NORTH CAROLINA 1974 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 6,486

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# SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NORTH CAROLINA 1975 DATA (OBSERVED, NOT ADJUSTED)

Total Cases = 6,974

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# SUMMARY OF FMVSS 108 FEFFCTIVENESS STUDY USING TEXAS 1972 DATA (SMODTHED, ADJUSTED)

Total Cases = 34,011

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# SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING TEXAS 1973 DATA (SMOOTHED, ADJUSTED)

Total Cases = 34,255

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## SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING TEXAS 1974 DATA (SMOOTHED, ADJUSTED)

Total Cases = 30,545

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38.3   9362   30.6   996   3.3   2657   8.7   1882   6.2	9937   12.9   11711   38.3   9362   30.6   2 9937   12.9   11711   38.3   9362   30.6   2 996   3.3   2697   8.7   188.1   198.2   5.2	1025   3.0%   5.0%   5.0%   11711   3.0%   3.0%   3.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%   5.0\%  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# SUMMARY OF FMVSS 108 EFFFCTIVENESS STUDY USING NEW YORK 1974 DATA (SMOOTHED, ADJUSTED)

Total Cases = 17,566

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# SUMMARY OF FMVSS 108 FFFECTIVENESS STUDY USING NORTH CAROLINA 1973 DATA (SMOOTHED, ADJUSTED)

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Total Cases = 6,249

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# SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NORTH CAROLINA 1974 DATA (SMOOTHED, ADJUSTED)

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Total Cases = 6,487

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## SUMMARY OF FMVSS 108 EFFECTIVENESS STUDY USING NORTH CAROLINA 1975 DATA (SMOOTHED, ADJUSTED)

Total Cases = 6,974

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