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Statistical Evaluation of FMVSS 213 (Child Seating Systems)

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CONTRACT TECHNICAL MANAGER'S ADDENDUM

Prepared for the National Highway Traffic Safety Administration in support of its program of regulatory reform - review of existing regulations - as required by Executive Order 12291. Agency staff will perform and publish an official evaluation of Federal Motor Vehicle Safety Standard 213 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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16. Abstract

This study investigates the effect of Federal Motor Vehicle Safety Standard 213 (Child Seating System) in terms of reducing injuries to children age 0-4 in crashes. The analysis is based on the police reported accident files from the states of New York (1975-1978) and Maryland (1977-1980). Because police reported accident data do not contain the necessary details needed to conduct a proper evaluation of the standard, this study is limited to measuring the effectiveness of child seating systems of all kind as they were used on the road whether or not properly installed and/or used. The results necessarily underestimate the true effectiveness of properly used and dynamically tested child seating systems.

The analysis suggests that both lap/lap and shoulder belts and child seating systems are most effective in reducing serious to fatal injuries in children, and less effective, though still significant, in reducing moderate to fatal, or any injuries. Although lap/lap and shoulder belts appear to be more effective than the child seating systems, the difference is not statistically significant. It is felt that this apparent difference could perhaps be attributed to improper usage of child seating systems.

Child seating systems placed on the front seats are significantly more effective than lap/lap and shoulder belts in reducing all levels of injuries, and particularly in serious to fatal injuries for children age 0-1.

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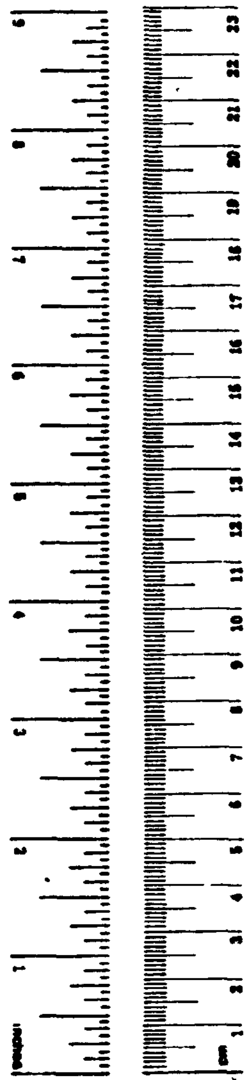
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

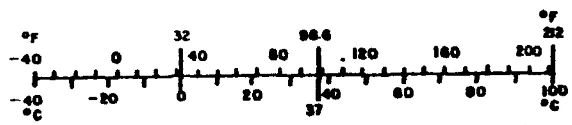
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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TECHNICAL SUMMARY

The Federal Motor Vehicle Safety Standard 213 (Child Seating Systems) was introduced with the objective of reducing fatalities and injuries to young children 0-4 years old in crashes. It establishes requirements for labeling, installing, adjusting and attaching child seating systems to vehicle seat belts. The standard became effective on April 1, 1971. Specific revision was made with respect to requirements for dynamic testing which became effective on January 1, 1981.

Police reported state accident files at best only indicate whether a "child restraint" was used, but do not provide any indication as to its brand name or whether its usage was proper, etc. Among the states whose data are available to HSRC, only New York and Maryland contain this information. The present study is limited to the accident files from these two states (NY: 1975-1978, MD: 1977-1980) and the evaluation is limited to measuring the effectiveness of child seating systems of all kinds as they were used on the road whether or not properly installed and/or used. The results necessarily underestimate the true effectiveness of properly used and dynamically tested child seating systems.

In the evaluation, three injury characterizations were used, namely A+K, B+A+K, and All-injury. A screening procedure was applied with respect to these injury characterizations, and the variables, number of vehicles involved, age of child, child seating position, and driver sex were essentially selected as the controls. Various models were then fit (via the Grizzle, Starmer, and Koch weighted least squares procedure) to each contingency table generated by cross-classifying injury, standard, and these control variables. Overall effectiveness estimates were then derived from the final models.

The analysis demonstrates that both child seating systems and lap/lap and shoulder belts are most effective in reducing (A+K)-injuries and less effective (though still significant) in reducing (B+A+K) and All-injuries as shown in Table S-1.

Lap/lap and shoulder belts seem to be uniformly more effective than the child seating systems. However, these differences are not statistically significant as shown in Table S-2. The seemingly lower effectiveness estimates for child seating systems could be due to the significant amount of improper usage and/or installation of the seats as reported in other studies.

However, detailed analyses from the various models show that there are a few situations as described in Table S-3 where the child seating systems are signifi-

Table S-1

Overall effectiveness of child safety seats and lap/lap and shoulder belts for New York State and Maryland.

Restraint Type	Injury Characterization	State of New York 1975-78	State of Maryland 1977-80
Child Safety Seats	(A+K)	34.12% (8.34%)*	36.18% (15.11%)
	(B+A+K)	23.96% (3.58%)	33.28% (8.89%)
	All	24.73% (3.44%)	16.59% (4.60%)
Lap/lap and shoulder belts	(A+K)	45.90% (5.12%)	59.48% (9.72%)
	(B+A+K)	28.84% (2.81%)	46.05% (6.34%)
	All	23.96% (2.23%)	21.72% (3.20%)

*Standard Error

Table S-2

Effectiveness of lap/lap and shoulder belts relative to child safety seats for New York State and Maryland.

Injury Characterization	State of New York	State of Maryland
(A+K)	19.13%* (13.69%)**	36.51% (20.52%)
(B+A+K)	6.40% (5.45%)	17.87% (12.45%)
All	-1.02% (5.32%)	6.19% (6.13%)

*Effectiveness of lap/lap and shoulder vs. child safety seats

**Standard Error

cantly safer than the lap/lap and shoulder belts. This is especially significant in light of the above discussion.

Table S-3

Specific instances where child safety seats are significantly more effective than belts

Injury Characterization	New York	Maryland
(A+K)	Children age 0-1 in front seats	---
(B+A+K)	Front seats	---
All	Front seats	Towaway crashes

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Chapter 1. BACKGROUND

The Federal Motor Vehicle Safety Standard 213 became effective April 1, 1971. The general purpose of this standard is to reduce fatalities and injuries to small children (age 0 through 4 years old) in crashes. The standard establishes requirements for labeling, installing, adjusting and attaching child seating systems to vehicle seat belts. It also requires manufacturers to produce child seating system components which meet specific static tests. The static test requires the child seating system to retain a torso block which is subjected to a static load of 1,000 lbs in a forward direction or 500 lbs in a rearward direction. This is intended to approximate a 30 mph frontal crash. Horizontal movement of the torso block is then measured. In March 1974, NHTSA published a revision to FMVSS 213 which replaced the static performance tests with dynamic tests requirements and also put car beds and infant carriers, covered by FMVSS 209 (seat belt assemblies), under FMVSS 213. This revision became effective starting January 1, 1981.

An evaluation of FMVSS 213 would ideally be based on accident data which specifies in each case whether a child seating system was present, and if so whether it was properly installed and used. Information on the type of child seating system is also desirable. However police reported State accident files at best only indicate whether a "child restraint" was used, but do not provide any indication as to its brand name or whether its usage was proper. In fact, only New York and Maryland, among the States whose data are available to HSRC, contain this information. Observational studies have indicated that there has been a great deal of improper usage (as much as 50%) as well as usage of <u>non-safety</u> child seating systems. Such improper usage includes improper installation of the seating system (for example the tether strap was not used) and/or incorrect usage of the restraint system component (for example, the three point harness was not used). Furthermore, many safety seats were capable of meeting the dynamic test criteria <u>before</u> the standard was put into effect and since the state data do not specify brand names, we would be unable to tell which cases involve these superior seats. Consequently, the proposed evaluation is limited to the New York and Maryland accident files and will measure the effectiveness of child seating systems of all kinds as they were <u>used on the road</u> whether or not properly installed and/or used. It will necessarily underestimate the effectiveness of <u>properly used</u> and <u>dynamically tested</u> child seating systems.

Chapter 2. METHODOLOGY

The purpose of this study is to evaluate the effectiveness of child seating systems as they were used on the road based on the 1975-1978 New York State police reported accident files and the 1977-1980 Maryland police reported accident files. The proposed method of analysis is outlined below and is carried out for each of the two states.

2.1. Creation of working files

An occupant-oriented subfile of children age 0-4 who were occupants in a crash-involved passenger car will be extracted from each state accident file. This file will contain various items of potential significance.

2.2. Preliminary data analysis

Having created the working file, checks will be made of the quality of the data, the rate of missing/unknown in items of interest, and the possibility of reclassifying some of these missing/unknown items. For example, the injury severity scores in the New York file are not given in the KABCO scale. The KABCO injury codes and weight of the striking vehicle can be derived based on the schemes as discussed in Chi and Reinfurt (1981). Since the sample size is expected to be small, one does not have the luxury of liberally discarding cases with missing items.

2.3. Variable screening

Because of the large number of factors to be considered and the anticipated small sample size, a variable screening procedure as outlined below will be needed to select a subset of factors to be controlled for in the subsequent modeling stage. The screening procedure extends the method proposed by Higgins and Koch (1977) to the situation encountered in the evaluation of Standards or in comparative studies. This procedure will be repeated for each of the three injury characterizations: any injury, (B+A+K) injury and (A+K) injury. This procedure is outlined below:

(a) Listing of potential confounding factors.

A list of potential confounding factors is determined by the relevancy of these factors to the problem at hand, and by the availability of information on these variables. From this list, a number of factors are then selected by the following selection or screening procedure.

(b) Calculation of relevant statistics.

At each stage of the selection procedure, the following statistics are calculated for each candidate variable V, or the joint distribution of V with variables already selected from the preceding stages:

(1) $T_1 = \chi^2$ (V x STANDARD): The Pearson Chi-square statistic for measuring the association between V and STANDARD, the associated degrees of freedom, and the corresponding p-value.

(2) $T_2 = \chi^2$ (V x INJURY): The Pearson Chi-square statistic for measuring the association between V and INJURY, the associated degrees of freedom, and the corresponding p-value.

If either or both of T_1 and T_2 are significant, then the following additional statistics are calculated:

(3) $T_{3,Pre} = \chi^2$ ([V x INJURY|PRE-STANDARD]) and $T_{3,Post} = \chi^2$ ([V x INJURY|POST-STANDARD]): These are the statistics for measuring the partial association of V and INJURY for PRE- and POST-STANDARD.

(4) $T_4 = \chi^2$ ([V x INJURY|STANDARD]) = The generalized Cochran-Mantel-Haenszel statistic for measuring the association of V and INJURY across STANDARD.

(c) The Screening Criteria

Consider the criteria:

Criterion A: Either or both of statistics T_1 and T_2 must be significant.

If the association between V and STANDARD as measured by T_1 is significant, then its inclusion is necessary if one wishes to attribute (to the extent possible) any observed difference in injury experience to the STANDARD. On the other hand, if the association between V and INJURY is significant, then the inclusion of V as a control will contribute significantly to the reduction of variation in injury.

Criterion B: The significant relationship between V and INJURY should be consistent for both PRE- and POST-STANDARD populations.

The relationship between V and INJURY is consistent for both PRE- and POST-STANDARD if $T_4 > \max\{T_{3,Pre}, T_{3,Post}\}$. The relationship is not consistent if $0 \leq T_4 \leq \max\{T_{3,Pre}, T_{3,Post}\}$.

By controlling for all such variables, one can presumably attribute the remaining variation in the injury experience to the Standard.

(d) The selection procedure

Among the variables that met both screening criteria, select one preferably with the largest T_1/d.f. and/or T_2/d.f. statistics. If there are several variables with about the same magnitude for the statistics, T_1/d.f. and/or T_2/d.f., then the variable with the least ambiguity and with the index $I = T_4/(T_{3,Pre} + T_{3,Post})$ closest to 1 is to be preferred.

Thus, a certain amount of subjectivity is involved in the selection process. The procedure repeats itself after each selection has been made and will be terminated if one of the following situations occurs.

(1) No more relevant factors are available for consideration;

(2) The statistics T_1/d.f. and T_2/d.f. are not significant for any of the remaining variables; or

(3) Sample size limits the usefulness of further screening.

2.4. Effectiveness estimates

Based on the appropriate set of control variables selected by the preceding procedure with respect to each one of the three injury characterizations, a multi-dimensional contingency table cross-classifying Standard by injury will be generated. Linear models of the form $\underset{\sim}{P} = \underset{\sim}{X}\underset{\sim}{\beta}$ will be fitted to the contingency table via the Grizzle-Starmer-Koch (GSK) method of weighted least squares, where P is the vector of observed injury rates in the various subpopulations stratified by the variables selected for control, $\underset{\sim}{X}$ is a design matrix, and $\underset{\sim}{\beta}$ is the vector of model coefficients.

A series of models will be fitted to the injury data starting with the analysis of a saturated model where the design matrix $\underset{\sim}{X}$ contains all main effects and interactions. Subsequent models are obtained by successively deleting non-significant interactions and/or main effect terms from the immediately preceding model.

Estimates together with the associated standard errors for overall injury rates and effectiveness of the Standard can then be computed from the predicted injury rates resulting from the final model.

Depending upon the set of control variables selected for each one of the three injury characterizations, injury rate and effectiveness estimates together with their associated standard errors for each of the following subpopulations will be obtained based on the final model.

(1) Child seating position (front vs. rear)

(2) Crash mode (frontal vs. side impact)

(3) Age of child

(4) Calendar year

Chapter 3. THE NEW YORK STATE ACCIDENT FILE

An occupant-oriented file of accidents involving children age 0-4 is created using the police-reported accident data from New York State covering the period 1975-1978. An extensive list of items such as injury severity, restraint type, age of child, seating position etc. is extracted and placed in this file. The basic contents of this file can be seen by examining the list of variables appearing in Table A-1.

Preliminary analysis shows that some items such as the KABCO injury codes and weight of the striking vehicle are not available from the New York State accident file. These items are derived based on the scheme as discussed in Chi and Reinfurt (1981). The KABCO child injury distribution for this file is given in Table 3-1. Table 3-2 gives the overall child restraint usage distribution.

Another item that is of substantial interest is Initial Impact Site. A simple cross-tabulation of Accident Year by Initial Impact Site (see Table 3-3) reveals that this item is mostly missing for accident years 1976-1978. A follow-up call to the NY State DMV reveals that, for economic reasons, values for this variable were not computerized from early 1976 through part of 1978. Since this variable might be of interest, it is suggested that this information be retrieved.

Table 3-1
Overall Child Injury Distribution
(New York)

Injury Level	Frequency	%
K	58	0.13
A	1045	2.29
B	6504	14.24
C	4899	10.73
O	33,159	72.61
Total	45,665	100.00

Table 3-2

Overall Child Restraint Usage Distribution

(New York)

Restraint Usage	Frequency	%
.	2315	5.07
Unbelted	34,060	74.59
Child Restraint	3,724	8.16
Belted	5,566	12.19
Total	45,665	100.00

Table 3-3*

Accident Year by Impact Site

Accident Year	Front	Side	Rear	Others + Unknown	Total
1975	6075 (58.91)**	1318 (12.78)	2392 (23.19)	528 (5.12)	10313
1976	1395 (14.04)	304 (3.06)	519 (5.22)	7719 (77.68)	9937
1977	0	0	0	9950	9950
1978	4289 (43.81)	1056 (10.79)	1658 (16.94)	2786 (28.46)	9789

*This table is based on the child oriented file.
**Row percent

Table 3-4 below compares the distribution of Impact Site (reconstructed)† by Accident Year. Note that the reconstruction scheme was not applied to the 1975 accident data.

---

†A scheme for reconstructing the variable Impact Site was outlined in the monthly report dated October 22, 1981.

Table 3-4*
Accident Year by Impact Site (reconstructed)

	Impact Site				
Accident Year	Front	Side	Rear	Unknown + Other	Total
1975	6075 59.6**	1318 13.0	2392 23.4	528	10313 25.8†
1976	5141 51.7	1774 17.9	1785 18.0	1237	9937 24.9
1977	5244 52.7	1663 16.7	1440 14.5	1603	9950 24.9
1978	5639 57.6	1430 14.6	1996 20.4	724	9789 24.5
Total	22,165	6208	7630	3986	39,989

*This table is based on the child oriented file.
**Row percent
†Column percent

Using only the 1975 data, the reasonableness of this scheme can be examined by cross-classifying this reconstructed Impact Site variable with the original Impact Site variable. Table 3-5 provides a measure of the misclassification involved in this reconstructed variable. It shows that with the exception of Impact Site = 'side', the reclassification scheme is satisfactory.

3.1 (A+K)-Injury Rate and Effectiveness Estimates

Applying the variable screening procedure outlined in the preceding section, the variables Number of Vehicles Involved, Age of Child, Child Seating Position, and Driver Sex were selected as the controls. Preliminary analysis indicated that Driver Sex was not significant and was dropped from the subsequent analysis. The various statistics generated in the variable screening process are given in Table A-1 in Appendix A.

Table 3-6 provides the contingency table cross-classifying Number of Vehicles Involved, Age of Child, Seating Position, Child's Restraint Type and Child's (A+K)-injury.

Table 3-5

Cross-classification of the Reconstructed Impact-Site Variable and Original Impact Site Variable for Accident Year 1975.

		Impact Site (Reconstructed)					
		•	Front	Side	Rear	Unknown + Other	Total
Impact Site (original)	•	289	--	--	--	--	289
	Front	--	3728 61.4*	1347 22.2	179 3.0	821	6075 58.9†
	Side	--	521 29.5	511 38.8	59 4.5	227	1318 12.8
	Rear	--	451 18.9	374 15.6	1418 59.3	149	2392 23.2
	Unknown+ Other	--	5	7	44	183	239 2.3
	Total	289	4705	2239	1700	1380	10313

*Row percent
†Column percent

Linear models were fit to the contingency table via the Grizzle-Starmer-Koch (GSK) weighted least squares procedure. For a detailed discussion on the procedure see Chi (1980). Table 3-7 provides the final parameter estimates and restraint effectiveness estimates corresponding to the final design $\underset{\sim}{X}_f$ as given in Figure 3-1.

The predicted injury rates, $\underset{\sim}{r} = \underset{\sim}{X}_f \underset{\sim}{\beta}$, corresponding to Table 3-6 are determined from the matrices in Figure 3-1, where $\underset{\sim}{\beta}$ is the vector of parameter estimates from Table 3-7.

The coefficients of the model can be explained as follows:

- Single-vehicle crashes have a higher injury risk than multivehicle crashes ($\beta_N = 0.0406$)
- The front seat is less safe than the rear seat ($\beta_N = 0.01$), especially in single vehicle crashes ($\beta_{N \times P} = 0.0217$)

Table 3-6

(A+K)-Injury distribution by type of Child Restraint, Seating Position, Age of Child and Number of Vehicles Involved

(New York)

No. of Vehicles Involved	Age of Child	Seating Position	Child Restraint Type	(A+K)-Injury No	(A+K)-Injury Yes	Total	Stratum Weight
1	0-1	Front	C*	125	5	130	
			L	68	2	70	796
			N	542	54	596	0.0211
		Rear	C	97	5	102	
			L	57	0	57	406
			N	230	17	247	0.0108
	2-4	Front	C	35	2	37	
			L	97	5	102	1407
			N	1156	112	1268	0.0374
		Rear	C	62	1	63	
			L	146	1	147	1556
			N	1275	71	1346	0.0413
2+	0-1	Front	C	968	12	980	
			L	693	13	706	5990
			N	4200	104	4304	0.1591
		Rear	C	975	10	985	
			L	532	2	534	3404
			N	1854	31	1885	0.0904
	2-4	Front	C	342	9	351	
			L	1288	23	1311	10680
			N	8788	230	9018	0.2836
		Rear	C	557	7	564	
			L	1619	19	1638	13421
			N	11049	170	11219	0.3564

*C = Child restraint
L = Lap/lap and shoulder
N = None used

Table 3-7

Final parameter estimates, goodness-of-fit statistic, and effectiveness estimates for (A+K)-injury

(New York)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.0152 (0.0010)	β_{NxP}	0.0217 (0.0073)
β_N^*	0.0406 (0.0054)	β_{NxC}	-0.0287 (0.0109)
β_P	0.0100 (0.0015)	β_{NxL}	-0.0404 (0.0077)
β_C	-0.0038 (0.0027)	β_{AxPxC}	-0.0095 (0.0044)
β_L	-0.0075 (0.0018)		

Goodness-of-Fit Statistic

χ^2 (due to error) = 8.96, d.f. = 15, p = 0.88

Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None†	33.28%†	8.89%
2. Lap/L+S vs. None	46.05%	6.34%
3. Lap/L+S vs. Child Restraint††	19.13%††	13.69%

$$*N = \begin{cases} 1 & \text{if single vehicle} \\ 0 & \text{if multi-vehicle} \end{cases} \qquad C = \begin{cases} 1 & \text{if child restraint} \\ 0 & \text{otherwise} \end{cases}$$

$$\dagger = (\hat{r}_N - \hat{r}_C)/\hat{r}_N * 100 \qquad \dagger\dagger = (\hat{r}_C - \hat{r}_L)/\hat{r}_C * 100$$

$$A = \begin{cases} 1 & \text{if age 0-1} \\ 0 & \text{if age 2-4} \end{cases} \qquad L = \begin{cases} 1 & \text{if lap/lap \& shoulder} \\ 0 & \text{otherwise} \end{cases}$$

$$P = \begin{cases} 1 & \text{if front seat} \\ 0 & \text{if rear seat} \end{cases}$$

Figure 3-1

Predicted injury rates

$\hat{\underset{\sim}{r}} = \underset{\sim}{X}f\hat{\underset{\sim}{\beta}}$

No. of Vehicles Involved	Age of Child	Seating Position	Child Restraint Type	$\underset{\sim}{X}f$									$\hat{\underset{\sim}{\beta}}$
1	0-1	Front	C*	1	1	1	1	0	1	1	0	1	μ
			L	1	1	1	0	1	1	0	1	0	β_N
			N	1	1	1	0	0	1	0	0	0	β_P
		Rear	C	1	1	0	1	0	0	1	0	0	β_C
			L	1	1	0	0	1	0	0	1	0	β_L
			N	1	1	0	0	0	0	0	0	0	β_{NxP}
	2-4	Front	C	1	1	1	1	0	1	1	0	0	β_{NxC}
			L	1	1	1	0	1	1	0	1	0	β_{NxL}
			N	1	1	1	0	0	1	0	0	0	β_{AxPxC}
		Rear	C	1	1	0	1	0	0	1	0	0	
			L	1	1	0	0	1	0	0	1	0	
			N	1	1	0	0	0	0	0	0	0	
2+	0-1	Front	C	1	0	1	1	0	0	0	0	1	
			L	1	0	1	0	1	0	0	0	0	
			N	1	0	1	0	0	0	0	0	0	
		Rear	C	1	0	0	1	0	0	0	0	0	
			L	1	0	0	0	1	0	0	0	0	
			N	1	0	0	0	0	0	0	0	0	
	2-4	Front	C	1	0	1	1	0	0	0	0	0	
			L	1	0	1	0	1	0	0	0	0	
			N	1	0	1	0	0	0	0	0	0	
		Rear	C	1	0	0	1	0	0	0	0	0	
			L	1	0	0	0	1	0	0	0	0	
			N	1	0	0	0	0	0	0	0	0	

*C = Child restraint
L = Lap/lap and shoulder
N = None used

- Child seats are effective (β_C = -0.0038), especially in single vehicle crashes (β_{NxC} = -0.0287)

- Child seats are especially effective for babies in the front seat (β_{AxPxC} = -0.0095). Note, however, that even this enhanced effectiveness does not overcome the added risk of sitting in the front seat (β_P = 0.01, $\beta_P + \beta_{NxP}$ = 0.0317).

- Lap belts are effective (β_L = -0.0075), especially in single vehicle crashes (β_{NxL} = -0.0404).

The overall restraint effectiveness estimates are obtained from the weighted average of the appropriate predicted stratum injury rates. For instance, the effectiveness estimate for none vs child restraint is defined as

$$\text{Effectiveness} = \frac{\sum_i W_i \, (\hat{r}_{N,i} - \hat{r}_{C,i})}{\sum_i W_i \, \hat{r}_{N,i}}$$

where $\hat{r}_{N,i}$ is the predicted (A+K)-injury rate for an unrestrained child in the ith-stratum, and $\hat{r}_{C,i}$ is the corresponding predicted injury rate for a child in some kind of child seating system as reported by police whether or not properly used and installed. The various effectiveness estimates are given in Table 3-7.

The effectiveness estimates in Table 3-7 indicate that both child safety seats as they are used (disregarding improper usage, etc.) and lap/lap and shoulder belts are very effective in reducing (A+K)-injuries. Relative to unrestrained children, child safety seats are 33.28% effective, while lap/lap and shoulder belts are 46.05% effective. The apparently higher overall effectiveness of lap/lap and shoulder belts is however not statistically significant. The only situation where child safety seats appear to be significantly more effective is in the case of children age 0-1 occupying the front seat. The injury rate is reduced by 0.95% ($\beta_{AxPxC} = -0.0095$) whereas for lap/lap and shoulder belts, the corresponding reduction is nil.

In view of the significance of the factors Number of Vehicles Involved, Age of Child, and Seating Position, the injury rate and effectiveness estimates are calculated based on the final model above for each subpopulation defined by the various strata of these factors. These estimates are given in Table 3-8 and Table 3-9.

Now for the variable Accident Year, since it was not selected as a control, one cannot derive the injury rate and effectiveness estimates based on the final model. However, Table 3-10 shows how the injury rates vary by Accident Year. There is a moderate downward trend for children in the unrestrained and lap/lap and shoulder belt groups and a stronger trend, especially, for children in some kind of child seating systems.

The fact that this downward trend is stronger for child seats than for unrestrained and belted children perhaps reflects the result of a combination of safer child seating systems and/or more proper usage of child restraints in later years. The differences of the trend lines, however are not statistically significant.

Table 3-8

(A+K)-Injury Rates Estimates by Child Age, Seating Position, and Number of Vehicles Involved

(New York)

	Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	1.47%† (0.25%)*	1.58% (0.17%)	2.79% (0.09%)
	2-4	1.84% (0.26%)	1.33% (0.16%)	2.53% (0.09%)
Seating Position	Front	2.20% (0.23%)	2.03% (0.20%)	3.25% (0.13%)
	Rear	1.27% (0.25%)	0.77% (0.16%)	1.95% (0.11%)
No. of Vehicles Involved	1	3.83% (0.98%)	2.47% (0.64%)	7.26% (0.44%)
	2+	1.47% (0.22%)	1.27% (0.16%)	2.02% (0.09%)

†Injury rate multiplied by 100
*Standard Error

Table 3-9

(A+K)-Injury Effectiveness Estimates by Child Age, Seating Position, and Number of Vehicles Involved

(New York)

	Effectiveness	Child Restraint vs None	Lap/L+S vs None	Lap/L+S vs Child Restraint
Age of Child	0-1	47.09% (9.10%)**	43.37% (6.02%)	-7.03% (21.25%)
	2-4	27.32% (10.58%)	47.21% (6.45%)	27.36% (13.22%)
Seating Position	Front	32.42% (6.89%)	37.59% (5.40%)	7.65% (11.53%)
	Rear	34.73% (13.43%)	60.25% (8.16%)	39.09% (17.37%)
No. of Vehicles Involved	1	47.20% (13.87%)	65.98% (8.86%)	35.56% (22.97%)
	2+	27.06% (11.15%)	37.14% (8.31%)	13.82% (16.54%)

* $\frac{(\hat{r}_N - \hat{r}_C)}{\hat{r}_N}$ = Effectiveness of Child Restraint vs. None

** Standard Error

Table 3-10

Observed (A+K)-Injury Rates by Accident Year

(New York)

	1975		1976		1977		1978	
Restraint Type	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	711	20 2.74*	725	9 1.23	841	11 1.29	895	11 1.21
Lap/L+S	1242	23 1.82	1089	23 2.07	1097	11 0.99	1082	9 0.82
None	7465	245 3.18	7327	221 2.93	7237	175 2.36	7148	151 2.07

*Injury rate

3.2. (B+A+K)-Injury Rate and Effectiveness Estimates

Application of the variable screening procedure relative to (B+A+K)-injury characterization produces the following set of variables as controls: Age of Child, Seating Position, Number of Vehicles Involved, and Driver Sex. The variables statistics generated in the process are given in Table A-2 of Appendix A.

Table 3-11 is the contingency table cross-classifying the Number of Vehicles Involved, Age of Child, Driver Sex, Seating Position, Child Restraint Type, and Child's (B+A+K)-injury status.

A sequence of linear models were fit to this table using the GSK-weighted least squares method. Table 3-12 gives the final parameter estimates and overall restraint effectiveness estimates corresponding to the final design matrix $\underset{\sim}{X}_f$ which is given in Figure 3-2.

The estimated model coefficients suggest the following interpretation:

- Single vehicle crashes have significantly higher injury risk than multivehicle crashes (β_N = 0.1804).
- The front seat is much less safe than the rear seat (β_P = 0.0958), especially so in single vehicle accidents (β_{NxP} = 0.0705).
- Babies 0-1 seem to sustain less injury than children 2-4 (β_A = -0.0147), especially in the front seat (β_{AxP} =-0.0272).

Table 3-11

Contingency table cross-classifying Number of Vehicles Involved, Age of Child, Driver Sex, Seating Position, Child Restraint Type, and Child's (B+A+K)-injury status

(New York)

No. of Vehicles Involved	Age of Child	Driver Sex	Seating Position	Child Restraint Type	(B+A+K)-injury 0	(B+A+K)-injury 1	Total	Wt.
1	0-1	Male	Front	C*	22	4	26	
				L	13	4	17	322
				N	190	89	279	
			Rear	C	26	7	33	
				L	15	4	19	181
				N	96	33	129	
		Female	Front	C	78	26	104	
				L	36	17	53	474
				N	179	138	317	
			Rear	C	56	13	69	
				L	32	6	38	225
				N	83	35	118	
	2-4	Male	Front	C	7	2	9	
				L	17	6	23	519
				N	272	215	487	
			Rear	C	17	5	22	
				L	52	15	67	682
				N	434	159	593	
		Female	Front	C	16	12	28	
				L	55	24	79	888
				N	402	379	781	
			Rear	C	32	9	41	
				L	68	12	80	874
				N	534	219	753	

*C = Child restraint
L = Lap/lap and shoulder belt
N = None used

Table 3-11 (Con't)

No. of Vehicles Involved	Age of Child	Driver Sex	Seating Position	Child Restraint Type	(B+A+K)-injury 0	1	Total	Wt.
2+	0-1	Male	Front	C*	229	25	254	
				L	218	31	249	2846
				N	1974	369	2343	
			Rear	C	322	29	351	
				L	211	17	228	1621
				N	937	105	1042	
		Female	Front	C	635	91	726	
				L	402	55	457	3144
				N	1608	353	1961	
			Rear	C	570	64	634	
				L	286	20	306	1783
				N	750	93	843	
	2-4	Male	Front	C	96	13	109	
				L	431	81	512	4713
				N	3277	815	4092	
			Rear	C	165	23	188	
				L	694	62	756	6219
				N	4606	669	5275	
		Female	Front	C	201	41	242	
				L	673	126	799	5967
				N	3860	1066	4926	
			Rear	C	335	41	376	
				L	810	72	882	7202
				N	5257	687	5944	

*C = Child restraint
L = Lap/lap and shoulder belt
N = None used

Table 3-12

Final Parameter Estimates, Goodness-of-Fit Statistic, and Effectiveness Estimate for (B+A+K)-injury

(New York)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.1212 (0.0029)	β_{NxP}	0.0705 (0.0148)
β_N^*	0.1804 (0.0130)	β_{NxC}	-0.0896 (0.0250)
β_A	-0.0147 (0.0059)	β_{NxL}	-0.0794 (0.0233)
β_P	0.0958 (0.0054)	β_{AxP}	-0.0272 (0.0084)
β_C	-0.0100 (0.0085)	β_{SxP}	-0.0188 (0.0059)
β_L	-0.0427 (0.0052)	β_{PxC}	-0.0457 (0.0127)
β_{NxS}	-0.0314 (0.0148)		

Goodness-of-Fit Statistic

χ^2 (due to error) = 25.01, d.f. = 35, p = 0.89

Overall Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None	23.96%†	3.58%
2. Lap/L+S vs. None	28.84%	2.81%
3. Lap/L+S vs. Child Restraint	6.40%††	5.45%

$*N = \begin{cases} 1 \text{ if single vehicle} \\ 0 \text{ if multi-vehicle} \end{cases}$ $\quad P = \begin{cases} 1 \text{ if front seat} \\ 0 \text{ if rear seat} \end{cases}$

† $(\hat{r}_N - \hat{r}_C)/\hat{r}_N * 100 = 23.96\%$

†† $(\hat{r}_C - \hat{r}_L)/\hat{r}_C * 100 = 6.40\%$

$A = \begin{cases} 1 \text{ if age 0-1} \\ 0 \text{ if age 2-4} \end{cases}$ $\quad C = \begin{cases} 1 \text{ if child restrained} \\ 0 \text{ otherwise} \end{cases}$

$S = \begin{cases} 1 \text{ if male driver} \\ 0 \text{ if female driver} \end{cases}$ $\quad L = \begin{cases} 1 \text{ if child belted} \\ 0 \text{ otherwise} \end{cases}$

Figure 3-2

Predicted (B+A+K)-Injury Rates $\hat{\underset{\sim}{r}} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$

(New York)

Age of Child	Driver Sex	Seating Position	Child Restraint Type	Number of Vehicles Involved: Single ($\underset{\sim}{X}_f$)	Number of Vehicles Involved: Multi ($\underset{\sim}{X}_f$)	$\hat{\underset{\sim}{\beta}}$
0-1	Male	Front	C	1 1 1 1 1 0 1 1 1 0 1 1 1	1 0 1 1 1 0 0 0 0 0 1 1 1	μ
			L	1 1 1 1 0 1 1 1 0 1 1 1 0	1 0 1 1 0 1 0 0 0 0 1 1 0	β_N
			N	1 1 1 1 0 0 1 1 0 0 1 1 0	1 0 1 1 0 0 0 0 0 0 1 1 0	β_A
		Rear	C	1 1 1 0 1 0 1 0 1 0 0 0 0	1 0 1 0 1 0 0 0 0 0 0 0 0	β_P
			L	1 1 1 0 0 1 1 0 0 1 0 0 0	1 0 1 0 0 1 0 0 0 0 0 0 0	β_C
			N	1 1 1 0 0 0 1 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0 0 0	β_L
	Female	Front	C	1 1 1 1 1 0 0 1 1 0 1 0 1	1 0 1 1 1 0 0 0 0 0 1 0 1	β_{NxS}
			L	1 1 1 1 0 1 0 1 0 1 1 0 0	1 0 1 1 0 1 0 0 0 0 1 0 0	β_{NxP}
			N	1 1 1 1 0 0 0 1 0 0 1 0 0	1 0 1 1 0 0 0 0 0 0 1 0 0	β_{NxC}
		Rear	C	1 1 1 0 1 0 0 0 1 0 0 0 0	1 0 1 0 1 0 0 0 0 0 0 0 0	β_{NxL}
			L	1 1 1 0 0 1 0 0 0 1 0 0 0	1 0 1 0 0 1 0 0 0 0 0 0 0	β_{AxP}
			N	1 1 1 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0 0 0	β_{SxP}
2-4	Male	Front	C	1 1 0 1 1 0 1 1 1 0 0 1 1	1 0 0 1 1 0 0 0 0 0 0 1 1	β_{PxC}
			L	1 1 0 1 0 1 1 1 0 1 0 1 0	1 0 0 1 0 1 0 0 0 0 0 1 0	
			N	1 1 0 1 0 0 1 1 0 0 0 1 0	1 0 0 1 0 0 0 0 0 0 0 1 0	
		Rear	C	1 1 0 0 1 0 1 0 1 0 0 0 0	1 0 0 0 1 0 0 0 0 0 0 0 0	
			L	1 1 0 0 0 1 1 0 0 1 0 0 0	1 0 0 0 0 1 0 0 0 0 0 0 0	
			N	1 1 0 0 0 0 1 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0 0	
	Female	Front	C	1 1 0 1 1 0 0 1 1 0 0 0 1	1 0 0 1 1 0 0 0 0 0 0 0 1	
			L	1 1 0 1 0 1 0 1 0 1 0 0 0	1 0 0 1 0 1 0 0 0 0 0 0 0	
			N	1 1 0 1 0 0 0 1 0 0 0 0 0	1 0 0 1 0 0 0 0 0 0 0 0 0	
		Rear	C	1 1 0 0 1 0 0 0 1 0 0 0 0	1 0 0 0 1 0 0 0 0 0 0 0 0	
			L	1 1 0 0 0 1 0 0 0 1 0 0 0	1 0 0 0 0 1 0 0 0 0 0 0 0	
			N	1 1 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0 0	

- Children in cars with male drivers have fewer injuries than those in cars with female drivers, in the more hazardous accident situations (β_{NxS} = -0.0314, β_{SxP} = -0.0188).
- Child restraint is effective in reducing injuries (β_C = -0.0100) and significantly so in the more hazardous situations (β_{NxC} = -0.0896, β_{PxC} = -0.0457).
- Lap/lap and shoulder belts are significantly effective in reducing injuries (β_L = -0.0427) particularly in single vehicle accidents (β_{NxL} = -0.0794).

Thus, even though the overall effectiveness estimates of lap/lap & shoulder belts and child seating systems are not significantly different, the above analyses show that child seating systems might be more effective than belts in single vehicle accidents (β_{NxC} = -0.0896 compare to β_{NxL} = -0.0794), especially in the front seat (β_{PxC} = -0.0457).

Based on the final model above, injury rate and effectiveness estimates are also calculated for each subpopulation defined by the levels of the factors: number of vehicles involved, seating position, and child's age. These estimates are given in Table 13 and 14.

Table 3-13

(B+A+K)-Injury Rates Estimates by Child Age, Seating Position, and Number of Vehicles Involved

(New York)

	Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	11.97%† (0.64%)*	11.74% (0.56%)	16.91% (0.38%)
	2-4	14.22% (0.65%)	13.10% (0.50%)	18.24% (0.24%)
Seating Position	Front	15.53% (0.92%)	16.95% (0.54%)	22.15% (0.31%)
	Rear	11.63% (0.80%)	8.46% (0.49%)	13.56% (0.27%)
No. of Vehicles Involved	1	23.97% (2.29%)	24.14% (2.13%)	36.35% (0.80%)
	2+	12.29% (0.62%)	11.29% (0.47%)	15.57% (0.22%)

†Injury rate multiplied by 100
*Standard Error

Table 3-14 shows that effectiveness estimates for child seating systems and lap/lap & shoudler belts are not statistically significantly different except for children in rear seats where lap/belts appear to be significantly more effective.

Since Accident Year was not significantly interrelated with restraint usage and injury risk and consequently was not selected as one of the controls, it is not possible to obtain injury rate and effectiveness estimates based on the final (contingency table) model. However, in order to see how the injury rates vary by Accident Year, Table 15 illustrates the trend.

Table 3-14

(B+A+K)-Injury Effectiveness Estimates by Child Age, Seating Position, and Number of Vehicles Involved

(New York)

	Effectiveness	Child Restraint vs None	Lap/L+S vs None	Lap/L+S vs. Child Restraint
Age of Child	0-1	29.24%* (3.91%)**	30.59% (2.99%)	1.91% (6.73%)
	2-4	22.05% (3.52%)	28.20% (2.76%)	7.89% (5.10%)
Seating Position	Front	29.88% (4.27%)	23.48% (2.32%)	-9.12% (7.31%)
	Rear	14.26% (6.17%)	37.62% (3.63%)	27.25% (6.49%)
No. of Vehicles Involved	1	34.06% (6.47%)	33.59% (6.03%)	0.71% (13.03%)
	2+	21.03% (4.16%)	27.45% (3.17%)	8.13% (5.94%)

* $\frac{(\hat{r}_N-\hat{r}_C)}{\hat{r}_N}$ = effectiveness of Child Restraint vs. None

** Standard Error

It appears that there is a trend of decreasing injury rates for children in lap/lap and shoulder belts and for unrestrained children. The corresponding trend is not so obvious for children in child seating systems. The trends would not appear to indicate that child restraints became safer (or more often properly used) in later years.

Table 3-15
Observed (B+A+K)-Injury Rates by Accident Year
(New York)

	1975		1976		1977		1978	
Restraint Type	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	633	98 13.41*	648	86 11.72	740	112 13.15	796	110 12.14
Lap/L+S	1094	171 13.52	972	140 12.59	986	122 11.01	970	121 11.09
None	6245	1465 19.00	6170	1378 18.26	6099	1313 17.71	6012	1287 17.63

*Injury rate

3.3. All-Injury Rate and Effectiveness Estimates

Application of the variable selection procedure relative to All-injury characterization produces the same set of variables for controls, namely Number of Vehicles Involved, Age of Child, Driver Sex, and Seating Position. The various statistics generated are presented in Table A-3 of Appendix A.

Table 3-18 is the cross-classification of the Number of Vehicles Involved, Age of Child, Driver Sex, Seating Position, Child Restraint Type, and Child's All-injury status.

A sequence of linear models were fit to the above table via the GSK-weighted least squares method. The final parameter estimates and overall restraint effectiveness estimates corresponding to the design matrix $\underset{\sim}{X}_f$ given in Figure 3-3 are presented in Table 3-19.

The estimated model coefficients suggest a similar interpretation as follows:

- Both single vehicle accidents (β_N = 0.1840) and front seat (β_P = 0.1168), especially in combination ($\beta_{N \times P}$ = 0.0875) offer higher injury risk.

Table 3-18

Contingency table cross-classifying Number of Vehicles Involved, Age of Child, Driver Sex, Seating Position, Child Restraint Type, and Child's All-Injury Status

(New York)

No. of Vehicles Involved	Age of Child	Driver Sex	Seating Position	Child Restraint Type	All-injury 0	All-injury 1	Total	Wt.
1	0-1	Male	Front	C*	20	6	26	
				L	11	6	17	322
				N	171	108	279	
			Rear	C	25	8	33	
				L	15	4	19	181
				N	85	44	129	
		Female	Front	C	67	37	104	
				L	34	19	53	474
				N	160	157	317	
			Rear	C	53	16	69	
				L	30	8	38	225
				N	70	48	118	
	2-4	Male	Front	C	6	3	9	
				L	13	10	23	519
				N	207	280	487	
			Rear	C	16	6	22	
				L	46	21	67	682
				N	366	227	593	
		Female	Front	C	15	13	28	
				L	50	29	79	888
				N	307	474	781	
			Rear	C	30	11	41	
				L	60	20	80	874
				N	451	302	753	

* C = Child restraint
L = Lap/lap and shoulder belt
N = None used

Table 3-18 (Con't)

No. of Vehicles Involved	Age of Child	Driver Sex	Seating Position	Child Restraint Type	All-injury 0	1	Total	Wt.
2+	0-1	Male	Front	C*	206	48	254	
				L	196	53	249	2846
				N	1791	552	2343	
			Rear	C	300	51	351	
				L	195	33	228	1621
				N	825	217	1042	
		Female	Front	C	578	148	726	
				L	371	86	457	3144
				N	1445	516	1961	
			Rear	C	516	118	634	
				L	270	36	306	1783
				N	689	154	843	
	2-4	Male	Front	C	88	21	109	
				L	378	134	512	4713
				N	2745	1347	4092	
			Rear	C	149	39	188	
				L	610	146	756	6219
				N	3982	1293	5275	
		Female	Front	C	182	60	242	
				L	592	207	799	5967
				N	3248	1678	4926	
			Rear	C	310	66	376	
				L	728	154	882	7202
				N	4661	1283	5944	

*C = Child restraint
L = Lap/lap and shoulder belt
N = None used

Table 3-19

Final Parameter Estimates, Goodness-of-Fit Statistic, and Effectiveness Estimate for All-Injury

(New York)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.2188 (0.0048)	$\beta_{N\times C}$	-0.0894 (0.0278)
β_N^*	0.1840 (0.0142)	$\beta_{N\times L}$	-0.0885 (0.0259)
β_A	-0.0307 (0.0093)	$\beta_{A\times S}$	-0.0182 (0.0099)
β_S	0.0274 (0.0066)	$\beta_{A\times P}$	-0.0419 (0.0106)
β_P	0.1168 (0.0071)	$\beta_{A\times C}$	0.0291 (0.0164)
β_C	-0.0488 (0.0143)	$\beta_{S\times P}$	-0.0347 (0.0092)
β_L	-0.0588 (0.0067)	$\beta_{P\times C}$	-0.0404 (0.0158)
$\beta_{N\times S}$	-0.0391 (0.0161)	$\beta_{N\times A\times P}$	-0.0532 (0.0232)
$\beta_{N\times P}$	0.0875 (0.0180)		

Goodness-of-Fit Statistic

χ^2 (due to error) = 22.8, d.f. = 31, p = 0.86

Overall Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None†	24.73%†	3.44%
2. Lap/L+S vs. None	23.96%	2.23%
3. Lap/L+S vs. Child Restraint††	-1.02%††	5.32%

$*N = \begin{cases} 1 \text{ if single vehicle} \\ 0 \text{ if multi-vehicle} \end{cases}$ $P = \begin{cases} 1 \text{ if front seat} \\ 0 \text{ if rear seat} \end{cases}$

† $(\hat{r}_N - \hat{r}_C)/\hat{r}_N * 100 = 24.73\%$

†† $(\hat{r}_C - \hat{r}_L)/\hat{r}_C * 100 = -1.02\%$

$A = \begin{cases} 1 \text{ if age 0-1} \\ 0 \text{ if age 2-4} \end{cases}$ $C = \begin{cases} 1 \text{ if child restrained} \\ 0 \text{ otherwise} \end{cases}$

$S = \begin{cases} 1 \text{ if male driver} \\ 0 \text{ if female driver} \end{cases}$ $L = \begin{cases} 1 \text{ if child belted} \\ 0 \text{ otherwise} \end{cases}$

Figure 3-3
Predicted All-Injury Rates $\hat{\underset{\sim}{r}} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$
(New York)

Age of Child	Driver Sex	Seating Position	Child Restraint Type	Number of Vehicles Involved: Single ($\underset{\sim}{X}_f$)	Number of Vehicles Involved: Multi ($\underset{\sim}{X}_f$)
0-1	Male	Front	C	1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1	1 0 1 1 1 1 0 0 0 0 0 1 1 1 1 1 0
			L	1 1 1 1 1 0 1 1 1 0 1 1 1 0 1 0 1	1 0 1 1 1 0 1 0 0 0 0 1 1 0 1 0 0
			N	1 1 1 1 1 0 0 1 1 0 0 1 1 0 1 0 1	1 0 1 1 1 0 0 0 0 0 0 1 1 0 1 0 0
		Rear	C	1 1 1 1 0 1 0 1 0 1 0 1 0 1 0 0 0	1 0 1 1 0 1 0 0 0 0 0 1 0 1 0 0 0
			L	1 1 1 1 0 0 1 1 0 0 1 1 0 0 0 0 0	1 0 1 1 0 0 1 0 0 0 0 1 0 0 0 0 0
			N	1 1 1 1 0 0 0 1 0 0 0 1 0 0 0 0 0	1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0
	Female	Front	C	1 1 1 0 1 1 0 0 1 1 0 0 1 1 0 1 1	1 0 1 0 1 1 0 0 0 0 0 0 1 1 0 1 0
			L	1 1 1 0 1 0 1 0 1 0 1 0 1 0 0 0 1	1 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0
			N	1 1 1 0 1 0 0 0 1 0 0 0 1 0 0 0 1	1 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0
		Rear	C	1 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0	1 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0
			L	1 1 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0	1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
			N	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2-4	Male	Front	C	1 1 0 1 1 1 0 1 1 1 0 0 0 0 1 1 0	1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 1 0
			L	1 1 0 1 1 0 1 1 1 0 1 0 0 0 1 0 0	1 0 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0
			N	1 1 0 1 1 0 0 1 1 0 0 0 0 0 1 0 0	1 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0
		Rear	C	1 1 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0	1 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0
			L	1 1 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0	1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0
			N	1 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0	1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
	Female	Front	C	1 1 0 0 1 1 0 0 1 1 0 0 0 0 0 1 0	1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0
			L	1 1 0 0 1 0 1 0 1 0 1 0 0 0 0 0 0	1 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0
			N	1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0	1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
		Rear	C	1 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0	1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
			L	1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0	1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
			N	1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

$$\hat{\underset{\sim}{\beta}} = \begin{bmatrix} \mu \\ \beta_N \\ \beta_A \\ \beta_S \\ \beta_P \\ \beta_C \\ \beta_L \\ \beta_{NxS} \\ \beta_{NxP} \\ \beta_{NxC} \\ \beta_{NxL} \\ \beta_{AxS} \\ \beta_{AxP} \\ \beta_{AxC} \\ \beta_{SxP} \\ \beta_{PxC} \\ \beta_{NxAxP} \end{bmatrix}$$

- Children age 0-1 generally have less injury than children age 2-4 (β_A = -0.0307, β_{AxP} = -0.0419, β_{AxNxP} = -0.0532).
- The presence of male drivers is generally a higher injury risk factor than female drivers (β_S = 0.0274). However, in the more hazardous accident situations, male drivers appear to be associated with lower injury risk than female drivers (β_{SxN} = -0.0391, β_{SxP}= -0.0347).
- Lap/lap and shoulder belts are significantly effective (β_L = -0.0588), especially in single vehicle crashes (β_{NxL} = -0.0885).
- Child restraint is significantly effective in reducing injuries (β_C = -0.0488), and especially in the more hazardous situations (β_{NxC} = -0.0894, β_{PxC} = -0.0404).

The overall effectiveness estimates seem to suggest that child safety seats and lap/lap & shoulder belts are about equally effective. However, the above analysis shows that child safety seats are relatively more effective for frontal position (a further reduction of 4.04%, β_{PxC} = -0.0404)). The injury rate and effectiveness estimates are also calculated for each subpopulation defined by the levels of the factors, Age of Child, Seating Position, and Number of Vehicles Involved. These estimates are given in Table 3-20 and Table 3-21. They indicate that in each case, overall the child safety seats and the lap/lap & shoulder belts are about equally effective.

Table 3-22 shows that there is a trend toward decreasing injury rate over the years; however, the trend is clearer for lap/lap & shoulder belts than for child safety seats which again exhibit a break in the trend for the accident year 1977. There is little evidence that child seats became more effective in later years.

Table 3-22

All-Injury Rates by Accident Year

(New York)

	1975		1976		1977		1978	
Restraint Type	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	569	162 22.16*	592	142 19.35	667	185 21.71	742	164 18.10
Lap/L+S	969	296 23.40	852	260 23.38	903	205 18.50	883	208 19.07
None	5421	2289 29.69	5351	2197 29.11	5267	2145 28.94	5232	2077 28.42

*Injury rate

Table 3-20

All-Injury Rates Estimates by Child Age, Seating Position, and Number of Vehicles Involved

(New York)

	Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	19.60%† (0.88%)*	18.29% (0.70%)	25.17% (0.48%)
	2-4	22.24% (1.28%)	23.11% (0.63%)	29.95% (0.29%)
Seating Position	Front	24.18% (1.26%)	26.19% (0.67%)	33.10% (0.36%)
	Rear	18.88% (1.17%)	17.30% (0.63%)	24.10% (0.34%)
No. of Vehicles Involved	1	31.87% (2.60%)	32.26% (2.36%)	46.98% (0.84%)
	2+	20.25% (0.98%)	20.45% (0.61%)	26.32% (0.27%)

†Injury rate multiplied by 100
*Standard Error

Table 3-21

All-Injury Effectiveness Estimates by Child Age, Seating Position, and Extent of Damage

(New York)

	Restraint Type	Child Restraint vs. None	Lap/L+S vs. None	Lap/L+S vs. Child Restraint
Age of Child	0-1	22.14%* (3.82%)**	27.34% (2.53%)	6.67% (5.50%)
	2-4	25.58% (4.34%)	22.85% (2.14%)	-3.67% (6.61%)
Seating Position	Front	26.95% (3.89%)	20.88% (1.95%)	-8.31% (6.29%)
	Rear	21.66% (4.99%)	28.22% (2.62%)	8.36% (6.58%)
No. of Vehicles Involved	1	32.16% (5.69%)	31.34% (5.17%)	-1.22% (11.03%)
	2+	23.08% (3.81%)	22.32% (2.46%)	-0.98% (5.75%)

* $\frac{(\hat{r}_N - \hat{r}_C)}{\hat{r}_N}$ = Effectiveness of child restraint vs none.

** Standard Error

Chapter 4. THE MARYLAND ACCIDENT FILE

A child-oriented file of accidents involving children age 0-4 in passenger cars is created using the police-reported accident data from the state of Maryland covering the period 1977-1980. The file contains 25943 cases. The basic contents of this file can be seen from the variables appearing in Table A-4. Some items such as the weight of the striking vehicles are not available from the Maryland accident data and are subsequently derived based on the scheme as discussed in Chi and Reinfurt (1981).

The Maryland injury severity codes are not given in the KABCO scale. For the purpose of this study, the following three injury characterizations are defined to correspond to the KABCO scale.

Injury Characterization	Definition
(A+K)	Fatal + Incapacitating Injury
(B+A+K)	Fatal + Incapacitating + Non-Incapacitating Injury
ALL	Any Injury

4.1. (A+K)-Injury Rate and Effectiveness Estimates

Application of the variable screening procedure relative to the (A+K)-injury characterization produces the variables, Extent of Damage, Age of Child, and Seating Position. A summary of the statistics generated in the process are given in Table A-3 of Appendix A.

Table 4-1 provides the contingency table cross-classifying Extent of Damage, Age of Child, Seating Position, Child Resraint Type, and (A+K)-injury status.

Starting from a saturated model, a sequence of linear models were fit to the above table. The final model corresponding to the design matrix $\underset{\sim}{X}_f$ given in Figure 4-1 produces the parameter estimates and overall effectiveness estimates given in Table 4-2.

The model coefficient estimates in Table 4-2 provide the following interpretation:

- Towaway accident ($\beta_E = 0.0391$) or front seat ($\beta_P = 0.0013$), or in combination ($\beta_{ExP} = 0.0113$) have higher injury risk.

Table 4-1

The Contingency Table Cross-Classifying Extent of Damage, Child's Age, Seating Position, Child Restraint Type, and (A+K)-Injury

(Maryland)

Extent of Damage	Age of Child	Seating Position	Child Restraint Type	(A+K)-Injury No	(A+K)-Injury Yes	Total	Stratum Weight
1	0-1	Front	C*	145	6	151	
			L	110	5	115	970
			N	670	34	704	0.0374
		Rear	C	138	5	143	
			L	57	0	57	439
			N	224	15	239	0.0169
	2-4	Front	C	50	2	52	
			L	219	8	227	2143
			N	1765	101	1866	0.0826
		Rear	C	78	1	79	
			L	206	2	208	2200
			N	1829	84	1913	0.0848
2+	0-1	Front	C*	391	0	391	
			L	389	0	389	3019
			N	2233	6	2239	0.1164
		Rear	C	353	1	354	
			L	222	0	222	1557
			N	979	2	981	0.0600
	2-4	Front	C	179	0	179	
			L	877	2	879	7217
			N	6123	36	6159	0.2782
		Rear	C	322	1	323	
			L	948	1	949	8396
			N	7098	26	7124	0.3237

*C = Child restraint
L = Lap/L+S
N = None used

Table 4-2

Final Parameter Estimates, Goodness-of-Fit Statistic, and Effectiveness Estimates for (A+K)-Injury.

(Maryland)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.0038 (0.0006)	β_L	-0.0025 (0.0009)
β_E^*	0.0391 (0.0042)	β_{ExP}	0.0113 (0.0053)
β_A	-0.0018 (0.0009)	β_{ExC}	-0.0174 (0.0087)
β_P	0.0013 (0.0008)	β_{ExL}	-0.0267 (0.0063)
β_C	-0.0012 (0.0014)		

Goodness-of-Fit Statistic

χ^2(due to error) = 8.76, d.f. = 15, p = 0.89

Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None	36.18%†	15.11%
2. Lap/L+S vs. None	59.48%	9.72%
3. Lap/L+S vs. Child Restraint	36.51%††	20.52%

$*E = \begin{cases} 1 \text{ if car was disabled} \\ 0 \text{ if not disabled} \end{cases}$

$C = \begin{cases} 1 \text{ if child restrained} \\ 0 \text{ otherwise} \end{cases}$

† $(\hat{r}_N-\hat{r}_C)/\hat{r}_N$ *100 = 36.18%

†† $(\hat{r}_C-\hat{r}_L)/\hat{r}_C$ *100 = 36.51%

$A = \begin{cases} 1 \text{ if age 0-1} \\ 0 \text{ if age 2-4} \end{cases}$

$L = \begin{cases} 1 \text{ if child belted} \\ 0 \text{ otherwise} \end{cases}$

$P = \begin{cases} 1 \text{ if front seat} \\ 0 \text{ if } \quad \text{ seat} \end{cases}$

Note: Seating position, β_P, is not significant but is retained so that one can calculate the injury rate and effectiveness estimates by position (see Table 4-3 and Table 4-4).

- Children age 0-1 have generally lower injury rate than children age 2-4 (β_A = -0.0018).
- Child restraint is effective (β_C = -0.0012), but primarily in towaway accidents (β_{ExC} = -0.0174).
- Lap/lap and shoulder belts are generally effective (β_L = -0.0025), and especially in towaway accidents (β_{ExL} = -0.0267).

Overall effectiveness estimates show that both child safety seats and lap/lap & shoulder belts are significantly effective, particularly in towaway accidents, in reducing injuries. However, the standard errors suggest that the apparent differences in the effectiveness of child safety seats and lap/lap & shoulder belts are not statistically significant. This is also observed in Table 4-3 and Table 4-4 for the effectiveness estimates obtained for each subpopulation defined by the levels of the factors, age of child, seating position and extent of damage.

Table 4-3

(A+K)-Injury Rate Estimates by Child Age, Seating Position, and Extent of Damage

(Maryland)

	Child Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	0.87%† (0.22%)*	0.52% (0.17%)	1.39% (0.09%)
	2-4	0.91% (0.21%)	0.59% (0.13%)	1.42% (0.08%)
Seating Position	Front	1.11% (0.23%)	0.76% (0.17%)	1.63% (0.12%)
	Rear	0.68% (0.21%)	0.37% (0.12%)	1.17% (0.10%)
Extent of Damage	Disabled	3.07% (0.81%)	2.03% (0.54%)	4.92% (0.32%)
	Not Disabled	0.28% (0.13%)	0.15% (0.08%)	0.40% (0.05%)

†Injury rate multiplied by 100.

*Standard error

Table 4-4

(A+K)-Injury Effectiveness Estimates by Child Age,
Seating Position, and Extent of Damage

(Maryland)

	Restraint Type	Child Restraint vs. None	Lap/L+S vs. None	Lap/L+S vs. Child Restraint
Age of Child	0-1	38.30%* (15.76%)**	62.78% (10.86%)	39.68% (22.49%)
	2-4	35.56% (14.96%)	58.51% (9.55%)	35.62% (20.03%)
Seating Position	Front	32.47% (13.71%)	53.25% (9.48%)	30.77% (18.41%)
	Rear	41.65% (17.39%)	68.67% (10.87%)	46.31% (23.89%)
Extent of Damage	Disabled	37.81% (16.69%)	59.13% (11.17%)	34.29% (24.04%)
	Not Disabled	30.53% (34.19%)	60.70% (19.62%)	43.44% (36.63%)

* $\frac{(\hat{r}_N - \hat{r}_C)}{\hat{r}_N}$ = Effectiveness of Child Restraint vs. None.

**Standard Error

Figure 4-1

Predicted (A+K)-Injury Rates $\hat{\underset{\sim}{r}} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$

(Maryland)

Age of Child	Seating Position	Child Restraint Type	Extent of Damage $\underset{\sim}{X}_f$: Disabled	Extent of Damage $\underset{\sim}{X}_f$: Not Disabled	$\hat{\underset{\sim}{\beta}}$
0-1	Front	C	1 1 1 1 1 0 1 1 0	1 0 1 1 1 0 0 0 0	μ
		L	1 1 1 1 0 1 1 0 1	1 0 1 1 0 1 0 0 0	β_E
		N	1 1 1 1 0 0 1 0 0	1 0 1 1 0 0 0 0 0	β_A
	Rear	C	1 1 1 0 1 0 0 1 0	1 0 1 0 1 0 0 0 0	β_P
		L	1 1 1 0 0 1 0 0 1	1 0 1 0 0 1 0 0 0	β_C
		N	1 1 1 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0	β_L
2-4	Front	C	1 1 0 1 1 0 1 1 0	1 0 0 1 1 0 0 0 0	β_{ExP}
		L	1 1 0 1 0 1 1 0 1	1 0 0 1 0 1 0 0 0	β_{ExC}
		N	1 1 0 1 0 0 1 0 0	1 0 0 1 0 0 0 0 0	β_{ExL}
	Rear	C	1 1 0 0 1 0 0 1 0	1 0 0 0 1 0 0 0 0	
		L	1 1 0 0 0 1 0 0 1	1 0 0 0 0 1 0 0 0	
		N	1 1 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0	

One can not discern from Table 4-5 any meaningful trend in injury rate as a function of accident year. The rise in injury rates in the accident years 1979 and 1980 is inexplicable, other than perhaps due to differences in reporting thresholds or injury classification practices.

Table 4-5
Observed (A+K)-Injury Rates by Accident Year
(Maryland)

	1977		1978		1979		1978	
Restraint Type	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	420	3 0.71*	485	3 0.61	499	5 0.99	262	5 1.87
Lap/L+S	953	4 0.42	908	4 0.44	812	6 0.73	380	4 1.04
None	5811	85 1.44	6689	82 1.21	5704	69 1.20	3085	69 2.19

*Injury rate.

4.2. (B+A+K)-Injury Rate and Effectiveness Estimates

The variable screening procedure selected in addition to Extent of Damage, the variables, Age of Child, Seating Position, and Driver Sex as controls. The contingency table cross-classifying these variables together with child restraint type and (B+A+K)-injury status is given by Table 4-6.

The parameter estimates, goodness of fit statistic, and the overall matrix $\underset{\sim}{X}_f$ are given in Figure 4-2 where $\underset{\sim}{\beta}$ is the vector of parameter estimates. The product $\underset{\sim}{X}_f$ in Figure 4-2 provides the predicted injury rates.

The model parameter estimates in Table 4-7 offer the following interpretation:

- Towaway crashes ($\beta_E = 0.1521$), or front seat ($\beta_P = 0.0189$), or in combination ($\beta_{ExP} = 0.0254$) have higher injury risk as noted before

Table 4-6

Contingency table cross-classifying extent of damage, age of child, driver sex, seating position, child restraint type, and (B+A+K)-injury

(Maryland)

Extent of Damage	Age of Child	Driver Sex	Seating Position	Child Restraint Type	(B+A+K)-Injury No	(B+A+K)-Injury Yes	Total	Stratum Weight
Disabled	0-1	Male	Front	C*	22	6	28	
				L	23	4	27	394
				N	265	74	339	0.0152
			Rear	C	48	8	56	
				L	18	1	19	179
				N	90	14	104	0.0069
		Female	Front	C	109	14	123	
				L	80	8	88	576
				N	299	66	365	0.0222
			Rear	C	71	16	87	
				L	33	5	38	260
				N	111	24	135	0.0100
	2-4	Male	Front	C	13	0	13	
				L	612	11	73	886
				N	634	166	800	0.0346
			Rear	C	18	1	19	
				L	77	9	86	936
				N	699	132	831	0.0361
		Female	Front	C	31	8	39	
				L	1318	16	154	1259
				N	822	244	1066	0.0485
			Rear	C	54	6	60	
				L	113	9	122	1264
				N	888	194	1082	0.0487

Table 4-6 (Con't)

Extent of Damage	Age of Child	Driver Sex	Seating Position	Child Restraint Type	(B+A+K)-Injury		Total	Stratum Weight
					No	Yes		
Not Disabled	0-1	Male	Front	C	82	1	83	
				L	127	1	128	1341
				N	1102	28	1130	0.0517
			Rear	C	115	1	116	
				L	99	0	99	694
				N	473	6	479	0.0268
		Female	Front	C	297	11	308	
				L	257	4	261	1678
				N	1083	26	1109	0.0647
			Rear	C	235	3	238	
				L	123	0	123	863
				N	491	11	502	0.0333
	2-4	Male	Front	C	53	1	54	
				L	343	11	354	3077
				N	2577	92	2669	0.1186
			Rear	C	116	3	119	
				L	421	6	427	3720
				N	3118	56	3174	0.1434
		Female	Front	C	121	4	125	
				L	507	18	525	4140
				N	3347	43 1	3490	0.1596
			Rear	C	201	3	204	
				L	520	2	522	4676
				N	3862	88	3950	0.1802

Table 4-7

Final Parameter Estimates Goodness-of-Fit Statistic
and Effectiveness Estimate for (B+A+K)-injury

(Maryland)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.0224 (0.0019)	β_{ExC}	-0.0938 (0.0256)
β_E^*	0.1521 (0.0077)	β_{ExL}	-0.0764 (0.0136)
β_A	-0.0032 (0.0030)	β_{AxP}	-0.0108 (0.0045)
β_S	-0.0056 (0.0023)	β_{SxL}	0.0101 (0.0047)
β_P	0.0189 (0.0026)	β_{ExAxP}	-0.0325 (0.0182)
β_C	-0.0046 (0.0040)	β_{ExAxC}	0.0672 (0.0330)
β_L	-0.0167 (0.0028)	$\beta_{ExAxSxP}$	0.0546 (0.0257)
β_{ExP}	0.0254 (0.0113)		

Goodness-of-Fit Statistic

χ^2(due to error) = 21.05, d.f. = 33, p = 0.95

Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None†	34.12%†	8.34%
2. Lap/L+S vs. None	45.90%	5.12%
3. Lap/L+S vs. Child Restraint††	17.87%††	12.45%

*E = $\begin{cases} 1 \text{ if car was disabled} \\ 0 \text{ if not disabled} \end{cases}$ P = $\begin{cases} 1 \text{ if front seat} \\ 0 \text{ if rear seat} \end{cases}$

† $(\hat{r}_N-\hat{r}_C)/\hat{r}_N$ *100 = 34.12%

†† $(\hat{r}_C-\hat{r}_C)/\hat{r}_C$ *100 = 17.87%

A = $\begin{cases} 1 \text{ if age 0-1} \\ 0 \text{ if age 2-4} \end{cases}$ C = $\begin{cases} 1 \text{ if child restrained} \\ 0 \text{ otherwise} \end{cases}$

S = $\begin{cases} 1 \text{ if male driver} \\ 0 \text{ if female driver} \end{cases}$ L = $\begin{cases} 1 \text{ if child belted} \\ 0 \text{ otherwise} \end{cases}$

NOTE: The Age effect, β_A, is not statistically significant, but is retained so that one can calculate the injury rates and effectiveness estimates by Child Age (see Tables 4-8, 4-9).

Figure 4-2

Predicted (B+A+K)-Injury Rates $\hat{\underset{\sim}{r}} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$

(Maryland)

Age of Child	Driver Sex	Seating Position	Child Restraint Type	Extent of Damage: Disabled ($\underset{\sim}{X}_f$)	Extent of Damage: Not Disabled ($\underset{\sim}{X}_f$)	$\hat{\underset{\sim}{\beta}}$
0-1	Male	Front	C	1 1 1 1 1 1 0 1 1 0 1 0 1 1 1	1 0 1 1 1 1 0 0 0 0 1 0 0 0 0	μ
			L	1 1 1 1 1 0 1 1 0 1 1 1 1 0 1	1 0 1 1 1 0 1 0 0 0 1 1 0 0 0	β_E
			N	1 1 1 1 1 0 0 1 0 0 1 0 1 0 1	1 0 1 1 1 0 0 0 0 0 1 0 0 0 0	β_A
		Rear	C	1 1 1 1 0 1 0 0 1 0 0 0 0 1 0	1 0 1 1 0 1 0 0 0 0 0 0 0 0 0	β_S
			L	1 1 1 1 0 0 1 0 0 1 0 1 0 0 0	1 0 1 1 0 0 1 0 0 0 0 1 0 0 0	β_P
			N	1 1 1 1 0 0 0 0 0 0 0 0 0 0 0	1 0 1 1 0 0 0 0 0 0 0 0 0 0 0	β_C
	Female	Front	C	1 1 1 0 1 1 0 1 1 0 1 0 1 1 0	1 0 1 0 1 1 0 0 0 0 1 0 0 0 0	β_L
			L	1 1 1 0 1 0 1 1 0 1 1 0 1 0 0	1 0 1 0 1 0 1 0 0 0 1 0 0 0 0	β_{ExP}
			N	1 1 1 0 1 0 0 1 0 0 1 0 1 0 0	1 0 1 0 1 0 0 0 0 0 1 0 0 0 0	β_{ExC}
		Rear	C	1 1 1 0 0 1 0 0 1 0 0 0 0 1 0	1 0 1 0 0 1 0 0 0 0 0 0 0 0 0	β_{ExL}
			L	1 1 1 0 0 0 1 0 0 1 0 0 0 0 0	1 0 1 0 0 0 1 0 0 0 0 0 0 0 0	β_{AxP}
			N	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0	β_{SxL}
2-4	Male	Front	C	1 1 0 1 1 1 0 1 1 0 0 0 0 0 0	1 0 0 1 1 1 0 0 0 0 0 0 0 0 0	β_{ExAxP}
			L	1 1 0 1 1 0 1 1 0 1 0 0 0 0 0	1 0 0 1 1 0 1 0 0 0 0 1 0 0 0	β_{ExAxC}
			N	1 1 0 1 1 0 0 1 0 0 0 0 0 0 0	1 0 0 1 1 0 0 0 0 0 0 0 0 0 0	$\beta_{ExAxSxP}$
		Rear	C	1 1 0 1 0 1 0 0 1 0 0 0 0 0 0	1 0 0 1 0 1 0 0 0 0 0 0 0 0 0	
			L	1 1 0 1 0 0 1 0 0 1 0 0 0 0 0	1 0 0 1 0 0 1 0 0 0 0 1 0 0 0	
			N	1 1 0 1 0 0 0 0 0 0 0 0 0 0 0	1 0 0 1 0 0 0 0 0 0 0 0 0 0 0	
	Female	Front	C	1 1 0 0 1 1 0 1 1 0 0 0 0 0 0	1 0 0 0 1 1 0 0 0 0 0 0 0 0 0	
			L	1 1 0 0 1 0 1 1 0 1 0 0 0 0 0	1 0 0 0 1 0 1 0 0 0 0 0 0 0 0	
			N	1 1 0 0 1 0 0 1 0 0 0 0 0 0 0	1 0 0 0 1 0 0 0 0 0 0 0 0 0 0	
		Rear	C	1 1 0 0 0 1 0 0 1 0 0 0 0 0 0	1 0 0 0 0 1 0 0 0 0 0 0 0 0 0	
			L	1 1 0 0 0 0 1 0 0 1 0 0 0 0 0	1 0 0 0 0 0 1 0 0 0 0 0 0 0 0	
			N	1 1 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0	

- Generally, the presence of male drivers presents a higher risk factor than that of female drivers ($\beta_S + \beta_{SxL} = 0.0045$)
- Child restraint is effective ($\beta_C = -0.0046$) and especially significant in towaway crashes ($\beta_{ExC} = -0.0938$)
- Lap/lap and shoulder belts are significantly effective ($\beta_L = -0.0167$), especially in towaway crashes ($\beta_{ExL} = -0.0764$).

The overall effectiveness estimates show again that both child safety seats and lap/lap & shoulder are significantly effective in reducing injuries as used. However, there is no significant difference in their effectiveness estimates. The same conclusion is drawn from the effectiveness estimates for each subpopulation defined by the levels of the factors, Age of Child, Seating Position, and Extent of Damage as shown in Table 4-8 and Table 4-9.

Table 4-8

(B+A+K)-Injury Rate Estimates by Child Age, Seating Position, and Extent of Damage

(Maryland)

	Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	4.94%† (0.56%)*	3.02% (0.39%)	6.03% (0.30%)
	2-4	3.96% (0.62%)	3.57% (0.25%)	6.46% (0.17%)
Seating Position	Front	5.38% (0.54%)	4.53% (0.37%)	7.54% (0.23%)
	Rear	2.95% (0.54%)	2.31% (0.33%)	5.13% (0.19%)
Extent of Damage	Disabled	11.00% (1.94%)	10.29% (1.22%)	19.16% (0.59%)
	Not Disabled	2.26% (0.39%)	1.49% (0.21%)	2.71% (0.13%)

†Injury rate multiplied by 100

*Standard Error

Table 4-9

(B+A+K)-Injury Effectiveness Estimates by Child Age, Seating Position, and Extent of Damage

(Maryland)

	Restraint Type	Child Restraint vs. None	Lap/L+S vs. None	Lap/L+S vs. Child Restraint
Age of Child	0-1	17.95%* (9.88%)**	50.06% (5.86%)	39.14% (9.94%)
	2-4	38.65% (9.62%)	44.73% (5.04%)	9.90% (15.88%)
Seating Position	Front	28.63% (7.06%)	40.03% (4.60%)	15.97% (9.96%)
	Rear	42.68% (10.48%)	55.04% (6.16%)	21.57% (17.14%)
Extent of Damage	Disabled	42.73% (10.17%)	46.33% (6.51%)	6.30% (19.56%)
	Not Disabled	16.81% (14.61%)	45.02% (8.00%)	33.91% (14.08%)

$$\frac{(\hat{r}_N - \hat{r}_C)}{\hat{r}_N}$$ = Effectiveness of child restraint vs. none

**Standard Error

No discernible trend is evident in Table 4-10 that would suggest an increasing effectiveness of child safety seats as a consequence of improved safety features of the child seats or an increasingly more proper usage of child safety seats.

Table 4-10
Observed (B+A+K)-Injury Rates by Accident Year
(Maryland)

	1977		1978		1979		1980	
Restraint Type	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	410	13 3.07*	464	24 2.96	483	21 4.17	239	28 10.49
Lap/L+S	928	29 3.03	885	27 2.96	788	30 3.67	365	19 4.95
None	5536	360 6.11	6370	401 5.92	5421	352 6.10	2887	267 8.47

*Injury rate.

4.3. All-Injury Rate and Effectiveness Estimates

Relative to all-injury characterization, the variable selection procedure basically produces the same set of variables as in the preceding section. The contingency table cross-classifying these factors by Child Restraint Type and All-Injury status is given by Table 4-11.

The parameter estimates, goodness of fit statistic, and the overall effectiveness estimates corresponding to the final design matrix X_f as given in Figure 4-3 are presented in Table 4-12.

The predicted all-injury rates, $\hat{\underset{\sim}{r}} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$ are determined by the matrices in Figure 4-3, where $\underset{\sim}{\beta}$ is the vector of parameter estimates from Table 4-12.

The model coefficient estimates in Table 4-12 render the following interpretation:

- Towaway accidents (β_E = 0.2837), or front seat (β_P = 0.0482) have higher injury risk
- Babies are generally less vulnerable than children age 2-4 (β_A = -0.0050, β_{AxP} = -0.0261). However, in towaway accidents, babies seem to be more vulnerable (β_{AxE} = 0.0401).
- Child restraint is most effective in towaway accidents (β_{ExC} = -0.0926).
- Lap/lap and shoulder belts are very effective (β_L = -0.0296) in reducing injuries, especially in front seat towaway crashes (β_{ExPxL}= -0.1122).

Table 4-11

Contingency table cross-classifying extent of damage, child age, driver sex, seating position, child restraint type and all-injury status

(Maryland)

Extent of Damage	Age of Child	Driver Sex	Seating Position	Child Restraint Type	All-injury 0	All-injury 1	Total	Stratum Weight
1	0-1	Male	Front	C*	13	15	28	
				L	19	8	27	394
				N	183	156	339	0.0152
			Rear	C	38	18	56	
				L	13	6	19	179
				N	57	47	104	0.0069
		Female	Front	C	85	38	123	
				L	62	26	88	576
				N	200	165	365	0.0222
			Rear	C	56	31	87	
				L	22	16	38	260
				N	78	57	135	0.0100
	2-4	Male	Front	C	10	3	13	
				L	48	25	73	886
				N	457	343	800	0.0346
			Rear	C	16	3	19	
				L	60	26	86	936
				N	498	333	831	0.0361
		Female	Front	C	24	15	39	
				L	109	46	154	1259
				N	575	491	1066	0.0485
			Rear	C	40	20	60	
				L	82	40	122	1264
				N	648	434	1082	0.0487

*C = Child restraint
L = Lap/lap and shoulder belt
N = None used

Table 4-11 (Con't)

Extent of Damage	Age of Child	Driver Sex	Seating Position	Child Restraint Type	All-injury 0	All-injury 1	Total	Stratum Weight
2+	0-1	Male	Front	C	70	13	83	
				L	113	15	128	1341
				N	982	148	1130	0.0517
			Rear	C	109	7	116	
				L	94	5	99	694
				N	422	57	479	0.0268
		Female	Front	C	268	40	308	
				L	236	25	261	1678
				N	968	141	1109	0.0647
			Rear	C	212	26	238	
				L	115	8	123	863
				N	443	59	502	0.0333
	2-4	Male	Front	C	46	8	54	
				L	308	46	354	3077
				N	2236	433	2669	0.1186
			Rear	C	110	9	119	
				L	385	42	427	3720
				N	2806	368	3174	0.1434
		Female	Front	C	104	21	125	
				L	446	79	525	4140
				N	2944	546	3490	0.1596
			Rear	C	184	20	204	
				L	479	43	522	4676
				N	3512	438	3950	0.1802

Table 4-12

Final Parameter Estimates, Goodness-of-Fit Statistic, and Effectiveness Estimate for All-Injury

(Maryland)

Parameter	Estimate (S.E.)	Parameter	Estimate (S.E.)
μ	0.1132 (0.0035)	β_{ExA}	0.0401 (0.0167)
β_E^*	0.2837 (0.0081)	β_{ExC}	-0.0926 (0.0264)
β_A	-0.0050 (0.0082)	β_{AxP}	-0.0261 (0.0105)
β_P	0.0482 (0.0051)	β_{ExPxL}	-0.1122 (0.0268)
β_C	-0.0167 (0.0096)	$\beta_{AxSxPxC}$	0.0655 (0.0380)
β_L	-0.0296 (0.0065)		

Goodness-of-Fit Statistic

X^2(due to error) = 25.50, d.f. = 37, p = 0.92

Overall Effectiveness Estimate

	Grizzle-Starmer-Koch Estimates	Standard Error
1. Child Restraint vs. None†	16.59%†	4.60%
2. Lap/L+S vs. None	21.75%	3.20%
3. Lap/L+S vs. Child Restaint††	+6.19%††	6.13%

$$*E = \begin{cases} 1 \text{ if car was disabled} \\ 0 \text{ if not disabled} \end{cases} \qquad P = \begin{cases} 1 \text{ if front seat} \\ 0 \text{ if rear seat} \end{cases}$$

$\dagger(\hat{r}_N - \hat{r}_C)/\hat{r}_N *100=16.59\%$

$\dagger\dagger(\hat{r}_C - \hat{r}_L)/\hat{r}_C *100= 6.19\%$

$$A = \begin{cases} 1 \text{ if age 0-1} \\ 0 \text{ if age 2-4} \end{cases} \qquad C = \begin{cases} 1 \text{ if child restrained} \\ 0 \text{ otherwise} \end{cases}$$

$$S = \begin{cases} 1 \text{ if male driver} \\ 0 \text{ if female driver} \end{cases} \qquad L = \begin{cases} 1 \text{ if child belted} \\ 0 \text{ otherwise} \end{cases}$$

Note: Age of Child is not significant but is retained so that one may calculate the injury rate and effectiveness etimates by Age of Child.

Figure 4-3

Predicted (All)-Injury Rates $\hat{r} = \underset{\sim}{X}_f \underset{\sim}{\hat{\beta}}$

(Maryland)

Age of Child	Driver Sex	Seating Position	Child Restraint Type	Extent of Damage: Disabled ($\underset{\sim}{X}_f$)	Extent of Damage: Not Disabled ($\underset{\sim}{X}_f$)
0-1	Male	Front	C	1 1 1 1 1 0 1 1 1 0 1	1 0 1 1 1 0 0 0 1 0 1
			L	1 1 1 1 0 1 1 0 1 1 0	1 0 1 1 0 1 0 0 1 0 0
			N	1 1 1 1 0 0 1 0 1 0 0	1 0 1 1 0 0 0 0 1 0 0
		Rear	C	1 1 1 0 1 0 1 1 0 0 0	1 0 1 0 1 0 0 0 0 0 0
			L	1 1 1 0 0 1 1 0 0 0 0	1 0 1 0 0 1 0 0 0 0 0
			N	1 1 1 0 0 0 1 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0
	Female	Front	C	1 1 1 1 1 0 1 1 1 0 0	1 0 1 1 1 0 0 0 1 0 0
			L	1 1 1 1 0 1 1 0 1 1 0	1 0 1 1 0 1 0 0 1 0 0
			N	1 1 1 1 0 0 1 0 1 0 0	1 0 1 1 0 0 0 0 1 0 0
		Rear	C	1 1 1 0 1 0 1 1 0 0 0	1 0 1 0 1 0 0 0 0 0 0
			L	1 1 1 0 0 1 1 0 0 0 0	1 0 1 0 0 1 0 0 0 0 0
			N	1 1 1 0 0 0 1 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0
2-4	Male	Front	C	1 1 0 1 1 0 0 1 0 0 0	1 0 0 1 1 0 0 0 0 0 0
			L	1 1 0 1 0 1 0 0 0 1 0	1 0 0 1 0 1 0 0 0 0 0
			N	1 1 0 1 0 0 0 0 0 0 0	1 0 0 1 0 0 0 0 0 0 0
		Rear	C	1 1 0 0 1 0 0 1 0 0 0	1 0 0 0 1 0 0 0 0 0 0
			L	1 1 0 0 0 1 0 0 0 0 0	1 0 0 0 0 1 0 0 0 0 0
			N	1 1 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0
	Female	Front	C	1 1 0 1 1 0 0 1 0 0 0	1 0 0 1 1 0 0 0 0 0 0
			L	1 1 0 1 0 1 0 0 0 1 0	1 0 0 1 0 1 0 0 0 0 0
			N	1 1 0 1 0 0 0 0 0 0 0	1 0 0 1 0 0 0 0 0 0 0
		Rear	C	1 1 0 0 1 0 0 1 0 0 0	1 0 0 0 1 0 0 0 0 0 0
			L	1 1 0 0 0 1 0 0 0 0 0	1 0 0 0 0 1 0 0 0 0 0
			N	1 1 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0

$$\underset{\sim}{\hat{\beta}} = \begin{bmatrix} \mu \\ \beta_E \\ \beta_A \\ \beta_P \\ \beta_C \\ \beta_L \\ \beta_{ExA} \\ \beta_{ExC} \\ \beta_{AxP} \\ \beta_{ExPxL} \\ \beta_{AxSxPxC} \end{bmatrix}$$

Overall effectiveness estimates again confirm the effectiveness of both the child seating systems as used and the lap/lap & shoulder belts. Although, no significant difference in overall effectiveness estimates are detected between child safety seats and lap/lap & shoulder belts as used, it is clear that generally in the more severe accidents, child safety seats are significantly more effective than conventional belt systems.

Generally, the same conclusion can be drawn with respect to each subpopulation defined by the levels of the factors, Age of Child, Seating Position, and Extent of Damage. However, for children age 0-1, or for children in front seat, lap/lap & shoulder belts are significantly more effective than child safety seats as used. This can be seen from Table 4-13 and Table 4-14.

Table 4-13

All-Injury Rate Estimates by Child Age, Seating Position, and Extent of Damage

(Maryland)

	Restraint Type	Child Restraint	Lap/L+S	None
Age of Child	0-1	17.97%† (1.26%)*	15.13% (0.74%)	19.94% (0.52%)
	2-4	16.08% (0.94%)	15.60% (0.62%)	19.76% (0.29%)
Seating Position	Front	19.14% (0.97%)	16.56% (0.76%)	22.13% (0.35%)
	Rear	13.72% (0.91%)	14.36% (0.64%)	17.33% (0.33%)
Extent of Damage	Disabled	32.24% (2.34%)	33.68% (1.40%)	42.74% (0.72%)
	Not Disabled	12.03% (0.91%)	10.31% (0.60%)	13.26% (0.26%)

†Injury rate multiplied by 100

*Standard Error

Table 4-14

All-Injury Effectiveness Estimates by Child Age, Seating Position, and Extent of Damage

(Maryland)

	Restraint Type	Child Restraint vs. None	Lap/L+S vs. None	Lap/L+S vs. Child Restraint
Age of Child	0-1	9.79%* (6.47%)**	23.99% (3.37%)	15.74% (6.98%)
	2-4	18.64% (4.71%)	21.07% (3.18%)	2.99% (6.49%)
Seating Position	Front	13.46% (4.38%)	25.20% (3.47%)	13.57% (5.68%)
	Rear	20.82% (5.29%)	17.07% (3.66%)	-4.74% (8.04%)
Extent of Damage	Disabled	24.53% (5.68%)	21.14% (3.30%)	-4.49% (8.76%)
	Not Disabled	9.29% (17.08%)	22.30% (4.73%)	14.35% (8.03%)

$\frac{(\hat{r}_N-\hat{r}_C)}{\hat{r}_N}$ = Effectiveness of child restraint vs. none

**Standard error

Finally, there seems to be a reverse trend in injury rates as a function of accident year. In fact, the observed injury rate for children in child safety seats in 1980 is about double the rates in 1977, 1978, and 1979. The corresponding trend is also observed for children in lap/lap & shoulder belts and unrestrained children but not as pronounced.

Table 4-15
Observed All-Injury Rates by Accident Year
(Maryland)

Restraint Type	1977		1978		1979		1980	
	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured	Not Injured	Injured
Child	372	51 12.06*	413	75 15.37	419	85 16.87	190	77 28.84
Lap/L+S	821	136 14.21	778	134 14.69	695	123 15.04	321	63 16.41
None	4795	1101 18.67	5552	1219 18.00	4621	1152 19.95	2368	786 24.92

*Injury rate

Chapter 5. SUMMARY

This analysis of the New York State and Maryland child files demonstrated that both child safety seats and lap/lap and shoulder belts are most (significantly) effective in reducing (A+K)-injuries and less effective (though still significant) in reducing (B+A+K)- and all-injuries as shown in Table 5-1.

Table 5-1
Overall effectiveness of child safety seats and lap/ lap and shoulder belts for New York State and Maryland.

Restraint Type	Injury Characterization	State of New York 1975-78	State of Maryland 1977-80
Child Safety Seats	(A+K)	34.12% (8.34%)*	36.18% (15.11%)
	(B+A+K)	23.96% (3.58%)	33.28% (8.89%)
	All	24.73% (3.44%)	16.59% (4.60%)
Lap/lap and shoulder belts	(A+K)	45.90% (5.12%)	59.48% (9.72%)
	(B+A+K)	28.84% (2.81%)	46.05% (6.34%)
	All	23.96% (2.23%)	21.72% (3.20%)

*Standard Error

Overall effectiveness estimates for lap/lap and shoulder belts seem to be uniformly higher than the corresponding estimates for child safety seats. However, these differences are not statistically significant as shown in Table 5-2.

Table 5-2

Effectiveness of lap/lap and shoulder belts relative to child safety seats for New York State and Maryland.

Injury Characterization	State of New York	State of Maryland
(A+K)	19.13%* (13.69%)**	36.51% (20.52%)
(B+A+K)	6.40% (5.45%)	17.87% (12.45%)
All	-1.02% (5.32%)	6.19% (6.13%)

$*\frac{(\hat{r}_C - \hat{r}_L)}{\hat{r}_C}$ = Effectiveness of Lap/L+S relative child safety seats

**Standard Error

The generally lower estimates for the effectiveness of lap/lap and shoulder belts relative to child safety seats could be due to the significant amount of improper usage and/or installation of the seats. Even so, detailed analyses from the various models show that there are a few specific instances as described in Table 5-3 where the child safety seats are significantly more effective than the lap/lap and shoulder belts.

Table 5-3

Specific instances where child safety seats are significantly more effective than (lap & shoulder) belts.

Injury Characterization	New York	Maryland
(A+K)	Children age 0-1 in front seats	---
(B+A+K)	Front seats	---
All	Front seats	Towaway crashes

The injury rates for children seem to be decreasing over the years as can be seen from the New York data. However, the trend is there for both the child safety seats, the lap/lap and shoulder belt systems and the unrestrained children. Consequently the downward trend observed cannot be attributed to safer child seats and/or more proper usage of such seats over the years without further information.

More definitive results require detailed accident data at a level that is not available at present from the police reported state accident data.

REFERENCES

1. Chi, G.Y.H. (1980). Statistical evaluation of the effectiveness of FMVSS 214: Side door strength. (Report No. 4254-676). Hartford, CT: The Center for the Environment and Man, Inc.

2. Chi, G.Y.H. and Donald W. Reinfurt (1981). A comparison of the automatic shoudler belt/knee bolster restraint system with the lap and shoulder belt system in VW Rabbits. Chapel Hill, N.C.: University of North Carolina Highway Safety Research Center.

3. Higgins, J.H. and Gary G. Koch (1977). Variable selection and generalized chi-square analysis of categorical data applied to a large cross-sectional occupational health survey. <u>International Statistical Review</u> <u>45</u>, 51-62.

4. Knoop, J.C., Kayla Costenoble, John T. BAll, and Garyland M. Northrop (1980). Statistical evaluation of the effectiveness of child restraints. (Report No. 4254-675). Hartford, CT: The Center for the Environment and Man, Inc.

Appendix

Statistics Generated in the Variable Screening Procedure for FMVSS 213.

The variable screening procedure is discussed in Section 2 of this report on FMVSS 213.

The following list of variables on the New York State file was screened on: accident year, number of vehicles involved, hour of the day, road type, accident type, intersection/non-intersection, day of the week, model year, extent of damage, tow, number of children in the car, weight of the vehicle, weight of the striking vehicle, impact site (reconstructed), vehicle size, age of driver, driver sex, driver belt usage, child age, child ejection status, sex of child, seating position, restraint type used by child.

Tables A-1, A-2 and A-3 contain the statistics generated for a selected list of variables for the screening procedure relative to (A+K), (B+A+K), and all-injury characterizations, respectively.

For the Maryland file, the variables, locality, weather, and road condition, were considered in addition to the list of variables indicated for the New York State file. Tables A-4, A-5 and A-6 contain the statistics generated for a selected subset of these variables.

Table A-1. Statistics derived for variable selection with respect to (A+K)-injury characterization.

(New York)

STAGE I

	χ^2 [Child Restraint x V]	χ^2 [(A+K)-Injury x V]	χ^2 [V x (A+K)-inj.| Restraint] χ^2 [V x (A+K)-inj.| No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	37.4 (3) † 12.5 (1)	27.5 (3) † 9.2 (1)	8.1 (3) 0.0441 22.6 (3) †	26.3 (3) †	0.86
No Vehicles (2)	4.4 (1) 0.04	352.7 (1) †	12.9 (1) † 338.0 (1) †	350.1 (1) †	1.00
Extent of Damage (5)	10.6 (4) 0.03** 2.7 (1)	302.2 (4) † 75.6 (1)	27.0 (4) † 279.1 (4) †	302.0 (4) †	0.99
Vehicle Weight (4)	45.6 (3) † 15.2 (1)	29.0 (3) † 9.7 (1)	10.7 (3) 0.01 25.3 (3) †	30.4 (3) †	0.84
Age of Driver (4)	246.7 (3) † 82.2 (1)	12.2 (3) † 4.1 (1)	2.1 (3) 0.56 10.5 (3) 0.01	12.0 (3) †	0.95
Age of Child (4)	3164.8 (3) † 1054.9 (1)	0.3 (3) 0.96 0.1 (1)	4.4 (3) 0.22 3.1 (3) 0.38	2.3 (3) 0.52	0.31
Child Seating (2) Position	20.6 (1) †	52.7 (1) †	1.4 (1) 0.23 50.4 (1) †	51.5 (1) †	0.99

*Number of levels (e.g., 1975, 1976, 1977 and 1978)

**χ^2 = 10.6 (d.f. = 4) p-value = 0.03

χ^2/d.f. = 2.7

$$***\text{Index} = \frac{\text{Mantel-Haenszel}}{\chi^2[\text{V x INJ}|\text{Restraint}] + \chi^2[\text{V x INJ}|\text{No Restraint}]}$$

†$p < 0.01$

Table A-1. (Con't)

STAGE II

	χ^2 [(No.Veh. x V) x Rest.]	χ^2 [(No.Veh. x V) x (A+K)-inj.]	χ^2 [(No.Veh. x V) x (A+K)-inj.| Rest.] χ^2 [(No.Veh. x V) x (A+K)-inj.| No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	43.5 † 6.2 (1)	388.3 † 55.5 (1)	25.3 (7) 0.01 373.5 (7) †	384.7 (7) †	0.96
Extent of Damage	20.2 (9) † 2.2 (1)	413.3 (9) † 46.0 (1)	38.4 (9) † 383.1 (9) †	411.8 (9) †	0.98
Vehicle Weight	49.7 (7) † 7.1 (1)	286.9 (7) † 40.9 (1)	38.4 (7) † 268.5 (7) †	286.9 (7) †	0.93
Age of Driver	252.3 (7) † 36.0 (1)	380.3 (7) † 54.3 (1)	23.5 (7) † 362.8 (7) †	375.3 (7) †	0.97
Age of Child	3177.1 (7) † 453.9 (1)	354.1 (7) † 50.6 (1)	19.6 (7) 0.01 343.5 (7) †	354.8 (7) †	0.98
Child Seating Position	24.7 (3) † 8.2 (1)	415.7 (3) † 138.6 (1)	14.1 (3) † 399.1 (3) †	411.5 (3) †	1.0

Table A-2. Statistics derived for variable selection with respect to (B+A+K)-injury characterization.

(New York)

STAGE I

	χ^2 [Child Restraint x V]	χ^2[(B+A+K)-Injury x V]	χ^2[V x (B+A+K)-inj.|Restraint] χ^2[V x (B+A+K)-inj.|No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	37.4 (3) † 12.5 (1)	12.4 (6) 0.054 2.1 (1)	1.4 (3) 0.72 6.1 (3) 0.11	6.3 (3) 0.10	0.85
No Vehicles (2)	4.4 (1) 0.04	943.5 (1) †	39.5 (1) † 901.0 (1) †	937.6 (1) †	1.00
Extent of Damage (5)	10.6 (4) 0.03** 2.7 (1)	636.4 (4) † 159.1 (1)	69.4 (4) † 578.6 (4) †	640.9 (4) †	0.99
Vehicle Weight (4)	45.6 (3) † 15.2 (1)	162.3 (3) † 54.1 (1)	29.7 (3) † 147.2 (3) †	167.7 (3) †	0.95
Age of Driver (4)	246.7 (3) † 82.2 (1)	59.5 (3) † 19.8 (1)	6.9 (3) 0.08 56.5 (3) †	62.5 (3) †	0.99
Age of Child (4)	3164.8 (3) † 1054.9 (1)	30.1 (3) † 10.0 (1)	6.0 (3) 0.11 14.8 (3) †	16.5 (3) †	0.80
Child Seating (2) Position	20.6 (1) †	403.2 (1) †	7.5 (1) 0.01 396.3 (1) †	396.3 (1) †	0.98

*Number of levels (e.g., 1975, 1976, 1977, and 1978)

**$\chi^2 = 10.6$ (d.f. = 4) p-value = 0.0003

χ^2/d.f. = 2.7

$$\text{***Index} = \frac{\text{Mantel-Haenszel}}{\chi^2[\text{V x INJ}|\text{Restraint}] + \chi^2\ [\text{V x INJ}|\text{No Restraint}]}$$

† $p < 0.01$

Table A-2. (Con't)

STAGE II

	χ^2[(No. Veh. x V) x Rest.]	χ^2[(No.Veh. x V) x (B+A+K)-injury]	χ^2[(No.Veh. x V) x (B+A+K)-inj.| Rest.] χ^2[(No.Veh. x V) x (B+A+K)-inj.| No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	43.5 (7) † 6.2 (1)	958.7 (7) † 137.0 (1)	52.4 (7) † 917.8 (7) †	952.2 (7) †	0.98
Extent of Damage	20.2 (9) † 2.2 (1)	1056.3 (9) † 117.4 (1)	89.5 (9) † 979.0 (9) †	1056.2 (9) †	0.99
Vehicle Weight	49.7 (7) † 7.1 (1)	875.1 (7) † 125.0 (1)	66.6 (7) † 827.1 (7) †	877.4 (7) †	0.98
Age of Driver	252.3 (7) † 36.0 (1)	976.2 (7) † 139.5 (1)	50.0 (7) † 929.9 (7) †	972.7 (7) †	0.99
Age of Child	3177.1 (7) † 453.9 (1)	982.8 (7) † 140.4 (1)	50.4 (7) † 920.0 (7) †	961.2 (7) †	0.99
Child Seating Position	24.7 (3) † 8.2 (1)	1356.2 (3) † 452.1 (1)	46.9 (3) † 1304.1 (3) †	1340.7 (3) †	0.99

Table A-3. Statistics derived for variable selection with respect to All-injury characterization.

(New York)

STAGE I

	χ^2[Child Restraint x V]	χ^2[(All)-Injury x V]	χ^2[V x (All)-inj.|Restraint] χ^2[V x (All)-inj.|No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	37.4 (3) † 12.5 (1)	18.1 (6) 0.01 3.0 (1)	5.7 (3) 0.12 2.8 (3) 0.42	4.8 (3) 0.19	0.56
No Vehicles (2)	4.4 (1) 0.04	663.9 (1) †	21.9 (1) † 641.7 (1) †	658.7 (1) †	0.99
Extent of Damage (5)	10.6 (4) 0.03 2.7 (1)	634.7 (4) † 158.7 (1)	61.8 (4) † 586.6 (4) †	642.7 (4) †	0.99
Vehicle Weight (4)	45.6 (3) † 15.2 (1)	170.6 (3) † 56.8 (1)	34.4 (3) † 159.5 (3) †	179.7 (3) †	0.93
Age of Driver (4)	246.7 (3) † 82.2 (1)	11.7 (3) 3.9 (1)	4.1 (3) 0.25 13.0 (3) †	10.9 (3) 0.01	0.64
Age of Child (4)	3164.8 (3) † 1054.9 (1)	110.4 (3) † 36.8 (1)	2.2 (3) 0.52 57.4 (3) †	58.4 (3) †	0.98
Child Seating (2) Position	20.6 (1) †	329.2 (1) †	8.2 (1) † 317.6 (1) †	321.0 (1) †	0.99

*Number of levels (e.g., 1975, 1976, 1977, and 1978)

**χ^2 =10.6 (d.f. = 4) p-value = 0.03

χ^2/d.f. = 2.7

$$\text{***Index} = \frac{\text{Mantel-Haenszel}}{\chi^2\,[V \times INJ|Restraint] + \chi^2\,[V \times INJ|No\ Restraint]}$$

† $p < 0.01$

Table A-3. (Con't)

STAGE II

	χ^2[(No.Veh. x V) x Child Rest.]	χ^2[(No.Veh. x V) x (All)-inj.]	χ^2[(No.Veh. x V) x (All)-inj.| Rest.] χ^2[(No.Veh. x V) x (All)-inj.| No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	43.5 (7) † 6.2 (1)	673.8 (7) † 96.3 (1)	37.0 (7) † 646.9 (7) †	667.5 (7) †	0.98
Extent of Damage	20.2 (9) † 2.2	953.1 (9) † 105.9 (1)	75.5 (9) † 889.8 (9) †	956.7 (9) †	0.99
Vehicle Weight	49.7 (7) † 7.1 (1)	642.7 (7) † 91.8 (1)	50.8 (7) † 622.0 (7) †	649.2 (7) †	0.96
Age of Driver	252.3 (7) † 36.0 (1)	667.9 (7) † 94.4 (1)	38.4 (7) † 644.5 (7) †	671.4 (7) †	0.98
Age of Child	3177.1 (7) † 453.9 (1)	783.9 (7) † 112.0 (1)	27.8 (7) † 705.9 (7) †	725.8 (3) †	0.99
Child Seating Position	24.7 (3) † 8.2 (1)	996.2 (3) † 332.1 (1)	32.1 (3) † 955.0 (3) †	978.1 (3) †	0.99

Table A-4. Statistics derived for variable selection with respect to (A+K)-injury characterization.

(Maryland)

STAGE I

Variable	χ^2[Child Restraint x V]	χ^2[(A+K)-Injury x V]	χ^2[V x (A+K)-inj.|Restraint] χ^2[V x (A+K)-inj.|No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	13.7 (3) † 4.6	20.2 (3) † 6.7	18.1 (3) † 3.2 (3) 0.36	20.3 (3) †	0.95
No Vehicles (2)	2.1 (1) 0.15	56.1 (1) †	51.1 (1) † 5.1 (1) 0.02	55.8 (1) †	0.99
Hour (4)	118.4 (3) † 39.4	21.7 (3) † 7.2	21.8 (3) † 7.5 (3) 0.06	21.4 (3) †	0.73
Road Type (5)	54.6 (4) † 13.6	51.1 (4) † 12.8	16.1 (4) † 6.1 (4) 0.1951	17.1 (4) †	0.77
Acc Severity (5)	4.5 (4) 0.35** 1.1	4724.5 (4) † 1181.1	4453.6 (4) † 282.7 (4) †	4721.0 (4) †	1.00
Ext Damage (4)	22.0 (3) † 7.3	580.3 (3) † 193.4	550.7 (3) † 33.1 (3) †	583.2 (3) †	1.00
Weight (4)	32.7 (3) † 10.9	19.6 (3) † 6.5	18.0 (3) † 5.5 (3) 0.14	20.3 (3) †	0.86
Site (3)	5.8 (2) 0.05 2.9	61.0 (2) † 30.5	58.3 (2) † 5.5 (2) 0.06	62.0 (2) †	0.97
Veh Size (2)	13.5 (1) †	14.2 (1) †	16.7 (1) † 0.8 (1) 0.37	14.8 (1) †	0.85
Child Age (4)	1804.8 (3) † 601.6	6.2 (3) 0.10 2.1	6.0 (3) 0.11 1.4 (3) 0.71	5.8 (3) 0.12	0.78
Seating (2)	18.9 (1) †	5.2 (1) 0.02	4.9 (1) 0.03 0.1 (1) 0.76	5.0 (1) 0.03	0.99

*Number of levels (e.g., 1975, 1976, 1977, and 1978)

**χ^2 = 4.5 (d.f. = 4) p-value = 0.35
χ^2/d.f. = 1.1

$$***\text{Index} = \frac{\text{Mantel-Haenszel}}{\chi^2\,[\text{V x INJ}|\text{Restraint}] + \chi^2\,[\text{V x INJ}|\text{No Restraint}]}$$

† $p < 0.01$

Table A-4. (Con't)

STAGE II

Variable	χ^2[(Ext Damage x V) x Belt]	χ^2[(Ext Damage x V) x INJ]	χ^2[(Ext Damage x V) x INJAK|Rest.] χ^2[(Ext Damage x V) x INJAK|No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	26.9 (7) † 3.8	694.1 (7) † 99.2	558.8 (7) † 35.9 (7) †	594.0 (7) †	1.00
No. Veh Involved	13.1 (3) † 4.4	267.0 (3) † 89.0	554.6 (3) † 37.8 (3) †	588.5 (3) †	0.99
Hour	128.9 (7) † 18.4	778.1 (7) † 111.2	578.9 (7) † 53.1 (7) †	607.7 (7) †	0.96
Road Type	32.4 (9) † 3.6	689.6 (9) † 76.6	419.5 (9) † 64.4 (9) †	447.2 (9) †	0.92
Acc Severity	77.0 (9) † 8.6	7424.8 (9) † 825.0	4923.4 (9) † 343.9 (9) †	5246.3 (9) †	1.00
Weight	26.2 (7) † 3.7	232.1 (7) † 33.2	464.9 (7) † 41.4 (7) †	492.1 (7) †	0.97
Site	20.9 (5) † 4.2	614.6 (5) † 122.9	777.9 (5) † 38.2 (5) †	801.5 (5) †	0.98
Veh Size	16.0 (3) † 5.3	274.0 (3) † 91.3	403.5 (3) † 32.6 (3) †	420.6 (3) †	0.96
Child Age	586.9 (3) † 195.6	435.4 (3) † 145.1	541.6 (3) † 35.2 (3) †	575.3 (3) †	1.00
Seating	1072.2 (3) † 357.4	571.5 (3) † 190.5	544.3 (3) † 35.1 (3) †	578.1 (3) †	1.00

Table A-5. Statistics derived for variable selection with respect to (B+A+K)-injury characterization.

(Maryland)

STAGE I

Variable	χ^2[Child Restraint x V]	χ^2[(B+A+K)-Injury x V]	χ^2[V x (B+A+K)-inj.|Restraint] χ^2[V x (B+A+K)-inj.|No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	13.7 (3) † 4.6	35.1 (3) † 11.7	25.5 (3) † 20.1 (3) †	35.4 (3) †	0.78
No Vehicles (2)	2.1 (1) 0.15	62.5 (1) †	160.1 (1) † 8.1 (1) †	168.2 (1) †	1.00
Hour (4)	118.4 (3) † 39.4	40.2 (3) † 13.4	39.5 (3) † 1.8 (3) 0.62	40.0 (3) †	0.97
Road Type (5)	54.6 (4) † 13.6	92.9 (4) † 23.2	10.2 (4) 0.04 2.8 (4) 0.59	11.0 (4) 0.03	0.85
Acc Severity (5)	4.5 (4) 0.34 1.1	6696.9 (4) † 1674.2	6266.8 (4) † 438.8 (4) †	6693.3 (4) †	1.00
Ext Damage (4)	22.0 (3) † 7.3	1797.6 (3) † 599.2	1717.7 (3) † 90.2 (3) †	1804.1 (3) †	1.00
Weight (4)	32.7 (3) † 10.9	66.1 (3) † 22.0	66.4 (3) † 2.5 (3) 0.48	67.8 (3) †	0.98
Site (3)	5.8 (2) 0.05 2.9	161.4 (2) † 80.7	148.8 (2) † 15.9 (2) †	163.9 (2) †	1.00
Veh Size (2)	13.5 (1) †	32.9 (1) †	30.9 (1) † 0.9 (1) 0.33	31.6 (1) †	0.99
Child Age (4)	1804.8 (3) † 601.6	5.4 (3) 0.15 1.8	4.5 (3) 0.22 2.9 (3) 0.41	4.0 (3) 0.26	0.55
Seating (2)	18.9 (1) †	60.9 (1) †	59.2 (1) † 1.4 (1) 0.24	60.0 (1) †	0.99

*Number of levels (e.g., 1975, 1976, 1977, and 1978)

**χ^2 = 4.5 (d.f. = 4) p-value = 0.34
χ^2/d.f. = 1.1

$$***\text{Index} = \frac{\text{Mantel-Haenszel}}{\chi^2\,[\text{V x INJ}|\text{Restraint}] + \chi^2\,[\text{V x INJ}|\text{No Restraint}]}$$

† $p < 0.01$

Table A-5. (Con't)

STAGE II

Variable	χ^2[(Ext Damage x V) x Belt]	χ^2[(Ext Damage x V) x INJ]	χ^2[(Ext Damage x V) x INBAK|Rest.] χ^2[(Ext Damage x V) x INBAK|No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	26.9 (7) † 3.8	3428.9 (7) † 489.8	1705.8 (7) † 108.1 (7) †	1800.8 (7) †	0.99
No. Veh Involved	13.1 (3) 4.4	661.3 (3) † 220.4	1756.5 (3) † 93.2 (3) †	1842.9 (3) †	1.00
Hour	128.9 (7) † 18.4	2240.6 (7) † 320.1	1726.3 (7) † 93.3 (7) †	1810.8 (7) †	1.00
Road Type	32.4 (9) † 3.6	2050.8 (9) † 227.9	1153.4 (9) † 94.3 (9) †	1230.3 (9) †	0.99
Acc Severity	77.0 (9) † 8.6	9056.8 (9) † 1006.3	6982.5 (9) † 496.4 (9) †	7461.9 (9) †	1.00
Weight	26.2 (7) † 3.7	210.1 (7) † 30.0	1335.2 (7) † 66.5 (7) †	1393.7 (7) †	0.99
Site	20.9 (5) † 4.2	1692.2 (5) † 338.4	2049.7 (5) † 107.3 (5) †	2147.9 (5) †	1.00
Veh Size	16.0 (3) † 5.3	737.6 (3) † 245.9	1107.1 (3) † 54.2 (3) †	1150.7 (3) †	0.99
Child Age	586.9 (3) † 195.6	1155.7 (3) † 385.2	1694.7 (3) † 92.4 (3) †	1782.5 (3) †	1.00
Seating	1072.2 (3) † 357.4	1805.3 (3) † 601.8	1748.1 (3) † 91.5 (3) †	1835.2 (3) †	1.00

Table A-6. Statistics derived for variable selection with respect to (All)-injury characterization.

(Maryland)

STAGE I

Variable	χ^2[Child Restraint x V]	χ^2[(All)-Injury x V]	χ^2[V x (All)-inj.|Restraint] χ^2[V x (All)-inj.|No Restraint]	Mantel-Haenszel Statistic	Index***
Accident Year (4)*	13.7 (3) † 4.6	91.6 (3) † 30.5	71.9 (3) † 32.4 (3) †	92.5 (3) †	0.89
No Vehicles (2)	2.1 (1) 0.15	168.9 (1) †	60.5 (1) † 1.9 (1) 0.17	62.1 (1) †	1.00
Hour (4)	118.4 (3) † 39.4	59.3 (3) † 19.8	50.4 (3) † 8.8 (3) 0.03	58.0 (3) †	0.98
Road Type (5)	54.6 (4) † 13.6	135.8 (5) † 27.2	41.1 (4) † 8.0 (4) 0.09	46.8 (4) †	0.95
Acc Severity (5)	4.5 (4) 0.34** 1.1	7930.0 (4) † 1982.5	7426.5 (4) † 504.7 (4) †	7928.7 (4) †	1.00
Ext Damage (4)	22.0 (3) † 7.3	2175.2 (3) † 725.1	2074.5 (3) † 114.0 (3) †	2182.4 (3) †	1.00
Weight (4)	32.7 (3) † 10.9	87.7 (3) † 29.2	79.2 (3) † 11.2 (3) 0.01	89.6 (3) †	0.99
Site (3)	5.8 (2) 0.05 2.9	61.9 (2) † 31.0	56.0 (2) † 5.4 (2) 0.07	60.1 (2) †	0.98
Veh Size (2)	13.5 (1) †	56.4 (1) †	42.6 (1) † 4.0 (1) 0.05	46.5 (1) †	1.00
Child Age (4)	1804.8 (3) † 601.6	5.1 (3) 0.17 1.7	7.2 (3) 0.07 4.9 (3) 0.18	6.0 (3) 0.11	0.50
Seating (2)	18.9 (1) †	78.9 (1) †	71.4 (1) † 6.3 (1) 0.01	77.7 (1) †	1.00

*Number of levels (e.g., 1975, 1976, 1977, and 1978)

**χ^2 = 4.5(d.f. = 4) p-value = 0.34
χ^2/d.f. = 1.1

$$***\text{Index} = \frac{\text{Mantel-Haenszel}}{\chi^2[\text{V x INJ}|\text{Restraint}] + \chi^2[\text{V x INJ}|\text{No Restraint}]}$$

† $p < 0.01$

Table A-6. (Con't)

STAGE II

Variable	χ^2[(Ext Damage x V) x Belt]	χ^2[(Ext Damage x V) x INJ]	χ^2[(Ext Damage x V) x ALLINJ|Rest.] χ^2[(Ext Damage x V) x ALLINJ|No Rest.]	Mantel-Haenszel Statistic	Index
Accident Year	26.9 (7) † 3.8	5967.4 (7) † 852.5	2098.2 (7) † 140.9 (7) †	2216.8 (7) †	0.99
No. Veh Involved	13.1 (3) † 4.4	493.7 (3) † 164.6	2077.1 (3) † 111.9 (3) †	2177.9 (3) †	0.99
Hour	128.9 (7) † 18.4	3065.5 (7) † 437.9	2087.8 (7) † 121.7 (7) †	2193.4 (7) †	0.99
Road Type	32.4 (9) † 3.6	1953.6 (9) † 217.1	1377.8 (9) † 100.8 (9) †	1469.5 (9) †	0.99
Acc Severity	77.0 (9) † 8.6	9134.2 (9) † 1014.9	7928.7 (9) † 532.0 (9) †	8452.4 (9) †	1.00
Weight	26.2 (7) † 3.7	252.3 (7) † 36.0	1565.6 (7) † 80.0 (7) †	1636.2 (7) †	0.99
Site	20.9 (5) † 4.2	2074.0 (5) † 414.8	2272.5 (5) † 112.5 (5) †	2373.9 (5) †	1.00
Veh Size	16.0 (3) † 5.3	801.0 (3) † 267.0	1233.1 (3) † 55.7 (3) †	1284.2 (3) †	1.00
Child Age	586.9 (3) † 195.6	1307.4 (3) † 435.8	2062.0 (3) † 110.1 (3) †	2165.3 (3) †	1.00
Seating	1072.2 (3) † 357.4	2276.1 (3) † 758.7	2109.9 (3) † 115.3 (3) †	2220.5 (3) †	1.00